

Comparison between Face and Object Processing in Youths with Autism Spectrum Disorder: An event related potentials study

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Objective: Incapability in face perception and recognition is one of the main issues in autism spectrum disorders (ASD). Event related potential (ERP) studies have revealed controversial insights on autistic brain responses to faces and objects. The current investigation examined the ERP components of young children with ASD compared to a typically developing (TD) group when looking at the upright and inverted images of faces and cars .

Methods: Fourteen children and adolescents aged between 9 and 17 diagnosed as having ASD were compared with 18 age- gender matched normally developing individuals. All participants' ERPs were recorded while they were seeing the images of human faces and objects in both upright and inverted positions. The ERP components including N170 (latency and amplitude) were compared between the two groups in two conditions of upright and inverted using the repeated measure analysis method.

Results: The processing speed for upright faces was faster than the inverted faces in the TD group; however, the difference was not significant. A significant difference was observed in terms of N170 latency between the two groups for different stimulus categories such as objects and faces ($p < 0.05$). Moreover, inverted vs. upright stimuli in both groups elicited a greater response in terms of N170 amplitude in both groups, and this effect was significantly prominent in the right hemisphere ($p < 0.05$). The N170 amplitude turned out to be greater for the inverted vs. upright stimuli irrespective of the stimuli type and group .

Conclusion: These data suggest youths with ASD have difficulty processing information, particularly in face perception regardless of the stimuli orientation.

Key words: Autism, face, N170, object, event related potentials

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Autism is a developmental disorder characterized by communication and social interaction impairments (1). The ability to perceive and recognize faces is an important aspect of social cognition. A large body of research has provided compelling evidence for impairment in perception and recognition of faces in individuals with Autism Spectrum Disorders (2, 3, 4, 5, 6, 7, and 8). Functional magnetic resonance imaging (fMRI) studies have reported that the right fusiform gyrus shows a pronounced activation when typically developing (TD) individuals look at faces. Conversely, when individuals with autism spectrum disorder (ASD) confront facial cues, the activation of the fusiform face area is modest (9, 10). Event-Related Potentials (ERPs) have provided temporal information on face processing. In adults, the N170 (a negative component seen 170 ms following the stimulus

onset) has been reported as a typical 'face' sensitive ERP component. Moreover, some studies have substantiated a lower amplitude and greater latency in N170 component captured in response to objects and words compared to that of faces. This non-face stimuli ERP pattern is predominantly seen in the right hemisphere rather than the left. Furthermore, inverted faces are found to induce N170 components of greater amplitude and shorter latency compared to the upright faces (11, 12, 13). On the other hand, literature has argued that while N170 may not specifically belong to the face as a category, it might be a widely experienced phenomenon in people when recognizing faces (14- 18). Having noted the inconsistency in ERP studies with regards to ASD and face processing, it has generally been reported that ASD individuals are worse in face processing compared to normal people (19, 20). Nevertheless, some behavioral studies have shown no difference

between autistic individuals and normal adults with regards to response to the inverted faces (21, 22). However, some investigators have reported the lack of inversion effect in autistic individuals (23). In line with these data, some ERP studies have revealed that the N170 amplitude and latency remain unchanged when ASD individuals look at the inverted vs. upright faces (24). Most behavioral studies have shown that the ASD patients' object recognition ability is comparable to that of the TD group (25-31). This is in contrast with the face processing ability which is profoundly impaired in individuals with ASD. Interestingly, some reports have pointed out that autistic people may possibly perform better in recognizing objects compared to normal individuals (32, 25). Behrmann et al. (2006a) who examined the object recognition ability of autistic adults using "Greeble" alien-like objects, found that the ASD group still had problems in the processing of some types of objects (33). In terms of ERP findings, it has been strongly suggested that face processing is worse in individuals with ASD vs. TD group (19, 34). The employed objects in such studies were different in terms of the experience of children when using them. Based on these experiments, it has been hypothesized that some experienced objects can produce ERP components similar to faces; for instance, "cars" have been of special interest particularly to boys with ASD. The main aims of this study were to find the difference between face and object processing in the ASD group and to evaluate the ERP components to examine the inversion effect of these stimuli, in the ASD and the normal group when they were shown the upright and inverted images of faces and cars.

Material and Methods

Participants

Our initial population consisted of 24 boys with autism spectrum disorder (ASD) including autism, Asperger and autism not otherwise specified (NOS) recruited from the patients who referred to a child and adolescent psychiatric clinic. A total number of 23 boys who were recruited from the elementary, middle, and high schools were also selected as the typically developing (TD) group. All the participants were between 9 to 17 years of age with the IQ above 70. All the patients with ASD had been diagnosed by a child and adolescent psychiatrist based on DSM-IV criteria. Upon the enrollment, the parents of ASD and TD participants were interviewed. Childhood Autism Rating Scale (CARS) and the Asperger Syndrome Diagnostic Scale (ASDS) questionnaires were fully answered (35, 36). The Persian version of these two questionnaires (CARS and ASDS) have been validated for clinical use and research purposes in Farsi speaking individuals (Tehrani-Doost et al. unpublished). Fulfilling diagnostic criteria and obtaining the cut-off CARS and ASDS scores were inclusion criteria for ASD and exclusion criteria for typically developing (TD) participants. In addition, the IQs of the

participants were evaluated using the Raven Progressive Matrices (37). The exclusion criteria for the both groups were seizures, movement disorders, any other significant psychiatry disorder, head trauma, use of anticonvulsants, antipsychotic medications, genetic disorders and any notable comorbidities limiting the participants to closely follow the instructions. TD individuals with any developmental abnormalities or disorders, neurologic or psychiatric symptoms or disorders and those who had first degree relatives with autism spectrum disorder were excluded from the study. Ten children with autism were excluded from the final ASD group. Three children had excessive pursuit eye movement interfering with signal acquisition and hence processing, one child refused to wear an electroencephalogram (EEG) cap, two could not technically keep up with the test, two were unable to fulfill the task as one of them had convergence problem when focusing on the monitor and one child had a positive history of seizure. Five control children were also excluded. Two participants could not technically continue the test. More than 15% of signals attributed to eye movement and artifacts in 3 participants; therefore, they were excluded. The final sample, from which the acquired datasets were analyzed, comprised of 18 controls as well as 14 participants with high-functioning autism. Upon enrollment and prior to any experiment, written informed consent, in accordance with the principles of the declaration of Helsinki, were obtained from the participants' parents. All assessments were done in accordance with the ethical standards leading to committee approval at the Institute for Cognitive Science Study (ICSS), Tehran, Iran.

EEG Recording Procedure

Stimuli: The stimuli for the face processing-EEG task were gray-scale photographs of vehicles and faces and included five stimuli per category. All stimuli were selected from Hamera photo-object picture set. All pictures were selected from the front view except for cars which were all in the pose view. These gray scaled and isoluminated visual stimuli (sized 420 x 420 pixels) were presented on a gray background (14.8cd/m²). For data presentation and analysis, we employed the MATLAB (matrix laboratory) Psychophysics Toolbox. With regards to stimuli types, in the face category, there were two female and three male face images with different races. In the car category, there were different car models with the same size. The stimuli included five upright, five inverted faces as well as five upright and five inverted cars. The stimuli were randomly presented 15 times and in three runs to avoid lacking interest in subjects. Each photograph was presented 200 ms followed by a blank screen 1000 ± 100ms. The participants were instructed to attentively look at the stimuli while maintaining fixation, refraining from any other body movement or taking deep breath.

Data Collection: Participants' parents completed the CARS and ASDS questionnaires upon the enrollment. Following the EEG recording, participants took the Raven IQ test. Disordered participants were asked to withhold their medications 3 days prior to the experiment. To conduct the experiment, each participant was asked to sit with a 60-cm distance from the monitor screen (a 19w monitor, LG F900P, with a 100-Hz screen refresh rate) and was instructed to fix his head on a chin rest, viewing the monitor screen at a $10.52^\circ \times 10.52^\circ$ visual angle. EEG was recorded using the Neuroscan system with 32 Ag/AgCl sintered electrodes mounted on an elastic cap. ERP recordings were in AC mode (0.05–30 Hz) and were obtained upon 1-kHz sampling rate. Linked mastoids were used as reference and grounded to Afz channel. To eliminate offline artifacts, four electrodes were used to monitor horizontal and vertical eye movements. Impedance was kept below $5 \text{ k}\Omega$ throughout the process. The acquired data were subsequently resembled offline at a 250-Hz sampling rate. To ascertain the quality of recording, baseline corrections were done almost 200 ms prior to the stimulus onset. Eye movement and blinking artifacts were excluded by detecting those trials in which the peak-to-peak voltage in the horizontal and vertical eye movement channels exceeded $40 \mu\text{V}$. The recording condition was in conformity with the required standards i.e., under the electrical shield and at a sound attenuated and dim lighted room.

Data Editing: The mean latency for N170 and P100 components were measured at 130–230ms and 50–200ms windows following the stimulus onset, respectively. The ERP time window was visually verified based on the grand average as well as the individual participants' data and was compared with the similar measures chosen as time windows in the literature (38). These intervals were selected so that they correspond to the waveforms across hemispheres, conditions and groups. Latency was defined as the time span between the stimulus onset and the minimal (most negative) or maximal (most positive) wave point within the same window. Epochs were visually inspected to ensure whether they represented a true local minimum. For each participant, "peak" and the "latency to peak" were averaged across P7 and P8 electrodes and within the specified time window.

Statistical Analysis

Statistical analyses were conducted on the datasets captured from P7 (left temporal lobe) and P8 (right temporal lobe) where N170 was exerted at the maximum. The three-factor repeated measures ANOVA (39) was applied as the preferred statistical method of choice to analyze the stimulus category (face vs. car), orientation (up vs. invert), hemisphere (right vs. left) and groups (ASD vs. TD) as factors besides mean amplitude and peak latency as variables. The independent t test and Greenhouse-Geisser correction were employed to define between-group

differences and the overall analysis, respectively. The linear regression was done to find the relationships between age and IQ with the ERP indices variables. Throughout the analyses, significance level was $\alpha=0.05$.

Result

Participants' Information

The mean age in ASD and control groups were 14.78(SD = 3.09) and 13.11years (SD = 2.78), respectively. The mean Raven IQ scores were 102.35 (SD = 16.44) and 121.23 (SD = 15.08) in the ASD and TD groups, respectively. Despite the ASD group's older average than the TD group, independent samples t-tests did not show any significant difference between the two groups with regards to age, though the Raven IQ difference was significant [$t(30)=-3.52$, $P=0.001$]. The regression analysis showed no significant correlation between the IQ and age with the ERP variables. The mean ASDS and CARS scores were 53.77 (SD = 16.25), and 31.88 (SD = 7.36) in the ASD group, while the mean ASDS and CARS scores of TD youths were 28.78 (SD = 8.03) and 20.02 (SD = 4.92), respectively. Independent t test indicated a significant mean differences in CARS ($M=-11.85$, $SD=12.04$, $t(30) = -5.38$, $P<0.0001$) and ASDS [$M=24.99$, $SD=25.96$, $t(30)=5.26$, $P<0.0001$] scores between the two groups. The demographic particulars as well as descriptive analyses are outlined in Table 1.

ERP Analysis

N170 Latency: We noted a significant group effect [$F(1, 30) = 7.79$, $P=0.009$] on the mean latency, being shorter in the TD ($M = 0.146$, $SD = 0.045$) compared to the ASD group ($M = 0.179$, $SD = 0.05$). Meanwhile, hemisphere on its own and the interaction between the hemispheres and group allocation elicited no effect on the N170 latency to peak (Table 4). Moreover, while there was no significant main effect of the stimulus type (car versus face) or their orientation (upright versus inverted) on the latency, the interaction between the group, stimuli and orientation [$F(1, 30) = 5.376$, $P = 0.027$] was significant (Table 2). Results indicated that in the TD group, the N170 latency for the upright cars ($M = 0.133$, $SD = 0.056$) was less than the same for the inverted cars. However, response to the inverted cars rather than the upright cars was faster in the ASD as compared to the TD individuals. In the TD group, the upright faces induced a shorter latency than the inverted faces although not significantly different. In addition, the effect of interaction between stimulus and orientation [$F(1, 30) = 6.091$, $P = 0.020$] was also significant. As the results indicated, N170 latency turned out to be longer for the inverted rather than the upright faces in both groups. On the other hand, inverted cars elicited a faster response than the upright ones in both groups (Table 2).

Table 1: Characteristics of the two groups in terms of demographic data and the obtained results of questionnaire variables

	Group		t(30)	P
	TD N=18 M±SD	ASD N=14 M±SD		
Age	13.11±2.78 [9-17]	14.78±3.09 [9-17]	-1.728	Ns
IQ	121.23 ±15.08	102.35± 16.44	-3.52	0.001
ASDS	28.78±8.03	53.77±16.25	5.26	0.0001
CARS	20.02±4.92	31.88±7.36	-5.38	0.0001

Table 2: Results of Repeated measure analysis for N170 latency

Effect			ASD M±SD	Normal M±SD	F	P
Group	-----	-----	0.179±0.05	0.146±0.045	7.790	0.009
Stimuli* Orientation* Group	Face	Upright Inverted	0.166±0.079 0.200±0.073	0.146±0.073 0.159±0.067	5.376	0.027
	car	Upright Inverted	0.193±0.062 0.159±0.084	0.133±0.056 0.144±0.073		
Stimuli* Orientation	Face	Upright Inverted	0.156±0.01 0.179±0.05	0.163±0.22 0.151±0.056	6.091	0.02
	car	Upright Inverted				
Temporal lobe* Orientation	Right temporal lobe	Upright Inverted	101±0.062 102±0.056	115±0.062 108±0.056	3.571	0.06
	Left temporal lobe	Upright Inverted				

Table 3: Results of Repeated measure analysis for N170 Amplitude

Effect			ASD M±SD	Normal M±SD	F	P
Group	-----	-----	-1.948±1.210	-1.807±1.069	0.754	0.392
Stimuli* Orientation* Group	Face	Upright Inverted	-1.960±1.487 -2.190±1.90	-1.307±1.312 -1.912±1.680	4.398	0.045
	car	Upright Inverted	-1.465±1.080 -2.178±2.166	-1.842±.956 -2.125±1.906		
Stimuli* Orientation	Face	Upright Inverted	-1.860± 0.752 -2.382±1.363	-1.919 ±1.187 -1.974±1.380	6.091	0.02
	car	Upright Inverted				
Temporal lobe* Orientation	Right temporal lobe	Upright Inverted	1.720±0.961 -1.42±1.640	-1.59±1.329 -1.935±1.108	11.155	0.002
	Left temporal lobe	Upright Inverted				

Table 4: Repeated measure analysis results of effects and their interaction for N170 latency and amplitude

Effect	N170 Latency		N170 Amplitude	
	F	P	F	P
Group	7.790	0.009	0.754	0.392
Stimuli	1.617	0.213	0.784	0.383
Stimuli*Group	0.159	0.693	0.579	0.315
Orientation	0.708	0.407	2.278	0.142
Orientation*Group	0.708	0.407	0.918	0.346
Temporal lobe	2.94	0.096	0.061	0.804
Temporal lobe* Group	0.196	0.661	0.108	0.744
Stimuli * Orientation	6.091	0.02	4.398	0.045
Stimuli*Orientation* Group	5.376	0.027	2.473	0.126
Stimuli*Temporal lobe	0.984	0.329	0.043	0.837
Stimuli*Temporal lobe*Group	1.085	0.306	2.904	0.099
Orientation* Temporal lobe	3.571	0.069	11.1554	0.0002
Orientation* Temporal lobe* Group	1.982	0.169	3.248	0.082
Stimuli*Orientation* Temporal lobe	1.264	0.270	0.197	0.661
Stimuli*Orientation*Temporal lobe* Group	0.038	0.846	0.498	0.486

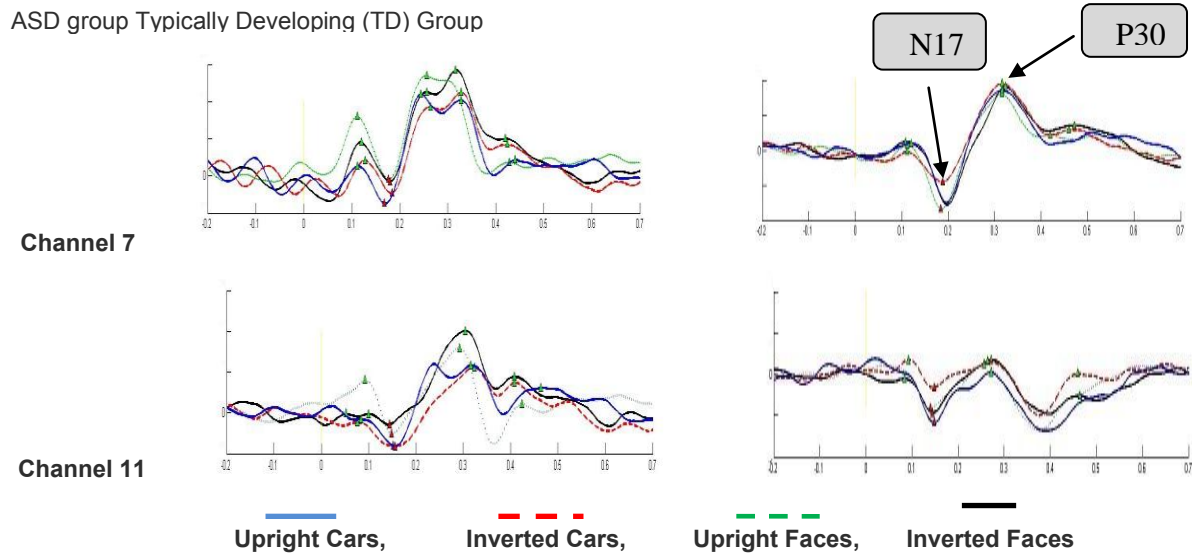


Figure 1: Waveforms for ASD and TD groups averaged across the P7, P8 electrodes in each hemisphere. This figure depicts the grand average across all subjects in each group for upright faces, upright cars, inverted faces, and inverted cars. Vertical line shows amplitude (μV) and horizontal line shows time (second).

The results of repeated measure analysis revealed that the effect of interaction between hemisphere and orientation was nearly significant in which the latency was shorter in the right temporal lobe [$F(1, 30) = 3.571, p = 0.06$] (Table 2).

N170 Peak Amplitude

There was no significant main effect exerted by group, event, orientation and hemisphere with regards to the N170 peak amplitude. Likewise, no significant interaction between the main factors and groups was noted (Table 4). On the contrary, the interaction between stimuli and orientation [$F(1, 30) = 4.398, P = 0.045$] in which the amplitude of the upright face was smaller than the upright car was significant while this variable for the inverted face was larger than the inverted car (Table 3). Taken together, the results of both groups demonstrated that the inverted faces lead to a larger amplitude compared to other mean values (Table 3). Also, the results revealed that the interaction between orientation and localization in the temporal lobe [$F(1, 30) = 11.155, P = 0.002$] was significant. Based on the data obtained from the both groups, the inverted stimuli were less negative in the right than the left temporal. Upright stimuli predominantly generated smaller amplitude in the left vs. right temporal lobe.

Discussion

To find the mechanisms underlying the face attention deficit observed in the youths with ASD and compare it with object processing, we conducted an ERP study on children and adolescents with autism spectrum disorder and normal developing youths when they were looking at faces and objects in the upright and inverted positions. In this study, it was found that individuals with autism spectrum disorders are different from

normal people in looking at human faces and other objects. Furthermore, a significant difference in terms of event related potentials (ERP) components have been documented when the participants looked at faces vs. objects stimuli (11). Behavioral studies have suggested that children and adolescents with ASD are better in object than face processing (25, 26, 40, 28, 29, and 30). In this study, it was revealed that N170 latency for face processing did significantly differ between the two groups. Regardless of groups, the upright face was processed faster than the other stimuli. Moreover, inverted vs. upright stimuli elicited a greater response in terms of N170 amplitude in both groups, and this effect was significantly prominent in the right hemisphere. Of note, was a significant difference between the two groups in terms of N170 latency regardless of stimuli (faces vs. cars) and orientation (upright vs. inverted). This finding is consistent with that of other studies which have shown delayed event related potentials in individuals with ASD compared to typically developing people (41, 24, 42, and 43). Based on the findings, we can conclude that the ERP components including the N170 have longer latencies in ASD individuals compared to TD individuals. This can potentially be attributed to the under connectivity hypothesis in autism which explains the extent of ASD individuals' problems in exchanging information for especially complex stimuli (such as faces) across the brain (44). Gunji et al. compared the processing of familiar vs. unfamiliar faces in people with pervasive developmental disorders (PDD) vs. control group. Their results demonstrated a shorter mean latency of N170 in the PDD group (20). This finding, however, is inconsistent with our results, because we have observed a longer latency for faces regardless of their orientation. The participants in Gunji's study were younger than ours and their sample size was smaller

which may explain the difference between the two findings. We noticed that in our ASD group, N170 latency was significantly greater for the inverted vs. upright faces. Furthermore, upright vs. inverted faces were processed significantly faster in the right hemisphere in the both groups. In an earlier study, Macpartl and et al. investigated the N170 component in autistic and typically developing adults and adolescents (24) when displaying upright and inverted pictures of faces and pieces of furniture to the participants. They found no significant difference between the inverted and upright faces in the ASD group in terms of N170 properties. Therefore, they suggested that there was no face inversion effect in autistic individuals (24). This is in contrast with our finding which indicates that N170 latency is longer for inverted vs. upright faces amongst the ASD participants. In our study, no significant difference was found in terms of N170 latency between the two groups for different stimulus categories such as objects and faces. According to O'Connor et al. there seem to be no difference between the ASD and typically developing children (mean age of 11 years) with regards to N170 component properties (19). This notion is in line with our results. Since this variable has been significantly presented differently in adult groups, it could be inferred that the electrophysiological properties of face processing may become prominent in ASD individuals of late adolescence. Moreover, based on our findings (although not significantly different), the N170 component for the inverted faces had a longer latency compared to the upright faces in the TD group. This difference, however, was significant in other studies in which inverted faces induced a longer latency for N170 (12). This might be partly attributed to the disturbance in configural processing of face in adults (11). Adding to this, some reports have documented that the prolonged N170 latency for inverted faces is prominent in the frontal and parietal areas (45, 46). Our data showed no significant difference between face and car processing in the TD youths group. In agreement with our findings are reports which have argued that N170 is not specific for face processing (16), while reflecting the adults experience in face processing (14). In addition, fMRI studies have revealed the activation of the fusiform face area (FFA) for both faces and experienced objects (47). Given this, there is insufficient evidence to support the specificity of N170 for face vs. experienced object processing in youths. We have found that the N170 amplitude is greater for the inverted vs. upright stimuli irrespective of the stimuli type. This difference was significant in the right vs. left hemisphere. Report from Eimer et al. supports this finding (48). Our results indicated that inverted faces elicited larger amplitude of N170 components compared to other stimuli regardless of the group. The above is in agreement with other researches exhibiting greater signal amplitude for inverted vs. upright faces in typically developing older children and/or adults (45, 46). Similar to what we have reported here, an earlier investigation showed

significant processing differences for inverted vs. upright faces both in ASD and typically developing groups (24). We observed no significant difference between the two groups in terms of upright faces and objects stimuli processing. O'Connor et al. investigated upright face stimuli processing in children and adults with ASD vs. normal individuals. They did not find any difference between the two groups; however, they found larger amplitude of N170 components for face stimuli amongst adult participants (19). Dependable findings on N170 component in typically developing and ASD children are limited and inconsistent compared to that of adult literature. As opposed to children, N170 is found to be specific to face processing amongst adults. Itier and Taylor (2004a) investigated upright and inverted face processing properties in participants of 8-15 year olds and adults (45). Despite the evident larger N170 amplitude among children aged 14-15 years and adults, they found no amplitude enhancement among younger children. This component was also larger for inverted faces. Right lateralization was prominent across all age groups for N170 in their study. They found that N170 was enhanced for inverted faces only in older age groups. In our study, the participants' age ranged between 9 to 17 years of age. Due to small number of participants, we were hardly able to assess the effect of age on N170 features. As discussed earlier, face inversion may disrupt the second order configural processing possibly represented by larger amplitude of N170 (49- 53). Rossion et al. have suggested two explanations for this finding. First is the difficulty in inverted face processing which demands more neurons (neural circuitries) to involve, and second is that the neurons involved in the processing of inverted face may share circuits with those for object recognition. This hypothesis may at least partly explain both the longer latency and larger amplitude for N170 in response to inverted faces. Thus, the N170 component features in TD and ASD groups (9-17 years) for inverted faces in the current investigation might have resulted from a second order configural disruption. We have found no significant difference for N170 amplitude between the stimuli and groups. The N170 amplitude was prominently larger for the inverted face stimuli irrespective of the group. Consistent with some other reports, we observed that experienced objects produced a shorter latency in N170 (14, 16, and 47). It was also found that the N170 amplitude is larger when participants viewed images of dogs and birds to which they are so familiar. We recorded larger N170 amplitudes for inverted cars vs. inverted faces. Referring to the literature, the corresponding results for inverted objects are quite controversial. Eimer et al. found that N170 is not specific to faces since objects inversion can alter the N170 deflection [38]. However, other researchers have suggested that amongst adults, the inversion effect is restricted to face stimuli (54, 55). Our specific finding that inverted cars elicited a significantly shorter N170 latency to peak compared to

upright cars and inverted faces in autistic individuals is perceived as novel and interesting since no such finding has already been reported. There are few papers on different objects processing in ASD population; of which, some have reported no differences between ASD and the control groups (25, 26, 27, 56, 28, 29, and 30). An ERP study demonstrated no difference between the processing of familiar and unfamiliar toys in ASD vs. TD children (29). This is inconsistent with our findings showing that experienced objects such as cars are processed faster compared to faces amongst ASD group. This inconsistency can be explained by the fact that the familiar objects are different from experienced ones which is the case in individuals with ASD. A functional MRI study examined the processing of bottles, chairs, planes and birds and failed to find significant differences between ASD and TD groups (9). This is in line with the current study in which we found no object processing differences between the two groups. Insights from some behavioral studies which indicate a feature-based object processing among ASD people (57, 58, and 59) may possibly help to explain our findings. In the current study, wheels were prominent in inverted car images. Since ASD children are interested in distinct parts of objects (such as wheels of a car), it is plausible that their interest in parts of the object has produced a shorter N170 latency to peak for the inverted cars. In our study, since the participants' age ranged from childhood to adolescence, some of our results are in line with those on adults and others with those on children. Some investigators such as Itier and Taylor (2004b) have pointed out that the inversion effect starts to appear since the age of 12-13 years and remains non-prominent until adulthood (46). In addition, Batty explained that N170 amplitude for emotional faces decreases until the age of 12-13 years after which it starts to increase (60). Putting our findings together with the so far available insights, may allow us to conclude that youths with ASD have difficulty processing information, particularly in face perception regardless of the stimuli orientation. It means that these individuals have a general deficit in paying attention to the environment. This impairment needs to be considered in interventional programs to enhance their attention to objects and faces.

The findings of this study should be considered in light of some limitations. First of all, the sample size was small which may prevent the generalization of the results, although the repeated stimuli can compensate for this limitation. The second limitation is the wide age range of the participants which can influence the results in terms of the effect of development. The significant difference in IQ between the groups can be considered as another limitation, although no significant relationship was found between IQ and ERP components. Therefore, further studies with larger sample sizes and different age groups should be conducted to find the effect of development on information processing in individuals with ASD.

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