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Patterns of Visual Attention and Gaze to Human and Animal Faces in Children with Autism Spectrum Disorders

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Abstract

The aim of the study is to investigate the patterns of visual attention and gaze to familiar female/male faces and animal faces in high-functioning children with Autism Spectrum Disorders (ASD). Seven children with ASD and ten (10) typically developing (TD) children participated in this study. To collect data, an eye-tracking system was used while participants looked at visual stimuli. According to the results of the study, high-functioning children with ASD have deficiency in getting relevant social information from the eyes though faces familiar to them, but they use information from the eye region in face exploration more than from the other parts of the faces. In addition, children with ASD seem to present gaze patterns similar to those of TD children during face exploration.

Keywords: Autism Spectrum Disorder (ASD), Visual Attention, Human Face, Animal Face, Eye-tracking, Human-Computer Interaction;

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1. Introduction

Through the ages, the student-teacher relationship has been the basis for the education of generation after generation. Even the origin of the word “pedagogy” makes reference to the support the teacher gives the student, in the same way that one would "take a child by the hand."

The distinctive feature of the Autism Spectrum Disorder (ASD) is the permanent deficiency of the social communication and interaction abilities (APA, 2000). Volkmar et al. (1997) state that there are many researches oriented to define the lack of the social communication abilities in ASD more accurately. It is thought that this deficiency is related to the dysfunctions of the brain regions

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specialized for social-information processing (Dawson et al., 2002). In a study in which the effects of the social and neutral stimuli on the eye-behavior are analyzed, there is some evidence about the lack of the ability of orientation to social stimuli of the children diagnosed with ASD (Dawson et al., 1998). In another study, the natural eye-behaviors of 20 months old children with ASD are observed while they are playing games and it is confirmed that when compared to the typically developing (TD) children, the children with ASD are looked at the human beings for a shorter period of time and observed the objects for a longer time (Swettenham et al., 1998). The results of the studies within the literature are supporting the idea that the children with ASD lack social perception (Hofsten et al., 2009; McPartland et al., 2010; Dawson et al., 2004; Swettenham et al., 1998; Pelphrey et al., 2002; Dawson et al., 1998).

The importance of face within the social communication, particularly in personal identification and as a means of the interpersonal communication, is emphasized in the related literature (Althoff & Cohen, 1999; Joseph & Tanaka, 2003). The facial photographs share a very similar structure that is formed by the same components (the eyes, mouth, and nose) within a similar basic configuration (the nose at the center, the eyes above, and the mouth below). In other words, the facial photographs are a class of stimuli which is highly homogeneous (Joseph & Tanaka, 2003). Despite this fundamental similarity, many people can easily recognize and distinguish thousands of different faces. According to another point of view, because of the minor structural differences, face is one of the most complex stimuli which challenge the human beings' visual systems (Jemel et al., 2006).

For children, paying attention to the face supplies information about the face and its relation with external events (e.g. speaking) and internal situations (e.g. emotions) (Sterling et al., 2008). The previous studies show that the TD individuals attend to inner features (Caldara et al., 2005; Sterling et al., 2008; Pelphrey & Carter, 2008) of the faces along with the eyes (Haith et al., 1977) while scanning the face. For instance, when people are asked to distinguish the identity or the sexuality of a face, they first use the information that is derived from the surrounding of the eyes and then from the surrounding of the mouth (Schyns et al., 2002). Falkmer et al. (2010) define that area (eyes and mouth) which is essential to perceive the social information of the face as the "face information triangle (FIT)". Thus, FIT involves the socially informative regions of the face.

In this context, the studies that investigated attention to the face and face processing abilities of the children with ASD show that not paying attention to the face is one of the main developmental indicators of autism (Osterling & Dawson, 1994; Swettenham et al., 1998). Volkmar et al. (2005) in their literature review state that orienting to faces is deficient in children with ASD from infancy. Although the experimental studies illustrate that the children with ASD are deficient in face processing abilities (Riby & Hancock, 2009; Chawarska & Shic, 2009; Joseph & Tanaka, 2003; Baron-Cohen et al., 2001), it is also denoted that those children see and scan faces differently from the TD children (Joseph and Tanaka, 2003; Sasson, 2006). Furthermore, there is serious evidence supporting that individuals with ASD encode and remember the faces in a different way from the typical individuals (Joseph & Tanaka, 2003). In addition, the individuals with ASD tend to focus less on the inner features of the face, particularly on the eyes (Trepagnier et al., 2002; Pelphrey, et al., 2002; Dalton, et al., 2005; Klin et al., 2002a; Falck-Ytter, 2008; Hernandez et al., 2009; Klin & Jones, 2008; Boraston et al., 2008; Sterling, et al., 2008; Pelphrey & Carter, 2008). Some studies demonstrate that individuals with ASD preferably attend to the mouth (Klin et al., 2002b; Joseph & Tanaka, 2003). From this point, it is argued that the individuals with ASD should be much more willing to look at to the familiar faces and thus should be better at processing this information (Sterling et al., 2008). A number of studies investigating neuroimaging of individuals with ASD found that they show atypical patterns of neural activation while viewing unfamiliar faces (Schultz et al., 2000; Hall et al., 2003; Wang et al., 2004; Pierce et al., 2001), but normal patterns of neural activation while viewing highly familiar faces (Pierce et al., 2004).

There is some reverse but serious evidence showing that the individuals with ASD do not focus or pay attention on the socially informative features of the faces such as eyes and mouth (Dapretto et al., 2006; van der Geest et al., 2002; Rutherford & Towns, 2008; Speer et al., 2007; Freeth et al., 2010). Jemel et al. (2006), within their evaluation of the related literature, state that when all findings are taken together, the face processing abilities of the individuals with ASD are underestimated.

There are very few studies examining the visual attention of the children with ASD using familiar faces and animal faces. Furthermore, to the authors' knowledge, there is no research studying the differences in the eye-behaviors of the children with ASD regarding recognizing female and male faces. Additionally, the literature has not matured yet about the difference in the visual attention and gaze of the children with ASD in recognizing human and animal faces. The present study aims to investigate the visual attention and gaze patterns of the children with ASD while staring at the faces on the human and animal photographs. For that purpose, by using the variables of fixation and gaze obtained from eye-tracking, a comparison with the TD children is made. In that context, the research problems of the study are given below.

1.1. Research Problems

The current study sought to examine the following research problems:

1. Do children with ASD and TD children significantly differ in visual attention and gaze to *socially informative* regions of the Familiar Female Face (FFF)?
2. Do children with ASD and TD children significantly differ in visual attention and gaze to *socially non-informative* regions of the FFF?
3. Do children with ASD and TD children significantly differ in visual attention and gaze to *socially informative* regions of the Familiar Male Face (FMF)?
4. Do children with ASD and TD children significantly differ in visual attention and gaze to *socially non-informative* regions of the FMF?
5. Do children with ASD and TD children significantly differ in visual attention and gaze to *socially informative* regions of the Animal Face (AF)?
6. Do children with ASD and TD children significantly differ in visual attention and gaze to *socially non-informative* regions of the AF?
7. Does visual attention of the children with ASD to socially informative regions of the FFF and the FMF significantly differ?
8. Does visual attention of the children with ASD to socially informative regions of the Human Face (HF) and the AF significantly differ?
9. Does visual attention of the children with ASD to socially informative regions of the HF and socially non-informative regions of the HF significantly differ?
10. Does visual attention of the children with ASD to socially informative regions of the AF and socially non-informative regions of the AF significantly differ?

2. Method

2.1. Participants

2.1.1 Children with ASD

Seven children diagnosed with ASD from Hamit İbrahimiye Autistic Children Training Center in Istanbul and Tekirdağ Autistic Children Protection Association in Tekirdag participated in this experiment. All participants were high-functioning, male and aged between 12 and 17 years. All of them were trained since the age of 3.

2.1.2. TD Children

Ten subjects (5 boys and 5 girls) aged between 12 and 17 participated in the experiment. Gender differences have been ignored in TD children.

2.2. Apparatus

Eye-tracking technique was used in this study which is one of the ways of collecting data about perceptual processes in individuals with ASD. This technique allows making implications about brain activation (Kemner & Engeland, 2006) and also can facilitate our understanding of underlying cognitive processes (Karatekin, 2007) involved in face exploration. Furthermore, this technique has advantages over observational techniques which are source of information about social attention, since the exact location of gazes can be determined which enables more detailed analysis of attention to faces (Anderson, Colombo, & Shaddy, 2006).

Eye movements were recorded using a remote SMI iView X RED eye-tracker system. This system uses the technology of non-invasive video-based eye tracking which can record the gaze position of the eyes binocularly with a cornea reflection technique. This technique includes the reflection of infrared light sources on the cornea which is measured relative to the centre of the pupil. The frequency of recording was 50 Hz and was accurate to $0,5^{o}$ of visual angle.

The photos were displayed on a 19’’ LCD monitor at a distance of approximately 70 cm. The screen resolution was set to 1680 x 1050 pixels. The eye-tracking device is mounted below the monitor. It has automatic eye and head tracker camera interface that allows free head movement in a wide operating range (40 cm x 40 cm). In this system, nothing is mounted on the subjects. In the present study, a fixation was registered if gaze was stationary for at least 0.08 s within an area of maximum 100 pixels. Lastly, the fixations can be organized in terms of predefined areas of interests (AOIs). SMI BeGaze software gives the visual results of eye-tracking within AOIs.

2.3. Stimuli

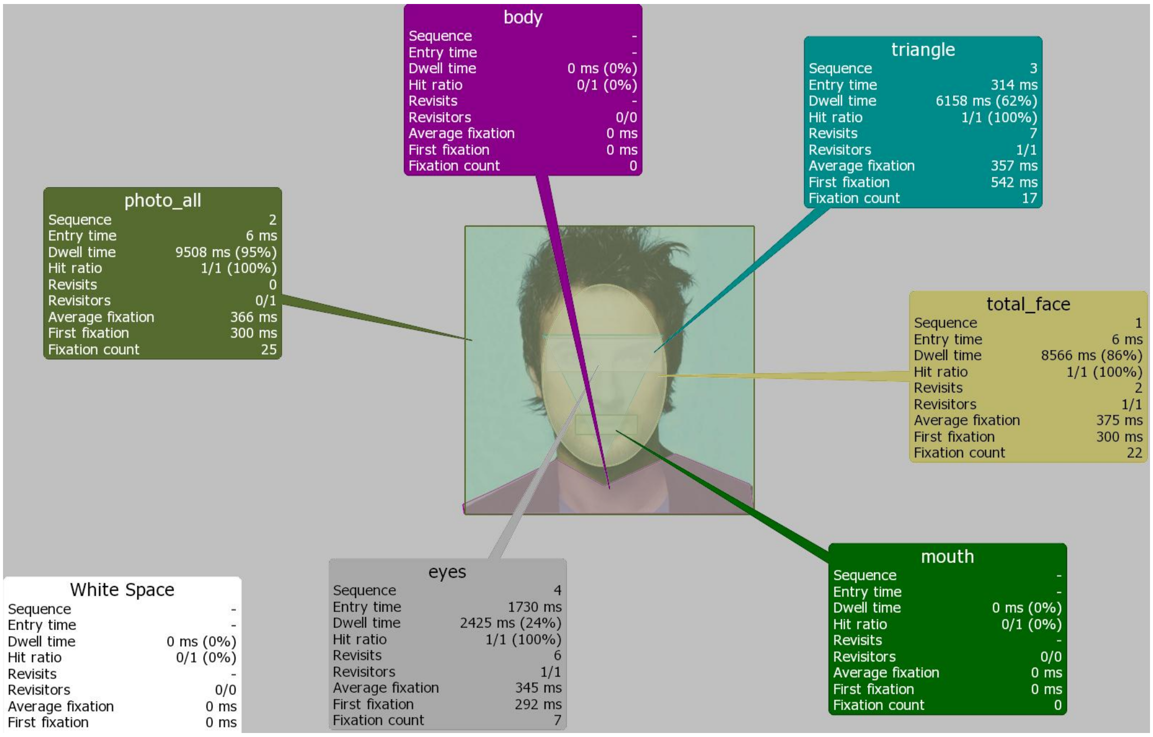
The visual stimuli were the photos of familiar female face, familiar male face, and animal face (Figure 1). Before conducting the experiment within the eye-tracking system, the parents of the children with ASD were asked whether they knew the two famous artists (shown in Figure 1) in Turkey. All of the parents confirmed that the participants with ASD were familiar with the artists. This was also tested during the experiment by asking the children with ASD to tell the name of the artists: all of them answered this question correctly. In addition, they all knew the animal as a dog. Each of the photos were shown for 10 s. Size of the photos was 6,01 x 5,98 cm. Areas of interests (AOIs) in the photos are shown in Figure 2.

Figure 1. The two famous artists and an animal used for stimuli (FMF, FFF and AF, respectively)

Figure 2. Areas of interests in the FMF photo

As shown in Figure 2, there are seven AOIs in the screenshot. One of them is out of the photo named "white space". Another one is "photo all" to represent the whole photo. The photos are divided into two parts called "body" and "total face". Faces are divided into three regions called "mouth", "eyes" and "(face information) triangle". An example of the visual results of the study including AOIs is given in the following figure (Figure 3). In this figure, AOIs are shown with the statistics of sequence, dwell time, average fixation time, and fixation count.

Figure 3. An example of the visual results of the eye-tracking analysis within AOIs



2.4. Design

In this study, observational and physiological methods were used to collect data. Researchers observed participants as an observational method, and eye-tracking technique was used as a physiological method. Descriptive and inferential statistics were used to compare TD children and children with ASD.

2..5 Procedure

First of all, children, who are appropriate for this study, diagnosed with ASD by a state hospital and a counseling research center, were selected by the teachers from Hamit İbrahimiye Autistic Children Training Center and Tekirdağ Autistic Children Protection Association. Informed consent was obtained from each participant's parents. After getting preliminary information (age, education level etc.) about the participants from their teachers and parents, they were brought to the Human-Computer Interaction (HCI) Lab at the Department of Computer Education and Instructional Technologies at the University accompanied by two teachers.

The participants accompanied by a teacher and a researcher were taken to the soundproof room in the HCI Lab one by one. The teacher stayed with children in this room, and the researcher left the room to observe from one-sided mirror in the observer room. The teacher was informed about the experiment beforehand. Participants were familiarized with the testing setting prior to the experiment. Then they were seated on a comfortable chair that eye-tracking device can record the eye movements. Participants were free to move their head position throughout the experiment but were asked to ''sit quite still''. The calibration with 7 points was conducted using SMI iView X. All of the participants succeeded in the calibration phase. The experiment began with a short introduction in which they were told that all they needed to do was to look at the photos and identify them.

The participants looked at the photos for 30 s in the experiment. After looking at the photos, experiment was terminated. During the experiment, participants were observed by both researchers and teachers, and if needed, they were given instructions. In addition, they were encouraged to accomplish the task and received a gift in return for participating in the study.

The same process was repeated for 10 TD children.

3. Results

Before the inferential statistics, the two groups (ASD and TD) of the participants were compared in terms of the age variable. There were no significant differences between the two groups according to age ($t_{(15)}$=.24, p>.05). Descriptive statistics and the results of the independent samples t-test are given in Table 1. Hence, these age-matched groups were tested in terms of the research problems of the study. In the analysis of the research questions, fixation duration and dwell time are given in terms of milliseconds.

Table 1. Descriptive statistics and comparison of the age variable of the participants

Group	N	Mean	SD	df	t	p
ASD	7	15	1.83	15	.24	.82
TD	10	14.8	1.62			

Research Problem 1: *Do children with ASD and TD children significantly differ in visual attention and gaze to socially informative regions of the FFF?*

The participants' visual attention (fixation count and duration) and gaze (dwell time) to socially informative regions (eyes, mouth and FIT) of the FFF were compared by MANOVAs. These tests showed that children with ASD and TD children do not differ significantly in their fixation counts, fixation duration and dwell time on socially informative regions of the FFF (*eyes*: (Λ)=.589, F(3, 13)=3.03, p=.068>.05; *mouth*: (Λ)=.921, F(3, 13)=.372, p=.775>.05; *FIT*: (Λ)=.601, F(3, 13)=2.88, p=.077>.05). Due to the closeness of p-values of the eyes and FIT regions to the significance, further analysis done to examine any differences between fixation counts, fixation duration and dwell time of the ASD and the TD groups with ANOVAs. The results of these tests were given in the following table (Table 2).

Table 2. Comparison of the groups by visual attention and gaze to socially informative regions of the FFF

Variable	Group	N	Mean	SD	df	F	p
FFF_Eyes_FC*	ASD	7	1.4	1.59	1-15	3.68	.074
	TD	10	3.8	3.01			
FFF_Eyes_FD*	ASD	7	250.2	288.82	1-15	8.16	.012
	TD	10	1829.2	1428.9			
FFF_Eyes_DT*	ASD	7	253.4	291.2	1-15	8.27	.012
	TD	10	1851.7	1436.4			
FFF_FIT_FC*	ASD	7	4.4	4.34	1-15	4.23	.058
	TD	10	9	4.67			
FFF_FIT_FD*	ASD	7	1588.2	1507.55	1-15	9.3	.008
	TD	10	4894.2	2559.18			
FFF_FIT_DT*	ASD	7	1608.2	1518.92	1-15	9.2	.008
	TD	10	4983.2	2637.4			

* FFF: Familiar Female Face, FC: Fixation Count, FD: Fixation Duration, DT: Dwell Time, FIT: Face Information Triangle

Results of the ANOVAs show that ASD and TD groups significantly differ in their fixation duration and dwell time on the eyes ($F(1, 15)=8.16$, $p<.05$ and $F(1, 15)=8.27$, $p<.05$; respectively) and FIT regions ($F(1, 15)=9.3$, $p<.05$ and $F(1, 15)=9.2$, $p<.05$; respectively) of the FFF whereas their fixation counts do not significantly differ in these AOIs ($F(1, 15)=3.68$, $p>.05$ and $F(1, 15)=4.23$, $p>.05$; respectively). Therefore, TD children attend to eyes and FIT of the FFF more than children with ASD.

Research Problem 2: *Do children with ASD and TD children significantly differ in visual attention and gaze to socially non-informative regions of the FFF?*

The participants' visual attention (fixation count and duration) and gaze (dwell time) to socially non-informative regions (the rest of the face (face except the FIT), body and background) of the FFF were compared by MANOVAs. These tests showed that children with ASD and TD children do not differ significantly in their fixation counts, fixation duration and dwell time on socially non-informative regions of the FFF (the *rest of the face*: $(\Lambda)=.879$, $F(3, 13)=.597$, $p=.628>.05$; *body*: $(\Lambda)=.900$, $F(3, 13)=.480$, $p=.702>.05$; *background*: $(\Lambda)=.729$, $F(3, 13)=1.61$, $p=.235>.05$).

Research Problem 3: *Do children with ASD and TD children significantly differ in visual attention and gaze to socially informative regions of the FMF?*

The participants' visual attention (fixation count and duration) and gaze (dwell time) to socially informative regions (eyes, mouth and FIT) of the FMF were compared by MANOVAs. These tests showed that children with ASD and TD children differ significantly in their fixation counts, fixation duration and dwell time on eyes of the FMF ($(\Lambda)=.533$, $F(3, 13)=3.80$, $p=.037<.05$) and do not differ significantly in their fixation counts, fixation duration and dwell time on mouth and FIT of the FMF (*mouth*: $(\Lambda)=.634$, $F(3, 13)=2.51$, $p=.105>.05$; *FIT*: $(\Lambda)=.572$, $F(3, 13)=3.24$, $p=.057>.05$). Due to the closeness of p-value of the FIT region to the significance, further analysis was done to examine differences between fixation counts, fixation duration and dwell time of the ASD and the TD groups with ANOVAs. The results of these tests were given in the following table (Table 3).

Table 3. Comparison of the groups by visual attention and gaze to FIT region of the FMF

Variable	Group	N	Mean	SD	df	F	p
FMF_FIT_FC*	ASD	7	9.25	5.4	1-15	.778	.392
	TD	10	11.4	4.62			
FMF_FIT_FD*	ASD	7	2974.75	1561.58	1-15	4.73	.046
	TD	10	4778.9	1760.67			
FMF_FIT_DT*	ASD	7	3124.75	1645.9	1-15	4.17	.059
	TD	10	4857.4	1770.26			

* FMF: Familiar Male Face, FC: Fixation Count, FD: Fixation Duration, DT: Dwell Time, FIT: Face Information Triangle

Results of the ANOVAs show that ASD and TD groups significantly differ in their fixation duration on the FIT region of the FMF (F(1, 15)=4.73, p<.05), whereas their fixation counts and dwell time do not significantly differ in this AOI (F(1, 15)=.778, p>.05 and F(1, 15)=4.17, p>.05; respectively). Therefore, TD children attend to eyes and FIT of the FMF more than children with ASD.

Research Problem 4: *Do children with ASD and TD children significantly differ in visual attention and gaze to socially non-informative regions of the FMF?*

The participants' visual attention (fixation count and duration) and gaze (dwell time) to socially non-informative regions (the rest of the face, body and background) of the FMF were compared by MANOVAs. These tests showed that children with ASD and TD children differ significantly in their fixation counts, fixation duration and dwell time on the rest of the face of the FMF ((Λ)=.452, F(3, 13)=5.25, p=.014<.05) and do not differ significantly in their fixation counts, fixation duration and dwell time on body and background of the FMF (*body*: (Λ)=.920, F(3, 13)=.38, p=.772>.05; *background*: (Λ)=.569, F(3, 13)=3.29, p=.055>.05). Therefore, TD children attend to the rest of the face (*fixation duration*: M=2315, SD=1147.7) and background (*fixation duration*: M=1857.3, SD=1194.3) of the FMF more than children with ASD (*fixation duration*: M=592, SD=391.2 and M=989.3, SD=844.8; respectively).

Research Problem 5: *Do children with ASD and TD children significantly differ in visual attention and gaze to socially informative regions of the AF?*

The participants' visual attention (fixation count and duration) and gaze (dwell time) to socially informative regions (eyes, mouth and FIT) of the AF were compared by MANOVAs. These tests showed that children with ASD and TD children differ significantly in their fixation counts, fixation duration and dwell time on eyes and FIT of the AF (*eyes*: (Λ)=.421, F(3, 13)=5.97, p=.009<.05; *FIT*: (Λ)=.406, F(3, 13)=6.33, p=.007<.05) and do not differ significantly in their fixation counts, fixation duration and dwell time on mouth of the AF ((Λ)=.739, F(3, 13)=1.53, p=.254>.05). Therefore, TD children attend to eyes (*fixation duration*: M=3713.9, SD=2162.2) and FIT (*fixation duration*: M=5798.9, SD=2459.3) of the AF more than children with ASD (*fixation duration*: M=362, SD=380.9 and M=2471, SD=1649; respectively).

Research Problem 6: *Do children with ASD and TD children significantly differ in visual attention and gaze to socially non-informative regions of the AF?*

The participants' visual attention (fixation count and duration) and gaze (dwell time) to socially non-informative regions (the rest of the face, body and background) of the AF were compared by MANOVAs. These tests showed that children with ASD and TD children do not differ significantly in their fixation counts, fixation duration and dwell time on socially non-informative regions of the AF (the *rest of the face*: (Λ)=.665, F(3, 13)=2.185, p=.139>.05; *body*: (Λ)=.615, F(3, 13)=2.71, p=.088>.05; *background*: (Λ)=.804, F(3, 13)=1.06, p=.401>.05).

Research Problem 7: *Does visual attention of the children with ASD to socially informative regions of the FFF and the FMF significantly differ?*

The ASD group's visual attention (fixation count and duration) to socially informative regions (eyes, mouth and FIT) of the FFF and FMF were compared by paired samples t-tests. These tests showed that children with ASD differ significantly in their fixation counts and fixation duration on eyes ($t_{(6)}$=3.12, p<.05 and $t_{(6)}$=3.45, p<.05; respectively) and fixation counts on FIT ($t_{(6)}$=3.07, p<.05) of the FFF and FMF and do not differ significantly in their fixation counts and fixation duration on mouth ($t_{(6)}$=1.26, p=.25>.05 and $t_{(6)}$=1.87, p=.11>.05; respectively) and fixation duration on FIT ($t_{(6)}$=2.20, p=.071>.05) of the FFF and FMF. Therefore, children with ASD attend to eyes (*fixation duration*: M=1588.25, SD=1155.88) and FIT (*fixation count*: M=9.25, SD=5.4) of the FMF more than the FFF (*fixation duration*: M=250.2, SD=288.8; *fixation count*: M=4.4, SD=4.34; respectively).

Research Problem 8: *Does visual attention of the children with ASD to socially informative regions of the HF and the AF significantly differ?*

To compare visual attention of the children with ASD to human and animal faces, human face variables were computed by taking the mean of the familiar female and male faces. The ASD group's visual attention (fixation count and duration) to socially informative regions (eyes, mouth and FIT) of the HF and AF were compared by paired samples t-tests. These tests showed that children with ASD differ significantly in their fixation duration on eyes ($t_{(6)}$=2.96, p<.05) of the HF and AF and do not differ significantly in their fixation counts on eyes ($t_{(6)}$=2.35, p=.057>.05) and fixation counts and fixation duration on mouth ($t_{(6)}$=.45, p=.67>.05 and $t_{(6)}$=.69, p=.51>.05; respectively) and FIT ($t_{(6)}$=.87, p=.42>.05 and $t_{(6)}$=.39, p=.71>.05; respectively) of the HF and AF. Therefore, children with ASD attend to eyes of the HF (*fixation duration*: M=919.23, SD=668.06) more than the AF (*fixation duration*: M=362, SD=380.85).

Research Problem 9: *Does visual attention of the children with ASD to socially informative regions of the HF and socially non-informative regions of the HF significantly differ?*

The ASD group's visual attention (fixation count and duration) to socially informative (FIT) and non-informative regions (the rest of the face) of the HF were compared by paired samples t-tests. These tests showed that children with ASD differ significantly in their fixation counts and fixation duration on FIT and the rest of the face of the HF ($t_{(6)}$=3.43, p<.05 and $t_{(6)}$=4.67, p<.05; respectively). Therefore, children with ASD attend to FIT (*fixation duration*: M=2281.48, SD=1287.5) more than to the rest of the face (*fixation duration*: M=779.1, SD=488.65) of the HF.

Research Problem 10: *Does visual attention of the children with ASD to socially informative regions of the AF and socially non-informative regions of the AF significantly differ?*

The ASD group's visual attention (fixation count and duration) to socially informative (FIT) and non-informative regions (the rest of the face) of the AF were compared by paired samples t-tests. These tests showed that children with ASD differ significantly in their fixation counts and fixation duration on FIT and the rest of the face of the AF ($t_{(6)}$=2.44, p<.05 and $t_{(6)}$=2.72, p<.05; respectively). Therefore, children with ASD attend to FIT (*fixation duration*: M=2471, SD=1649) more than to the rest of the face (*fixation duration*: M=560, SD=587.88) of the AF.

4. Discussion

According to the results of the study, firstly, children with ASD attend to eyes and FIT of the FFF and AF; to eyes, FIT and the rest of the face of the FMF significantly less than TD children. However, they do not attend to mouth of FFF, FMF and AF; to socially non-informative regions of the FFF and AF; to body and background of the FMF less than TD children. These results reveal that the TD children get social information of static photos of faces from the eyes region and not from the mouth region, and high-functioning children with ASD have deficiency in getting relevant social information from the eyes though faces familiar to them. The finding that children with ASD attend to the eyes less than the TD children is in line with the most studies (Sterling et al., 2008; Trepagnier et al., 2002; Pelphrey et al., 2002; Dalton et al., 2005; Klin et al., 2002b; Joseph & Tanaka, 2003); however, not with the some (Anderson et al., 2006; Rutherford & Towns, 2008). Falkmer et al. (2010) stated that TD children have better structured visual search strategy than children with ASD because of attending more to the FIT region of faces. There are studies found that the social component of the conversation failed to attract the attention of the children with ASD in a video (Hofsten et al., 2009; Bayram & Esgin, 2010).

Secondly, children with ASD attend to eyes and FIT of the FMF significantly more than to that of the FFF; to eyes of the HF significantly more than to the eyes of the AF. Nevertheless, they do not attend to mouth of the FMF more than to that of the FFF; to mouth and FIT of the HF more than to that of the AF. Therefore, FMF attracts children with ASD more than FFF, and HF attracts them more than AF. The finding of different attention duration to HF and AF contradicts the results of McPartland et al. (2010) and Anderson et al. (2006). This result reveals that although HF and AF share a common visual configuration, they differ in social relevance and developmental exposure. However, the patterns of visual attention to HF and AF were similar in children with ASD and TD children in that both groups attended to the eyes of HF and AF more than other parts of the faces. The reasons of difference in attending to FMF and FFF should be investigated in further research.

Lastly, children with ASD attend to the FIT significantly more than the rest of the face of the HF and AF. These results imply that children with ASD use information from the eye region to a great extent in face exploration (Lahaie et al., 2006; van der Geest et al., 2002; Falkmer et al., 2010). On the contrary, Pelphrey et al. (2002) found that children with ASD attend to the non-feature areas of the faces more than the core features such as the eyes, mouth and nose. Furthermore, the present study did not support earlier findings that people with ASD have a strong tendency to focus on the mouth area (Klin et al., 2002b; Pelphrey et al., 2002; Spezio et al., 2007). Although not given in the findings, children with ASD spent more time on the eye region than on the mouth during face exploration. This is parallel with the results of Hernandez et al. (2009), Sterling et al. (2008), Chawarska and Shic (2009), Freeth et al. (2010), McPartland et al. (2010) and inconsistent with the results of Joseph and Tanaka (2003) and Klin et al. (1999). Here, it is interesting that the present study contradicts Hernandez et al. (2009) in that children with ASD attend more to the FIT than the rest of the face. Consequently, it can be argued that children with ASD seemed to present similar gaze patterns to those of TD children during face exploration.

In visual attention studies, the visual stimuli and the task are very important at detecting differences. Attention and gaze behavior of the children with ASD may differ according to the stimuli, whether it is static or dynamic and isolated or social; also, according to the task, whether it is exploration, identification or just scanning. Eyes convey very important social information both in dynamic and static stimuli, but mouth conveys less important social information in static stimuli than in dynamic stimuli. In dynamic stimuli, mouth has motion which attracts attention of the children with ASD. Therefore, the literature has conflicting results. McPartland et al. (2010) state that viewing times and resolution of the visual stimuli may also influence results. In this respect, the present study contributed to the literature by revealing that high-functioning children with ASD have the same visual attention patterns as TD children, but their fixation duration is less on the eye regions of the faces than TD children in static and isolated face exploration.

Pelphrey and Carter (2008) stated that children with ASD scan faces randomly and they cannot understand the significance of the socially informative features of the faces. Therefore, they cannot use the information which they get from looking at the face to explain the individual's mental states and behaviors. According to Speer et al. (2007, p. 273), such findings suggest that "the amount of time an individual spends fixating on others' eyes in social interactions may reflect the degree to which they are able to process or make sense of social information or facial cues". In addition, Dawson et al. (2002) claimed that atypical face processing in children with ASD may be related to atypicality in social attention, and, more specifically, dysfunction of the neural mechanisms that naturally draw the typical infant's attention to the eyes.

The present study is limited in some respects. Firstly, a highly controlled laboratory is not an ecologically valid environment, so children with ASD may be affected more than TD children. Secondly, participants in the TD and ASD groups were not matched on IQ. Factors such as different intelligence among the participants may have influenced the effects observed in this study. However, there are studies comparing eye-tracking results of human beings and animals such as chimpanzees without any IQ matching (Kano & Tomonaga, 2009; Hattori, Kano, & Tomonaga, 2010). Thirdly, this research involved a relatively small sample of participants. Lastly, the photos of human faces are smiling, whereas animal face is neutral. In spite of these limitations, the results of the present study advance our understanding of the visual attention and gaze differences between the children with ASD and TD children and open new perspectives for future research.

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