Does gaze direction affect the recognition of facial expressions of emotion in children with autism?

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Master's Thesis
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April 2006

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MUSTALAHTI, SUSANNA: Does gaze direction affect the recognition of facial expressions of emotion in children with autism?
Master's Thesis, 38 pages
Psychology
April 2006

ABSTRACT

This study investigated whether eye gaze direction affects the recognition of facial expressions in children with autism. The study was especially targeted at investigating whether children with autism use gaze direction similarly as typically developing children in recognizing basic facial expressions (happiness, sadness, anger and fear). Twelve clinically diagnosed high-functioning children with autism and fifteen typically developing control children participated in the experiment. The study used a behavioral experiment in which reaction times and performance accuracy were measured in a facial expression recognition task. The expressions were displayed with both straight and averted eye gaze direction. The children were required to perform a two-choice response indicating whether a facial image presented on the computer screen looked happy or sad (happiness-sadness –condition) or whether it looked angry or fearful (anger-fear –condition. The response was executed by pressing one of the two buttons in a response box.

The results did not reveal significant group differences in recognition of expressions of happiness and sadness as a function of gaze direction. However, significant group differences were found in recognition of expressions of anger and fear. Typically developing children recognized anger more quickly when displayed with direct rather than averted gaze, whereas gaze direction did not have an effect on the recognition of anger in children with autism. Furthermore, there was a tendency showing that the children with autism recognized fear more quickly when displayed with direct rather than averted gaze, whereas the gaze direction did not affect the recognition of fear in typically developing children. These differences can not be explained by any general abnormalities in facial expression recognition in children with autism, because significant group differences were not found in response accuracy when recognizing anger and fear. The results suggest that there are abnormalities in the way children with autism use gaze direction in recognition of expressions of anger and fear.

KEY WORDS: High functioning autism, reaction times, facial expression recognition, gaze direction

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1. Introduction

Other person's gaze direction and facial expression convey information about their focus of visual attention and inner emotional states to others. Both eye gaze direction and facial expression have been implicated in signaling the expressor's approach-avoidance behavioral tendencies. Facial expressions associated with positive emotions (and anger) and direct gaze have been related to approach motivation and facial expressions associated with negative emotions (except anger) and averted gaze, in turn, have been related to withdrawal motivation (see Argyle & Cook, 1976; Kleinke, 1986). Recent research has found evidence that gaze direction and facial expression have a combined information value in expression recognition (Adams & Kleck, 2003, 2005). Facial expression combined with a gaze direction having congruent behavioral tendency (approach/avoid) is found to facilitate the recognition of that expression. Direct eye gaze is demonstrated to facilitate the recognition of expressions of happiness and anger, whereas averted gaze is found to facilitate the recognition of sadness and fear. Thus, the interdependence of gaze direction and facial expression enables an effective perception of social information from the face.

Autism is a pervasive neurodevelopmental disorder which is characterized by abnormalities in reciprocal social interaction and communication, accompanied by stereotyped and obsessional behavior. People with autism are found to have difficulties in attending to social stimuli, in imitating other people and perceiving and understanding the feelings of another person, among other things (see e.g. Lord & Bailey, 2002). The social and communicational problems associated with autism have been studied extensively over the past few years. Autism is associated with abnormal perception and processing of faces, abnormalities in gaze behavior and difficulties in recognition of facial expression (e.g. Celani, Battachi, & Arcidiacono, 1999; Deruelle, Rondan, Gepner, & Tardiff, 2004; Senju et al., 2003). The aim of this study is to investigate whether gaze direction affects the recognition of facial expressions in children with autism. This is studied by comparing the performance of children with autism and typically developing children in a facial expression recognition task in which the gaze direction is altered. The current study aims to acquire information about how children with autism use gaze direction cues in recognizing facial expressions.

1.1. Face processing

The human face conveys information which is critical for social interaction and communication, such as the identity and emotional states of other people. The neural and cognitive processing of faces seems to differ from the processing of other visual objects (Diamond & Carey, 1986; Farah, 1996; Puce, Allison, Gore, & McCarthy, 1995; Yin, 1969), in other words, faces might be somehow special.

Infants prefer to look at faces at a very early age (Johnson, Dziurawiec, Ellis, & Morton, 1991). It has been shown that newborns and 1-month-old infants can already make discriminations between identity of faces (De Haan, Johnson, Maurer, & Perrett, 2001) and also between emotional expressions (Pascalis & de Schonen, 1994). Apart from other facial features, infants seem to stare longer at the eyes (Maurer, 1985) and they direct their attention according to another person's gaze direction as young as three-months-old (Hood, Willen, & Driver, 1998). Despite that humans appear to have an early preference for facial stimuli and rather impressive abilities to process facial information already very early in life, it is also evident that these abilities develop both through the first years of life and through childhood (De Haan, Pascalis, & Johnson, 2002; Passarotti et al., 2003). Adults' superiority in face processing compared to children has been related to age-related development of face-specialized neural mechanisms as well as to acquired visual expertise and learning (De Haan, Pascalis, & Johnson, 2002).

Face perception seems to be based more on configural and holistic visual processing than on featural and analytical processing (Carey & Diamond, 1977; Farah, Tanaka, & Drain, 1995; Hole, George, & Dunsmore, 1999; Tanaka & Farah, 1993). Faces are processed more as a whole and by using the relations among facial features rather than by depending on independent features of faces. This is supported by findings showing that inverted faces (faces presented up-side-down) are recognized more slowly and more inaccurately than upright faces (Farah, Tanaka, & Drain, 1995; Yin, 1969). The processing of nonface objects (i.e. houses) has been found to rely more on feature based mechanisms (Farah, Tanaka, & Drain, 1995). Brain imaging studies (fMRI) have also provided evidence for holistic rather than feature-based face processing (Gauthier & Tarr, 2002; Gauthier et al., 2000).

1.2. The processing of facial expressions and eye gaze

Effective social functioning obliges for accurate perception and recognition of emotional information communicated by others. Facial expressions and eyes convey information about other people's emotional states and intentions and therefore enable us to react and adapt appropriately to the social situation. Human abilities for facial expression recognition seem to emerge during the first year of life (Nelson, 1987; Nelson & De Haan, 1997). From 3-moths-old on, infants are demonstrated to discriminate basic facial expressions from adults (data from visual preference and habituation studies) (Schwartz, Izard, & Ansul, 1985; Young-Browne, Roschfield, & Horowitzh, 1977). However, these findings are advised to be interpreted cautiously given the possibility that infants may have responded only to changes in inner facial features rather than to expressed emotions (Nelson, 1987; Vicari et al., 2000). By the age of 5-months children have been shown to discriminate between expressions of fear and happiness in the same and different people and to categorize different intensities of smiling (Bornstein & Arterberry, 2003). However, these studies suggest that discriminating and categorizing facial expression do not automatically imply understanding their meaning (Bornstein & Arterberry, 2003). The research results indicate that emotion expression recognition skills improve with age (Boyatzis, Chazan, & Ting, 1993; Markham & Adams, 1992). Adults are found to be nearly twice as fast as children (aged 7-11 yrs.) in identifying emotions from facial expressions (De Sonneville et al., 2002). Adults' advantage in speed is suggested to reflect the increased level of knowledge and more automatized and configural processing of faces and facial expressions of emotion (De Sonneville et al., 2002). The ability to recognize facial expressions of emotion seems to develop gradually over time, with happiness being the first expression to be accurately recognized, followed by sadness, anger and fear (Vicari et al., 2000).

Eyes also play a central role in social communication. Eye gaze direction informs about a person's attentiveness to environment or to the other person in a communicative situation and regulates social interaction (Kleinke, 1986). The eyes can also provide information about this person's mental states (Baron-Cohen, 1995). Infants prefer to look at the eyes rather than other facial features (Morton & Johnson, 1991) and both infants and adults are extremely sensitive to gaze direction of other people (Vecera & Johnson, 1995). Eye contact is a strong indication of possible social interaction (Kleinke, 1986) and it can be considered as a signal of threat or an indication of interest. Eye contact has been shown to increase physiological arousal (Nicholas & Champness, 1971). Furthermore, direct eye gaze is found to facilitate the processing of faces, namely face recognition and gender categorization (Hood, Macrae, Cole-Davies, & Dias, 2003; Macrae et al., 2002). Finally, another person's averted gaze tends to automatically shift the attention of the perceiver in the same direction (Driver et al., 1999; Friesen & Kingstone, 1998; Hietanen, 1999).

1.3. A distributed human neural system for face perception

A cognitive model of face perception by Bruce and Young (1986) stresses the distinction between cognitive processes involved in the recognition of facial identity and in the recognition of facial expressions and face-related movements. Haxby, Hoffman, & Gobbini (2000, 2002) have taken this model further and state that perceiving faces activates a distributed neural system that consists of multiple, bilateral brain regions. According to the latter model, the core system of face perception involves occipito-temporal regions in the extrastriate cortex [inferior occipital gyrus, superior temporal sulcus (STS), lateral fusiform gyrus (FG)]. These face-sensitive regions have been found to activate differentially to different aspects of face information. Several functional neuroimaging studies in typically developing individuals have found stronger activation during face perception than during the processing of nonface objects or nonsense stimuli in bilateral regions in the middle aspect of the FG (Puce, Allison, & Gore, & McCarthy, 1995; Haxby et al., 1994; Kanwisher, McDermott, & Chun, 1997). This face-sensitive region has been given the name of “fusiform face area” (FFA) (Kanwisher, McDermott, & Chun, 1997).

While the FFA activity have been shown to play a critical role in the perception of facial identity, the STS and the amygdala are shown to be important in processing of facial expressions and eye gaze (e.g. Allison, Puce, & McCarthy, 2000; Haxby, Hoffman, & Gobbini, 2000). The posterior STS is consistently demonstrated to respond to the perception of biological motion, including eye, mouth and body movements (Bonda, Petrides, Ostry, & Evans, 1996; Puce et al. 1998) and during the perception of still pictures of faces as well (Hoffman & Haxby 2000; Kanwisher, McDermott, & Chun, 1997). Hence, it is proposed that the STS is involved in the perception of potential movement of the face or the evaluation of different aspects of the face which can vary with movement (i.e. in facial expressions) (Haxby, Hoffman, & Gobbini 2002). When judging emotional expressions, the posterior STS is demonstrated to interact with amygdala (Streit et al., 1999).

The amygdala appears to play an important role in emotional behavior (LeDoux, 1994, 1996). Perceiving fearful faces is demonstrated to increase activity in bilateral regions of the amygdala in adults (Breiter et al., 1996; Critchley et al., 2000) and adolescents (Baird et al., 1999). These results, attained by functional resonance imaging (fMRI), are supported by human lesion studies which have consistently demonstrated impaired recognition of facial expressions in bilateral amygdala damage, especially in recognition of fearful faces (Adolphs, Tranel, Damasio, & Damasio, 1994; Calder et al., 1996). Although this structure is associated with the processing of threat and danger and negative emotions (especially fear, as mentioned earlier), it has been found to be more responsive to other emotions also as compared to neutral faces (Breiter et al., 1996). In addition to amygdala involvement in facial expression processing, it is also an important structure for gaze processing (Kawashima et al., 1999; Wicker, Michel, Henaff, & Decety, 1998).

1.4. Autism and abnormalities in face processing

People who for some reason lack the abilities to attend to, identify, and understand the emotional information provided by the face are not in a very favorable situation considering communication with other people. This seems to be the case when people with autism are concerned. Autism is a pervasive neurodevelopmental disorder which is characterized by abnormalities in reciprocal social interaction and communication, accompanied by stereotyped and obsessional behavior (see e.g. Lord & Bailey, 2002). Studies have given evidence that individuals with autism are impaired at labeling and recognizing facial expressions of emotion and inclined to use different strategies in facial processing compared to normally developing individuals (e.g. Celani, Battachi, & Arcidiacono, 1999; Deruelle, Rondan, Gepner, & Tardiff, 2004). Autism has also been associated with abnormal eye gaze behavior and especially with difficulty in processing eye-contact (Howard et al., 2000; Senju et al., 2003).

In the light of the knowledge offered by experimental research it seems that faces are not (at least) perceptually as special to individuals with autism as they are to typically developing individuals. As face recognition is normally thought to be more dependent on holistic and configural processing than object recognition, individuals with autism seem to be inclined to use more part-based processing when perceiving faces (Hobson, Ouston, & Lee, 1988; Tantam, Monagham, Nicholson, & Stirling, 1978) and they seem to have a preference to the lower face area/ mouth area (Joseph & Tanaka, 2003). The notion of abnormal face processing associated with autism has been reinforced by studies showing less inversion effect for faces and better abilities in object processing compared to face processing in autism (Hobson, Ouston, & Lee, 1988; Klin et al., 1999). Furthermore, according to Hubl et al. (2003) individuals with autism seem to need more visuospatial effort for face processing and less for pattern processing compared with typically developing controls.

In a study by Weeks and Hobson (1987), autistic and non-autistic retarded children matched for verbal ability were shown pairs of photographs of people who differed in one to three of the following respects: sex, age, facial expression, and the type of hat they were wearing. The majority of children with autism sorted photographs of people according to the hat that was worn rather than according to people's facial expressions, contrary to non-autistic children. In addition to this insensitivity to facial expressions, individuals with autism spectrum disorder are found to have particular difficulty in recognizing and identifying facial expressions (Celani, Battacchi, Arcidiacono, 1999; Deruelle, Rondan, Gepner, & Tardif, 2004; Geoffrey, Szechtman, Nahmias, 2003; Gross, 2004; Hobson, Ouston, & Lee, 1988; Wallace, 2002). Individuals with autism have found to make more errors in matching expression pictures, matching emotional quality of the voice with the corresponding facial expression, and in discriminating expression pictures by choosing a label from two or more alternatives, among other things. Individuals with autism are found to have difficulties in interpreting complex emotional states from the face (Adolphs, Sears, & Piven, 2001), in interpreting affective meaning from the eyes (Baron-Cohen, Weelwright, & Joliffe, 1997), and in recognizing basic facial expressions (Wallace, 2002). Some expressions seem to be more challenging to individuals with autism than others as individuals with autism have been repeatedly found to have difficulties in processing the facial expression of fear (Howard et al., 2000; Pelphrey et al., 2002; Wallace, 2002).

The eyes seem to be somewhat problematic to individuals with autism. Abnormalities in eye contact (e.g. diminished eye gaze fixation) are considered to be one of the core symptoms in autism (DSM-IV; APA 1994). Autism has been associated to difficulty in detecting faces with direct gaze (Senju et al., 2003; Howard et al., 2000) and impaired understanding of mental states and intentions of others communicated through eyes (Baron-Cohen, Weelwright, & Joliffe, 1997). This difficulty with eyes appears to be connected to the processing of eye-contact, since studies have shown that individuals with autism seem to be able to discriminate the direction of another person's gaze (Baron-Cohen et al., 1995; Kylliäinen & Hietanen, 2004; Leekam, Baron-Cohen, Perrett, Milders, & Brown, 1997). Furthermore, perceiving another person's averted eye gaze is found to trigger an automatic shift of visual attention both in typically developing individuals and individuals with autism (Kylliäinen & Hietanen, 2004; Senju, Tojo, Dairoku, & Hasegawa, 2004).

Neurophysiological and neuroimaging studies have provided evidence for abnormal brain activity related to processing of faces in individuals with autism. Functional magnetic resonance imaging (fMRI) studies have shown inconsistent and irregular face processing activation in individuals with autism compared to highly consistent FG activation in typically developing individuals. The abnormalities in face processing in individuals with autism are related to lower or absent activation in face-sensitive brain regions and also higher activation in regions which are typically not related to face processing. (Pierce et al., 2001; Schultz et al., 2000; Hubl et al., 2003) However, a recent research (Castelli, Frith, Happé, & Frith, 2000) has demonstrated FFA activation in a social attribution task without faces in typically developing individuals, implicating that the hypoactivation of FFA in autism may reflect a core social cognitive impairment in the disorder (see Schultz et al., 2003). These differences in brain activation have been demonstrated although the behavioural data have not indicated any significant differences in performance accuracy in processing of e.g. identity, gender, and facial expression of happiness. Individuals with autism are therefore thought to use different strategies for visual processing than normal controls. Dawson et al. (2002) examined event-related potentials in children (3-4 yrs.) and found that children with autism did not show differential brain activity to familiar versus unfamiliar faces as did typically developing children and children with developmental delay. However, children with autism demonstrated differential brain activity for familiar versus unfamiliar toys. Hence, abnormal face processing has been demonstrated already very early in life in autism.

In addition to the evidence for less activation in the FFA/FG in persons with autism compared to healthy controls when processing facial identity (see e.g. Schultz et al., 2003), functional neuroimaging studies have shown amygdala hypoactivation when persons with autism process emotional information from the face (Baron-Cohen et al., 1999; Critchley et al., 2000). Furthermore, there have been findings on morphological abnormalities in the amygdala of persons with autism (Bauman & Kemper, 1995) and there is also neuroanatomical evidence to suggest abnormal amygdala volume when persons with autism are compared to normal controls (Howard et al., 2002). A recent study reported disrupted white matter structure in subjects with autism (Barnea-Goraly et al., 2004). In this study, abnormalities in white matter tracts were seen especially next to regions important for face and gaze processing and for awareness of mental states and emotional processing.

Recent research has demonstrated heightened emotional responses to direct gaze in autism and it has been suggested that diminished eye contact in autism serves as a way to reduce the over arousal to social stimuli (Dalton et al., 2005). Kylliäinen and Hietanen (2006) studied skin conductance responses (SCR) to another person's gaze direction in children with autism and found that the SCR was stronger to straight than to averted gaze in the clinical group compared to normal gender- and mental-age-matched control children. This result led to an implication that in autism, eye contact may produce a stronger arousal level than averted gaze. Klin et al. (2002) suggested that individuals with autism do not find the eyes meaningful or informative. This suggestion was based on their eye-tracking study, in which individuals with autism demonstrated abnormal visual fixation patterns to naturalistic social situations – mouths, bodies, and objects were more salient to them than eyes.

1.5. The effect of gaze direction on recognition of facial expressions

Both gaze direction and facial expression have been associated with behavioral motivations to approach and avoid (Harmon-Jones & Sigelman, 2001). In other words, eye gaze and facial expressions of emotion are thought to act as social signals that help the observer predict other people's behavior. Emotions of happiness and anger and direct gaze direction are associated with approach-oriented motivation, whereas emotions of sadness and fear and averted gaze direction are associated with avoidance-oriented motivation (see Argyle & Cook, 1976; Kleinke, 1986). Therefore, the interesting question is: Do gaze direction and facial expression offer combined information value to social interaction based on motivational tendencies? Does gaze direction have an effect on processing of facial expressions?

A research by Adams and Kleck (2003) showed indeed that gaze direction and facial expression are combined in the processing of emotionally relevant facial information. The behavioral results demonstrated that facial expressions of anger and happiness were recognized more quickly when displayed with direct rather than averted gaze. On the other hand, fear and sadness were recognized more quickly when displayed with averted rather than direct gaze. The authors concluded that gaze direction and facial expression seem to share an information value as signals of behavioral approach and avoidance. Adams and Kleck (2005) confirmed the shared signal hypothesis in yet another study. In this study the participants were asked to rate neutral displays of faces on four emotion scales (anger, fear, sadness, joy). Gaze direction of the faces was altered (direct/half averted). They were asked to indicate how likely the person depicted in the photograph is to experience each emotion. The results showed that direct gaze led more to anger and joy dispositional attributions, whereas averted gaze led more to fear and sad dispositional attributions when neutral faces were viewed. In the same study, Adams and Kleck (2005) investigated the effect of gaze direction on the perceived intensity of clear emotional expressions. In this other task, pairs of photographs of faces displaying four prototypical emotional expressions (anger, fear, sadness, joy) were shown to the participants. One face was placed above the other and the otherwise identical photographs were manipulated to display either direct or averted gaze. Facial displays of emotion were manipulated to exhibit three levels of expressive intensity. The results of this task demonstrated that direct gaze enhanced the perceived intensity of expressions of anger and joy, whereas averted gaze enhanced the perceived intensity of fear and sadness. Ganel, Goshen-Gottstein and Goodale (2005) explored the relationship between the processing of facial expressions and the processing of gaze direction by using Garner (1974) speeded classification task. This paradigm examines the ability to process one dimension of visual stimulus such as face, while ignoring another dimension of the same stimulus. The participants were asked to make speeded classifications of either expression (i.e. smiling or angry) or gaze direction (direct or averted). Ganel, Goshen and Goodale (2005) found that the participants were not able to ignore gaze direction when classifying facial expression (anger/happiness) or to ignore facial expression while classifying gaze direction. Thus, gaze direction appears to be an essential component of the processing of expression.

Research has found amygdala involvement in the processing of both eye gaze (Kawashima et al., 1999; Wicker, Michel, Henaff, & Decety, 1998) and facial expressions (Baird et al., 1999; Breiter et al., 1996; Chritchley et al., 2000). Adams et al. (2003) used fMRI to investigate whether amygdala sensitivity to anger and fear displays would differentially vary as a function of gaze direction. They found higher activity in left amygdala to anger faces coupled with averted gaze (than with straight gaze) and to fearful faces coupled with direct gaze (than with averted gaze). The previous behavioral results (Adams & Kleck, 2003) found enhanced recognition of expression of anger when displayed with direct gaze and enhanced recognition of fear displayed with averted gaze. Hence, the fMRI results evidenced a different pattern of interaction for facial expressions and gaze direction than was demonstrated in the behavioral study. Based on these results, the authors suggested that amygdala is involved in processing threat related ambiguity of social stimuli. However, there has also been evidence for stronger amygdala activation to head direction and facial expression congruent in signal value (Sato, Yoshikawa, Kochiyama, & Matsumara, 2004). In a study by Sato, Yoshikawa, Kochiyama, and Matsumara (2004), angry and neutral expressions looking toward/away from the subject were presented and brain activity was depicted using fMRI. The results found higher activity of left amygdala for angry expressions looking towards the subject than for angry expressions looking away. Nevertheless, behavioral findings show that gaze direction affects the recognition of facial expressions. Gaze direction and facial expression seem to be combined in recognizing expressions according to the behavioral motivation associated to them.

1.6. The present study

The aim of the present study is to investigate whether gaze direction affects the recognition of facial expressions of emotion (happiness, sadness, anger and fear) in children with autism. Previously it has been demonstrated that gaze direction affects the recognition of expressions in typically developing adults (Adams & Kleck, 2003). Facial expressions of happiness and anger were recognized more quickly when displayed with direct rather than averted gaze, whereas sadness and fear were recognized more quickly when displayed with averted rather than direct gaze. The current study uses a behavioral experiment in which reaction times and response accuracy are measures in a facial expressions recognition task. The children are required to perform a two-choice response indicating whether a facial image presented on the computer screen looked happy or sad (happiness-sadness –condition) or whether it looked angry or fearful (anger-fear –condition. The expressions are displayed with both straight and averted eye gaze direction. The current study is especially targeted at exploring whether children with autism use gaze direction similarly as typically developing children in recognizing basic facial expressions. The aim is to acquire more information about the abnormalities in recognizing facial expressions in autism in a hope for better understanding of socio-communicational difficulties in the disorder.

2. Methods

2.1. Participants

Twelve clinically diagnosed children with autism and 15 typically developing children participated in this study. Children in both groups were school-aged and they were recruited based on their previous participation in studies in the Human Information Processing Laboratory (University of Tampere/ Department of Psychology). All the children in the study participated voluntarily and with the approval of their parents. The parents of the children with autism were administered the Autism Diagnostic Interview – Revised (ADI-R, Autism Diagnostic Interview - Revised) and all these children met the ADI algorithm criteria for autism spectrum disorder (social: 10, communication: 8, stereotypical behavior: 3). The groups were individually matched for gender, chronological and mental age (WISC-R). No significant differences were found between the groups in chronological age and performance IQ. However, the scores in verbal IQ and full scale IQ were higher in normal control children (Table 1).

Table 1. Descriptive information of the participants: sex (M: male, F: female), age, IQ's, ADI-R scores

	Clinical group	Control group	T-score
N (sex)	12 (11M, 1F)	15 (14M, 1F)	
Age (years)			
mean (SD)	11.5 (1.9)	10.7 (1.4)	t(25)=1.32, ns
Full scale IQ			
mean (SD)	92 (19)	105 (12)	t(25)=-2.17, p<.05
Verbal IQ			
mean (SD)	94 (22)	109 (14)	t(25)=-2.21, p<.05
Performance IQ			
mean (SD)	92 (18)	102 (15)	t(25)=-1.59, ns
ADI-R domains			
Social			
mean (SD)	18 (3.1)		
Communication			
mean (SD)	13 (2.9)		
Stereotypy			
mean (SD)	6 (2.0)		

2.2. Stimuli

The experiment included synthesized female and male facial expression images (Figure 1) made with a three-dimensional mesh-based modeling program, Poser 5 (Curious Labs, Santa Cruz, CA). A total of 20 individual face images (10 female, 10 male) was made. For every individual face a facial expression of happiness, sadness, anger, fear and neutral was created. The creation of the facial expression images was guided by Ekman and Friesen's (1976) Facial Action Coding System (FACS). Thirty undergraduate students (24 female, 6 male), with a mean age of 22.2 years, participated in a pilot experiment in which they were asked to assess the created facial expressions of happiness, sadness, anger and fear. Neutral faces were also included in the assessment. The participants were tested in an auditorium where the stimuli were projected on to a screen with a video projector. They were asked to assess the facial emotion of the image by choosing one emotion label from five alternatives in a response sheet. A total of 100 pictures was shown (20 individual faces × 5 facial expressions). The presentation time of the stimuli was 700 ms. The participants were instructed to mark the answer immediately after seeing a stimulus. The experiment lasted approximately 15 minutes. The identification accuracy for the expressions ranged from 70 % to 91% (a confusion matrix of the mean percentages of happy, sad, angry, fear and neutral responses is shown in Table 2), indicating that facially conveyed emotions were reliably recognized. Further improvements to the facial expression images were made using the information from the image ratings.

Table 2. A Confusion Matrix Showing Mean Percentages (and standard errors of mean) of Happiness, Sadness, Anger, Fear and Neutral Responses for Different Facial Expressions.

	Response category									
	Happiness		**Sadness**		**Anger**		**Fear**		**Neutral**	
Expression	*Mean%*	*(SE)*	*Mean%*	*(SE)*	*Mean%*	*(SE)*	*Mean%*	*(SE)*	*Mean%*	*(SE)*
Happiness	**91.0**	(2.1)	23.5	(0.8)	1.0	(0.6)	0.5	(0.3)	5.0	(1.3)
Sadness	2.0	(0.7)	**70.0**	(2.6)	8.0	(1.8)	0.5	(0.4)	19.5	(2.1)
Anger	0.0	(0.0)	5.5	(1.3)	**78.5**	(2.6)	8.0	(1.4)	8.0	(1.5)
Fear	0.0	(0.0)	3.0	(1.1)	1.0	(0.5)	**95.5**	(1.3)	0.0	(0.0)
Neutral	23.5	(3.1)	3.0	(0.9)	2.0	(0.6)	6.0	(1.2)	**65.5**	(3.4)

The experiment proper included 20 individual face images (10 female, 10 male). Each individual was presented with all of the four expressions (happiness, sadness, anger, fear). In every expression the eyes of the individuals in the images were directed either straight, to the left (30 degrees) or to the right (30 degrees). Neutral faces were not used in the experiment proper. The facial stimuli were presented on a 17-inch computer monitor (1024 X 768, 75Hz). The size of the stimuli on the computer screen was 15, 1 × 9, 3 cm (male face) or 14, 5 × 8, 9 cm (female face). Stimulus delivery and recording of behavioral data (reaction time and accuracy) were controlled by E-prime software.

Figure1. Examples of the facial stimuli used in the happiness-sadness –condition (upper images) and in the anger-fear –condition (lower images) in the reaction time experiment.

2.3. Design and Procedure

The experiment consisted of eight blocks. Four consecutive blocks included angry and fearful faces and the other four blocks happy and sad faces. Each block consisted of 40 trials. Because each face was presented twice in the averted gaze condition (left and right), each face was also presented twice in the direct gaze condition to balance out the design. Thus the trial number for each expression pair (happiness/sadness, anger/fear) was 160, the overall trial number being 320 [(20 x 4 (expression) x 4 (gaze condition)]. The images were displayed randomly within each block. Half of the children in both groups started the experiment with happy and sad faces, the other half with angry and fearful faces. In addition, in both groups the order of the button labels was switched for half of the children.

In the experiment the children were asked to indicate whether the face in the computer screen looks happy or sad / angry or fearful by pressing one of the two buttons in a response box. On each trial, a fixation point (+) was presented to the center of the computer screen. After the appearance of the fixation point (and making sure that the child was concentrating) the experimenter triggered the stimulus by pressing a mouse button (the image appeared on the screen 1000 ms after the button press). Each face remained on the screen until the child responded.

The experimental procedure was explained to the child using pictures representing events that took place during the task (including example pictures of the stimuli). In the beginning of four blocks containing angry/fearful or happy/sad faces, the child was shown face pictures displaying the expression pair involved. Each of the four example pictures depicting four facial emotions were framed with a different color (happiness->yellow, sadness->blue, anger-> red, fear->green). The child was familiarized with the two response buttons which were marked with the initials of the emotion words and also with the colors associated to the facial emotion. The color association was done to alleviate the possible language load when discriminating facial expressions. The correct use of the buttons was ensured by practice trials before the actual task. Children were told that the gaze direction in the facial images will vary, but that it is not an issue to be concerned of and has no association with the facial expressions. They were also instructed to do the task as quickly and yet as accurately as possible.

All the experiments were conducted in a quiet room at the Human Information Processing Laboratory in Tampere. Children sat at a 50-cm distance from the computer monitor. A mirror was placed above the computer screen and during the experiment the experimenter stood behind the child and observed via the mirror that the child looked to the fixation point on the screen and concentrated properly to the task. Experimenter initiated each trial by pressing a wireless computer mouse and therefore had the possibility to ensure that the child was fixating at the beginning of each trial and pause the task if needed. Before each block, the progress of one's performance was visualized on the computer screen. Halfway through the experiment the child was offered something to drink and several minutes to rest. The experiment lasted approximately 20 to 30 minutes altogether.

3. Results

First, incorrect responses and responses with reaction times shorter than 350 ms and longer than 3500 ms were eliminated from subsequent calculations. Secondly, trials in which the reaction times exceeded a time-window of +/- two standard deviations from each child's mean were also excluded.

Regarding the error data, two 2 (clinical group vs. control group) × 2 (happiness vs. sadness or anger vs. fear) × 2 (direct vs. averted gaze) repeated measures analyses of variance (ANOVA) were conducted (the normality of the distribution was confirmed). The mean error rates made in labeling the expression of happiness, sadness, anger and fear, as a function of gaze direction, are shown in Table 3. *In happiness-sadness condition* no significant main effect was found. A significant interaction of Group and Gaze Direction emerged, $F(1, 25) = 5.71$, $p<.05$. Planned pairwise comparisons revealed that the clinical group made more errors with averted gaze ($M = 4.2$, $SE = 0.8$) than with direct gaze ($M = 3.0$, $SE = 0.6$) stimuli $t(11) = 2.25$, $p<.05$., whereas gaze direction did not have an effect on the response accuracy in the control group. A three-way interaction was not found. *In anger-fear condition* a main effect of Gaze emerged, $F(1, 25) = 4.95$, $p<.05$. More errors were made when discriminating expressions displayed with averted gaze ($M = 4.06$, $SE = 0.58$) than direct gaze ($M = 3.22$, $SE = 0.52$). There were no other significant main effects or interactions.

Table 3. The Mean Error Rates (and standard errors of mean) in Labeling Expressions of Happiness and Sadness (upper) and Anger and Fear (lower), as a Function of Gaze Direction.

Happiness - Sadness

	Control group		Autism group	
	Direct gaze	Averted gaze	Direct gaze	Averted gaze
Happiness	2.0 (0.6)	1.9 (0.9)	2.9 (0.7)	5.7 (1.1)
Sadness	2.3 (0.6)	1.9 (0.6)	3.0 (0.7)	2.8 (0.7)

Anger - Fear

	Control group		Autism group	
	Direct gaze	Averted gaze	Direct gaze	Averted gaze
Anger	2.6 (0.8)	3.33 (0.84)	4.4 (0.9)	5.9 (0.9)
Fear	2.8 (0.8)	2.47 (0.89)	3.1 (0.9)	4.5 (1.0)

The reaction times were also analyzed with two repeated measures analyses of variance (ANOVA) with Group (clinical vs. control) as the between-subject factor and Expression (happiness vs. sadness or anger vs. fear) and Gaze Direction (directed vs. averted) as within subject factors. Mean response latencies to correctly labeled expressions of happiness, sadness, anger and fear, as a function of gaze direction, are shown in Table 4. *In happiness-sadness condition* no main effects were found. A significant interaction of Expression and Gaze Direction was found, $F(1, 25) = 9.66$, $p<.01$. However, other interactions were not significant. Planned pairwise comparisons revealed that happiness was recognized more quickly when displayed with direct ($M = 730.4$, $SE = 33.8$) than with averted gaze ($M = 758.4$, $SE = 37.2$), $t(26) = 3.87$, $p<.001$. For the recognition of sadness, there was no difference between direct ($M = 753.3$, $SE = 42.0$) and averted gaze ($M = 737.7$, $SE = 37.5$). *In anger-fear condition* a significant main effect for Gaze Direction emerged, $F(1, 25) = 4.84$, $p< .05$. Expressions were recognized more quickly with direct ($M = 765.1$, $SE = 46.9$) than averted gaze ($M = 784.4$, $SE = 49.2$). No significant two-way interactions were found. However, a significant three-way interaction of Group, Expression and Gaze Direction was found, $F(1,25) = 4.86$, $p < .05$. Pairwise comparisons revealed that control children recognized anger more quickly when displayed with direct gaze ($M = 817.2$, $SE = 74.4$) than with averted gaze ($M = 824.6$, $SE = 83.1$), $t(14) = 2.80$, $p < .05$. For the clinical group, no difference was found between direct and averted gaze in recognition of anger. For expression of fear, there was no difference between direct and averted gaze for the control group. In contrast, children with autism recognized fear more quickly when combined with direct gaze ($M = 758.9$, $SE = 67.5$) than averted gaze ($M = 792.6$, $SE = 65.3$), an effect approaching significance, $t(11) = 2.05$, $p < .07$.

Table 4. Mean Response Latencies in Milliseconds (and standard errors of mean) to Correctly Labeled Expressions of Happiness and Sadness (upper) and Anger and Fear (lower), as a Function of Gaze Direction.

Happiness - Sadness

	Control group		Autism group	
	Direct gaze	Averted gaze	Direct gaze	Averted gaze
Happiness	711.5 (45.1)	742.4 (49.7)	749.2 (50.4)	774.4 (55.5)
Sadness	718.3 (56.0)	722.0 (50.0)	788.3 (62.6)	753.3 (55.9)

Anger - Fear

	Control group		Autism group	
	Direct gaze	Averted gaze	Direct gaze	Averted gaze
Anger	728.3 (66.6)	765.8 (74.3)	817.2 (74.4)	824.6 (83.1)
Fear	756.0 (60.3)	754.7 (58.4)	758.9 (67.5)	792.6 (65.2)

4. Discussion

The aim of this study was to investigate if gaze direction has an effect on recognition of facial expressions in children with autism. This was explored with a behavioral experiment in which reaction times and performance accuracy were measured in a facial expression recognition task. The experiment consisted of two parts in which children with autism and typically developing children were required to perform a 2-choise response indicating whether a face presented on the computer screen looked happy/sad or angry/fearful. The expressions were displayed with both direct and averted eye gaze direction. The results showed no significant group differences in response accuracy in recognition of anger and fear whereas reaction time data revealed significant group differences in recognition of anger and fear as a function of gaze direction. These differences are discussed in more detail in the following.

Regarding the *response accuracy* data, a significant interaction between group and gaze direction was found when recognizing expressions of *happiness* and *sadness*. Children with autism made more errors identifying happiness and sadness with averted gaze than with direct gaze, whereas gaze direction did not affect the performance accuracy of typically developing children. This difference may suggest that averted gaze direction distracted the recognition of happiness and sadness in children with autism. Moreover, the group difference may reflect abnormalities in the way gaze direction affects the recognition of happiness and sadness in children with autism. However, no significant interaction of emotion and group emerged, suggesting comparable expression recognition accuracy in both groups. As for the expressions of *anger* and *fear* a main effect of gaze emerged. Children in both groups made more errors when recognizing expressions of anger and fear with averted gaze than direct gaze. However, no significant interactions were found in recognition accuracy. There are other studies which have also demonstrated comparable performance accuracy in individuals with autism and typically developing individuals when recognizing basic facial expressions of emotion (Adolphs, Sears, & Piven, 2001; Baron-Cohen, Weelwright, & Joliffe, 1997), discriminating the intensity of facial emotions (Adolphs, Sears, & Piven, 2001), recognizing expressions of happiness (Gross, 2004; Wallace, 2002) and recognizing other basic facial expressions but fear (Howard et al., 2000; Pelphrey et al., 2002). However, several recent studies have found that individuals with autism are less accurate (make more errors) in recognizing facial expressions of emotion when compared to typically developing individuals (e.g. Celani, Battachi, & Arcidiacono, 1999; Critchley et al., 2000; Deruelle, Rondan, Gepner, & Tardiff, 2004; Wallace, 2002). One possible explanation for not finding any impairment in expression recognition skills in children with autism in this study could be related to task difficulty. In the present study, in order to respond correctly, the children had to choose among just two possible responses (e.g. if it is not happiness, it must be sadness) and so the difficulty is not comparable to tasks which require choosing among multiple alternatives of emotional expressions (e. g. Wallace, 2002). Nevertheless, the results of this study together with previous research findings suggest that high-functioning children with autism are able to recognize basic facial expressions of emotion.

For the present *reaction time* results, no differences were found between children with autism and typically developing children in recognizing the expressions of *happiness* and *sadness.* The children in both groups recognized happiness more quickly when displayed with straight gaze than with averted gaze, whereas the gaze direction did not affect the recognition of sadness in either of the groups. Regarding the expressions of *anger* and *fear*, the results showed a main effect of gaze indicating that both groups recognized anger and fear expressions more quickly when displayed with direct than averted gaze. However, and more importantly, a significant three-way interaction of group, gaze direction, and expression was found. Typically developing children recognized anger more quickly when displayed with direct rather than averted gaze, whereas gaze direction did not have an effect on the recognition of anger in the clinical group. Furthermore, there was a tendency (approaching significance) that the children with autism recognized fear more quickly when displayed with straight rather than averted gaze, whereas the gaze direction did not have an effect on recognition of fear in typically developing children. These differences can not be explained by any general abnormalities in facial expression recognition in children with autism, because significant group differences were not found in recognition accuracy of anger and fear. Hence, the present results suggest abnormalities in the way that gaze direction affects the recognition of facial expressions of anger and fear in children with autism.

In a previous study Adams and Kleck (2003) demonstrated that the information provided by facial expression and gaze direction is combined in facial affect recognition in typically developed adults. Facial expressions of happiness and anger were recognized more quickly when presented with direct rather than averted gaze, whereas sadness and fear were recognized more quickly when presented with averted rather than with direct gaze. The results of the current study in typically developing children differed from the results obtained by Adams and Kleck (2003). In the current study the control children recognized happiness and anger (which are associated with a behavioral tendency for approaching) more quickly when displayed with straight gaze rather than averted gaze, and this was also demonstrated in the adult study by Adams and Kleck. However, in contrast with the adults' results, gaze direction did not have an effect on the recognition of sadness and fear (which are associated with a behavioral tendency for withdrawal/avoiding) in typically developing children. In typically developing children averted gaze did not facilitate the recognition sadness and fear. Although the results by Adams and Kleck (2003) in typically developing adults differed from the current results obtained in typically developing children, caution is warranted when interpreting the current results in terms of developmental differences in the effect of gaze direction on recognizing facial expressions. The facial stimuli in the current study differed from the stimuli used by Adams and Kleck (2003). Instead of natural face stimuli (photographs), the current experiment employed facial images created by a 3D modeling program. Therefore, one possible explanation for the differing results obtained in healthy adults and children in these two studies could be that the synthetic 3D-images were not perceived in the same way as the natural faces were. However, it should be noted that according to the conducted pilot study, the present synthetic images were nevertheless reliably identified. The possible developmental differences in recognition of facial emotions as a function of gaze direction need to be further explored with an experimental setup built exclusively for comparing children's and adult's performance.

As mentioned earlier, the results of this study revealed that direct eye gaze facilitated the recognition of fear in children with autism, whereas the gaze direction did not have an effect on the recognition of fear in typically developing children. What might make the influence of gaze direction on recognition of fear different to children with autism as compared to typically developing children? One possible explanation could relate to the wide open eyes in the expressions of fear and to previous findings showing that individuals with autism have difficulties in processing eye contact (Howard et al., 2000; Senju, Yaguchi, Tojo, & Hasegawa, 2003). Previous research has found higher physiological arousal (Kylliäinen & Hietanen, 2006) and heightened emotional response (Dalton et al., 2005) to eye contact in autism. It has been speculated that higher arousal to eye contact than averted gaze in autism may reflect the interpretation of another person's direct gaze as a hostile signal or a signal expressing intimacy at a level witch is experienced uncomfortable (Dalton et al., 2005; Kylliäinen & Hietanen, 2006). In light of these speculations, it is possible that the size of the eyes in fear is relevant when interpreting the current results. Fearful eyes looking straight ahead may have represented enhanced eye contact to children with autism "alerting" them to more effective recognition of expression of fear. Another possible explanation can be considered based on these results. According to the hypothesis introduced by Adams and Kleck (2003) an approach oriented gaze direction (direct gaze) should impede the recognition of an avoidance oriented facial expression (fear). Since direct gaze actually enhanced the recognition of fear in children with autism, it is possible that a direct fearful gaze may not, after all, represent a signal of approach to them. Instead, fearful eyes looking straight ahead may have represented a signal of avoidance to children with autism. As for the expressions of anger, the gaze direction affected the recognition of anger the same way in typically developing children as in adults in the Adams and Kleck study (2003). Both typically developing children and adults recognized anger (approach oriented) more quickly when displayed with direct gaze (approach oriented) rather than with averted gaze (avoidance oriented). Instead, in children with autism, gaze direction did not have an effect on recognition of angry faces. One possibility is that the present experimental design involving presentation of facial expressions of anger together with facial expressions of fear might have affected the results regarding the recognition of angry faces in children with autism. Staring fearful eyes may have altered the information value of (smaller) angry eyes to children with autism when these two expressions had to be discriminated and, therefore, they did not use the information from the gaze direction in the same way as typically developing children did.

Finally, there are a few issues that need to be considered when the current results are interpreted. First, the control group included 15 typically developing children, whereas only 12 children with autism participated in the clinical group. Since the effect of gaze direction to recognition of fear was marginally significant in children with autism, increasing the number of children in the clinical group might have resulted in an effect reaching a level of statistical significance. Second, one should be cautious when drawing any conclusions based on the current results concerning individuals with autism in general, as the children in the clinical group were high-functioning children with autism (rather good cognitive performance level).

The current study did not find impairment in expression recognition abilities in children with autism. Children with autism were able to recognize basic facial expressions of happiness, sadness, anger and fear as accurately as typically developing children. However, there were differences in recognition of facial expressions of anger and fear as a function of gaze direction when children with autism and typically developed children were compared. The gaze direction did not have an effect on recognizing expression of anger in children with autism, whereas direct gaze facilitated the recognition of anger in typically developing children. Furthermore, there was a tendency showing that direct gaze direction (approach oriented) facilitated the recognition of expression of fear (avoidance oriented) in children with autism, whereas gaze direction did not affect the recognition of fear in typically developing children. Overall, these results indicate that children with autism use gaze direction information differently when recognizing facial expressions of anger and fear when compared to typically developing children. Especially, the results suggest abnormalities in the effect of direct eye gaze when recognizing expression of fear in children with autism. The current study offers preliminary data exploring the effect of gaze direction on recognition of facial expressions in children with autism. The findings of this study are important in suggesting that focusing on the combined processing of gaze direction and facial expression may be relevant when the socio-communicational difficulties in autism are studied. Additional research is needed to elucidate this issue.

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