Research in Autism Spectrum Disorders 7 (2013) 1043–1053

Contents lists available at SciVerse ScienceDirect

Research in Autism Spectrum Disorders

Journal homepage: http://ees.elsevier.com/RASD/default.asp

Effects of eye gaze directions of facial images on looking behaviour and autonomic responses in adolescents with autism spectrum disorders

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ARTICLE INFO

Article history:
Received 7 February 2013
Received in revised form 16 April 2013
Accepted 23 April 2013

Keywords:
Autism spectrum disorders
Eyes
Gaze direction
Eye-tracking
Heart rate
Skin conductance response

ABSTRACT

It has been suggested that atypical eye contact of individuals with autism spectrum disorders (ASDs) arises from an unusually high level of autonomic activity elicited by another person's gaze. The present study investigated visual fixation duration and autonomic reactivity (heart rate, skin conductance response) simultaneously, while adolescents looked towards photographs of neutral faces, with either direct eye gaze, averted eye gaze or closed eyes. Both cognitively able adolescents with ASD ($n = 31$, mean age = 16 years, mean IQ = 104) and typically developing (TD) adolescents ($n = 34$, mean age = 16 years, mean IQ = 108) looked significantly longer towards the eye region of faces with direct eye gaze compared with faces with averted eye gaze or closed eyes. The adolescents with ASD did not show higher levels of autonomic activity than TD adolescents while they were instructed to look at the eye region. This suggests that looking at the eye region of static faces does not particularly trigger high autonomic arousal in adolescents with ASD.

1. Introduction

Human eye gaze is an important cue for social interaction and communication. Gaze is used to provide and obtain information, to regulate conversations, and to express intimacy and control (Kleinke, 1986). Individuals prefer to fixate on the eye region when looking at faces of others (Maurer & Salapatek, 1976). This preference is present from early development: a newborn baby's attention is attracted by the eye gaze of another person (Hainline, 1978). Atypical attention towards eye gaze is a prominent feature of the qualitative impairment in social interaction in individuals with an autism spectrum disorder (ASD, APA, 2000).

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http://dx.doi.org/10.1016/j.rasd.2013.04.013

Gaze behaviour in ASD is studied in experimental settings using eye-tracking methods (for a review see: Senju & Johnson, 2009). Some studies reported that individuals with ASD looked shorter towards the eye region of faces than typically developing (TD) individuals (Dalton et al., 2005; Jones, Carr, & Klin, 2008; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Neumann, Spezio, Piven, & Adolphs, 2006), whereas others did not find such an effect (Freeth, Chapman, Ropar, & Mitchell, 2010; Sawyer, Williamson, & Young, 2012; van der Geest, Kemner, Verbaten, & van Engeland, 2002). These contrasting findings might be related to the nature of the stimuli used: static images or dynamic movies (Riby & Hancock, 2009; Speer, Cook, McMahon, & Clark, 2007). With static images, fixation duration is usually not atypical in individuals with ASD (e.g. Sawyer et al., 2012). Dynamic movies, on the other hand, do result in shorter fixation duration to the eye region in individuals with ASD compared to TD individuals (e.g. Klin et al., 2002). However, such dynamic stimuli are usually more complex, with variation in eye gaze direction, social interactions between people, and the use of audio; all this makes it hard to determine which specific aspect of the stimuli triggers atypical gaze behaviour in individuals with ASD.

The underlying mechanisms of atypical gaze behaviour in individuals with ASD are also still unclear. Some researchers suggested that reduced gaze duration can be explained by a lower attentional priority to social stimuli in individuals with ASD (Riby & Hancock, 2009). Atypical fixation might be the result of reduced understanding of the significance of the eyes for social interaction (Baron-Cohen, Campbell, Karmiloff-Smith, Grant, & Walker, 1995; Klin et al., 2002). Others suggest that individuals with ASD fixate less on the eye region to regulate their levels of arousal. They state that fixation to eyes triggers over-arousal in individuals with ASD, which can be reduced by looking less to the eye region of others (Dalton et al., 2005; Hutt & Ounsted, 1966).

Arousal in response to social stimuli can be measured using several indices of the activity of the autonomic nervous system, such as heart rate (HR) or skin conductance level (SCL). Various recent studies investigated such measures in individuals with ASD in response to social stimuli (Joseph, Ehrman, McNally, & Keehn, 2008; Kylliäinen & Hietanen, 2006; Kylliäinen et al., 2012; Riby, Whittle, & Doherty-Sneddon, 2012). However, results have been inconsistent. Some studies showed higher autonomic arousal levels (Joseph et al., 2008), while others showed lower levels of autonomic arousal in individuals with ASD compared to TD individuals (Hubert, Wicker, Monfardini, & Deruelle, 2009; Vaughan Van Hecke et al., 2009). When autonomic responses to direct eye gaze were compared to averted eye gaze or closed eyes, some studies found higher autonomic arousal to direct eye gaze stimuli than to averted eye gaze stimuli in individuals with ASD, but not in TD adolescents (Kylliäinen & Hietanen, 2006; Kylliäinen et al., 2012). Other studies did not find this higher level of arousal in reaction to direct eye gaze stimuli in individuals with ASD (Joseph et al., 2008).

Until now, studies concerning autonomic arousal in individuals with ASD did not use an eye-tracking device to measure how long individuals looked at the eye region. It thus remains to be clarified whether autonomic responses in individuals with ASD are the result of looking towards the eye region. Visual fixation duration and autonomic responses should be measured simultaneously to unravel whether atypical gaze behaviour is associated with autonomic activity in individuals with ASD (Riby et al., 2012; Vaughan Van Hecke et al., 2009). In TD individuals, fixation durations towards the eye region depend on the direction of the eye gaze in the stimulus. Direct eye gaze triggers longer fixation durations than averted eye gaze or closed eyes (Batki, Baron-Cohen, Wheelwright, Connellan, & Ahluwalia, 2000; Caron, Caron, Roberts, & Brooks, 1997; Farroni, Menon, & Johnson, 2006), which suggests that direct eye gaze is more socially relevant. To our knowledge, no eye-tracking studies compared fixation durations of direct eye gaze to averted eye gaze and closed eyes in ASD. Examining specific mechanisms behind atypical eye gaze in individuals with ASD is needed to determine which aspects of social situations triggers atypical gaze behaviour in individuals with ASD.

The current study aims to extend the current research by examining fixations to the eye region and the consequent arousal levels in individuals with ASD versus TD individuals. This study investigated the effect of gaze direction (direct eye gaze, averted eye gaze, and closed eyes) on visual fixation duration and autonomic arousal responses in ASD. Eye-tracking measures, measures of autonomic arousal (HR and SCL) and subjective ratings were combined in one experimental session. In two related tasks, fixation duration towards the eye region and the associated autonomic and subjective responses were assessed. In addition, the association between autonomic responses during direct eye gaze and the severity of social deficits was evaluated for the ASD group. We hypothesized that under spontaneous viewing conditions in the first task, the effect of gaze direction would have similar effects on fixation durations for individuals with ASD and TD individuals. When instructed to look at the eye region in the second task, however, we expected that direct eye gaze of the stimulus would elicit stronger autonomic and subjective responses than averted eye gaze or closed eyes in the ASD group. We also expected that the autonomic responses during direct eye gaze were correlated with social deficits in the ASD group (Kaartinen et al., 2012).

2. Methods

2.1. Participants

2.1.1. ASD

Thirty-nine adolescents with ASD and 42 TD adolescents participated in this study, which was approved by the Medical Ethical Committee of the Erasmus MC. Informed consent was obtained from all adolescents and also from their parents if the adolescent was younger than 16 years of age. Only male adolescents with an IQ above 70 were included. To confirm an IQ above 70, the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999), was administered. There was no significant difference between the mean total IQ of the adolescents with ASD (mean IQ = 103.7 ± 13.6 SD) and the TD