Research in Autism Spectrum Disorders 17 (2015) 78–85

Contents lists available at ScienceDirect

Research in Autism Spectrum Disorders

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

Gaze performance during face-to-face communication: A live eye tracking study of typical children and children with autism

Terje Falck-Ytter [a,b,*]

[a] Center of Neurodevelopmental Disorders at Karolinska Institutet (KIND), Pediatric Neuropsychiatry Unit, Department of Women's & Children's Health, Karolinska Institutet, Stockholm, Sweden
[b] Uppsala Child & Babylab, Department of Psychology, Uppsala University, Uppsala, Sweden

ARTICLE INFO

Article history:
Received 21 January 2015
Received in revised form 18 June 2015
Accepted 22 June 2015
Available online 2 July 2015

Keywords:
Eye tracking
Attention
Social interaction
Teaching
School
Special Education

ABSTRACT

Autism Spectrum Disorder (ASD) is characterized by socio-communicative impairments, and limited attention to other people's faces is thought to be an important underlying mechanism. Here, non-invasive eye-tracking technology was used to quantify the amount of time spent looking at another person's face during face-to-face communication in children with ASD ($n = 13$, age 6 years) and age and IQ-matched neurotypical children ($n = 27$, 6 years). We found that in one context of high ecological relevance – listening to an adult telling a children's story – children with ASD showed a markedly reduced tendency to look at the adult's face. In interactions between typical children and the adult, the amount of gaze to the other's face aligned between the two individuals. No such relation was found when the ASD group interacted with the adult. Despite these differences in the storytelling context, we also observed that social looking atypicalities did not generalize to another and more structured context, implying that social looking cannot not be considered fundamentally disrupted in children with ASD.

1. Introduction

When we act, our eyes are free to move and facilitate perceptual access to the most useful visual information given the intention of the individual and the current situational constraints (Land & Furneaux, 1997; Rosander & von Hofsten, 2011). In social contexts, looking at other people's faces provides important information about their intentions and emotions, and can facilitate encoding of speech (McGurk & Macdonald, 1976; Senju & Csibra, 2008; Smith, Cottrell, Gosselin, & Schyns, 2005; Vatikiotis-Bateson, Eigsti, Yano, & Munhall, 1998). Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder marked by severe socio-communicative deficits, and influential models of ASD hold that reduced or altered attention to social stimuli is a key component of the condition (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Dalton et al., 2005; Klin, Jones, Schultz, Volkmar, & Cohen, 2002). Behavioral observation studies of children with ASD support this view (Ozonoff et al., 2010), and reduced looking time to social stimuli is considered to be a cardinal sign of autism in gold standard

* Corresponding author at: Center of Neurodevelopmental Disorders (KIND), Department of Women's & Children's Health, Karolinska Institutet, Gävlegatan 22B, SE-11330 Stockholm, Sweden. Tel.: +46 070 4581475; fax: +46 0517 79696.
E-mail address: terje.falck-ytter@ki.se

http://dx.doi.org/10.1016/j.rasd.2015.06.007
1750-9467/

diagnostic tests (Lord et al., 2000). Nevertheless, because the eyes tend to move several times per second, there are limits to what behavioral observation of children can reveal about the nature of gaze behavior in ASD in everyday life.

Eye tracking allows assessment of the gaze distribution with high spatial and temporal resolution, and can be used to use to quantify gaze performance in complex naturalistic environments. Although many previous eye-tracking studies have provided support for the view that atypicalities in social looking are indeed present in ASD (e.g. Falck-Ytter, Rehnberg, & Bölte, 2013a; Klin et al., 2002; Shic, Macari, & Chawarska, 2014), the validity of these studies are often compromised by the use of video or pictures as stimuli. Several studies point to the importance of distinguishing between live and non-live presentation. For example, studying typically developing adults, Hietanen, Leppanen, Peltola, Linna-Aho, and Ruuhiala (2008) showed that ERP and galvanic skin responses were strongly modulated by other people's gaze direction in a live context, but not when the stimuli were presented as videos. Live presentation entails using multimodal three-dimensional objects as stimuli. Moreover, when the stimulus is a person, it entails bi-directional contingent responding. Both these aspects are key components of social interaction in everyday life.

Only a handful live eye-tracking studies have been published so far involving children with ASD (Falck-Ytter, Carlström, & Johansson, 2015; Hanley et al., 2014; Nadig, Lee, Singh, Bosshart, & Ozonoff, 2010; Noris, Nadel, Barker, Hadjikhani, & Billard, 2012). One reason why so few studies of this type have been conducted may be that eye-tracking experiments involving live person-to-person interaction can be more methodologically challenging and time consuming than conventional (screen-based) eye tracking (Gredebäck, Fikke, & Melinder, 2010; Risko, Laidlaw, Freeth, Foulsham, & Kingstone, 2012).

Of the live eye tracking studies of ASD published so far, all except one (Falck-Ytter et al., 2015) confirmed the prevailing view of reduced looking time to social stimuli in children with ASD. In contrast, Falck-Ytter et al. (2015) reported not only that children with ASD and typical controls looked equally long to an interlocutor's face, but also that both groups modulated their gaze adaptively (and similarly) as a function of task demands (e.g. looking more at the lower part of the face when listening; looking higher up when answering, etc.). An aspect of the Falck-Ytter et al. study that differed from all the other reports was that the eye tracking was conducted during a 'maximum performance' cognitive testing session. Specifically, the authors were measuring gaze performance during a short term memory (digit span) task, which is included in common intelligence tests, and in which the child is required to perform at his or her very best. Thus, one potential explanation for the discrepancy across studies is that the atypicalities in social looking in ASD are found for some contexts but not others. However, because the aforementioned live eye tracking studies differed in a number of aspects in addition to the nature of the tasks involved, this conclusion remains premature. Another explanation could be that the sample studied in Falck-Ytter et al. (2015) was non-representative, and that these particular children would display normal looking patterns in all contexts.

Here, we analyzed gaze data from a group of children that both were part of the experiment reported in Falck-Ytter et al. (2015) as well as in a less structured task where were no task instructions were given and where no response was required from the child; listening to the adult telling a brief children's story. In addition to providing a contrast to the cognitive testing context, this task resembles many teaching situations the children encounter in school, and thus is of high ecological relevance.

All children participating in the current study contributed to the data reported previously (Falck-Ytter et al., 2015). In addition, to increase sample size, data from five additional children (three with ASD) were included in the current study. Based on the previous studies of gaze performance in social 'average performance' tasks (Hanley et al., 2014; Nadig et al., 2010; Noris et al., 2012), we predicted reduced gazing to the adult's face in the ASD group relative to the TD group in the current setting.

2. Materials and methods

2.1. Participants

Thirteen high-functioning individuals with ASD (1 girl and 12 boys, age range 4.9 to 10.4 years) and 27 typically developing (TD) children (8 girls and 19 boys, age range 5.1 to 10.2 years) were studied (final samples, after exclusion; Table 1). Autistic children were recruited from habilitation centers in the greater Stockholm region and had a clinical community diagnosis of ASD (Autistic Disorder, Asperger Syndrome, or Pervasive Developmental Disorder—Not Otherwise Specified) according to DSM-IV (American Psychiatric Association, 1994). We selectively recruited children judged by their clinical psychologist at the habilitation center to have an IQ above 70 (subsequently confirmed by formal testing). A this particular habilitation center, the use of the ADOS (Lord et al., 2000) or the ADI-R (Lord, Rutter, & Lecouteur, 1994) is standard when diagnosing ASD, and in our sample the medical records specified the use of these instruments in ten out of 13 cases. The TD group was recruited from birth records from the same geographical area as the ASD group. None of the TD children had relatives (including second degree) with ASD. None of the children in this study had major medical conditions (e.g., epilepsy). In all children, we assessed intelligence using the Wechsler Intelligence Scales (WISC-IV/WPPSI-III; Wechsler, 1967/2002, 2003), autistic symptomatology using the Social Responsiveness Scale (SRS; Constantino, 2005; Constantino & Gruber, 2009), and socio-economic status (SES) using an in-house form (Table 1). Recruited families were predominantly Caucasian.

One participant with ASD was excluded because of technical failure and two (one with ASD) because of too little eye-tracking data (cut-off for exclusion: data from less than 30% of the duration of the story). Parents provided written consent, and the study was approved by the Local Ethics Committee in Stockholm and conducted in accordance with the standards