



Research report

Zoom-out attentional impairment in children with autism spectrum disorder

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ABSTRACT

Autism spectrum disorder (ASD) has long been associated with an inability to experience wholes without full attention to the constituent parts. A zoom-out attentional dysfunction might be partially responsible for this perceptual integration deficit in ASD. In the present study, the efficiency of attentional focusing mechanisms was investigated in children affected by ASD. We measured response latencies to a visual target onset displayed at three eccentricities from the fixation. Attentional resources were focused (zoom-in) or distributed (zoom-out) in the visual field presenting a small (containing only the nearest target eccentricity) or large (containing also the farthest target eccentricity) cue, 100 or 800 msec, before the target onset. Typically developing children, at the short cue-target interval, showed a gradient effect (i.e., latencies are slower at the farthest eccentricity) in the small focusing cue, but not in the large focusing cue condition. These results indicate an efficient zoom-in and zoom-out attentional mechanism. In contrast, children with ASD showed a gradient effect also in the large focusing cue condition, suggesting a specific zoom-out attentional impairment. In addition, the ASD group showed an atypical gradient effect at the long cue-target interval only in the small cue condition, suggesting a prolonged zoom-in and sluggish zoom-out attentional mechanism. This abnormal attentional focusing – probably linked to a dysfunctional top-down feedback from fronto-parietal network to the early visual areas – could contribute to the atypical visual perception associated to individuals with ASD which, in turn, could have consequences in their social-communicative development.

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1. Introduction

Autism Spectrum Disorder (ASD) is a complex neurodevelopmental disorder characterized by abnormalities in communication, social interaction and presence of markedly

restricted interests and stereotyped behaviours (American Psychiatric Association, 1994).

Although the dysfunctions in social cognition and communication are typically considered the “core” deficits in individuals with ASD, there is growing evidence of abnormalities in

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their visual perception and attention (e.g., Grandin, 2009; Vlamings et al., 2010; see Dakin and Frith, 2005; Happé, 1999; Mottron et al., 2006 for reviews). The idea that individuals with ASD pay attention to the world differently, and that the consequent atypical perception might contribute to abnormalities in both social and “non-social” (e.g., repetitive behaviours, insistence on sameness and preoccupation with parts of objects) domains, is perhaps one of the most intriguing aspects of the current ASD research (see Mazer, 2011 for a recent review). According to the neuro-constructivist approach (see Karmiloff-Smith, 1998; Johnson, 2011 for reviews) low-level attentional and perception abnormalities could, indeed, cause impairments in the higher level cognitive modules (e.g., Elsabbagh et al., 2011).

It is well known that perception of relevant information is mediated by attention orienting (see Reynolds and Chelazzi, 2004 for a review). Attention orienting is often compared with a “spotlight” that moves to a specific region in the visual space, improving information processing in the attended area at the expense of other locations (see Posner and Petersen, 1990; Corbetta and Shulman, 2002 for reviews). However, the attention spotlight is not only oriented in a specific location, but has also to be adjusted in its size. This ability allows to process visual stimuli from a narrow (zoom-in) or a broad visual region (zoom-out). Eriksen and St. James (1986) suggested a “zoom-lens” model, in which the attentional spotlight size can be varied continuously (see also the attentional scaling by Luo et al., 2001). In particular, the zoom-lens model explicitly predicts an increase of processing efficiency within the focus when the attentional spotlight is decreased in size. This prediction has been supported by behavioural, neuro-imaging and neurophysiological data demonstrating a partial independence between the focusing and the orienting mechanisms (e.g., Castiello and Umiltà, 1990; Müller et al., 2003; Fu et al., 2005; Turatto et al., 2000).

Although several studies investigated the attentional orienting in ASD (e.g., Townsend et al., 1996a, 1996b), only a few of them are related to the ability to adjust the size of the attentional spotlight (hereafter, attentional focusing). In a recent review Ames and Fletcher-Watson (2010) reported that only two studies attempted to explore the attentional focusing mechanisms in ASD (Burack, 1994; Mann and Walker, 2003). In the Burack's study (1994) participants (four mental-age matched groups composed by subjects: with autism, with organic mental retardation, with familial mental retardation, and with no handicap) performed a forced-choice reaction time (RT) task to assess the filtering component of selective attention. The independent variables were the presence/absence of a window which narrowed the attentional spotlight (zoom-in), the number (zero, two, or four) and the location of distractors. The RTs of the subjects with autism improved relative to the other groups in the presence of the window without distractors, but this effect was negated when distractors were also presented. Performance of the autism group was, indeed, the most impaired in the presence of distractors. These findings represent a behavioural evidence of an inefficient broad attentional lens among persons with autism. In the second study, Mann and Walker (2003) employed a paradigm requiring participants to make a judgement about which one of the two pairs of cross-hairs was the

longer. ASD participants were less able than comparison group in making this judgement when the previous pair of cross-hairs was smaller than the one to be judged. The authors argued that individuals with ASD have a difficulty in the zoom-out of the attentional spotlight, even if they speculated that this deficit could arise from a general difficult in orienting attention to a target in the periphery.

We hypothesise that the “inability to experience wholes without full attention to the constituent parts” (Kanner, 1943, p. 246) in ASD could be related to an abnormal attentional focusing mechanism. Precisely, we suppose that children with ASD present a poorer ability to enlarge the size of their attentional spotlight: i.e., a specific zoom-out attentional impairment. This deficit in the zoom-out of the attentional spotlight, although it could lead to superior performances in several perceptual tasks (see Dakin and Frith, 2005; Mottron and Burack, 2001 for reviews), it could also result in poor performance in other visual paradigms. For example, in coherent dots motion detection paradigm (Newsome and Pare, 1988), observers with ASD require about 10% more of coherent motion to correctly report direction (e.g., Milne et al., 2002; Pellicano and Gibson, 2008; Ronconi et al., under review; Spencer et al., 2000; but see De Jonge et al., 2007; see Grinter et al., 2010 for a recent review). A narrow attentional spotlight could contribute to worsen the coherent motion performance because it would filter the information outside the attentional focus, leading individuals with ASD to base their judgement on a restricted portion of moving dots. Moreover, Navon Task (Navon, 1977) performance in ASD indicates a preference for the local level of hierarchical stimulus analysis – maybe due to a deficit in the zoom-out of the attentional spotlight (e.g., Milne et al., 2002; Rinehart et al., 2000). These findings suggest that a detail-oriented visual perception could be a possible mechanism for the “weak central coherence” (Frith and Happé, 1994; Happé and Frith, 2006; see Happé, 1999 for a review).

In the present study, we investigated the attentional focusing mechanisms (i.e., zoom-in and zoom-out) in children with and without ASD, to verify the hypothesis for which children with ASD present a specific deficit in zooming-out their attentional spotlight. We employed a simple RTs task to measure the target detection – presented at three eccentricities from the fixation point – when a non-informative small or large focusing cue guided participants to scale the attentional processing in a restricted or enlarged visual field area, respectively. The “attentional gradient” is defined as the specific RTs pattern evoked in presence of a small cue-size that focuses the attentional spotlight (i.e., zoom-in mechanism): it predicts that the RTs to the target are slower at the farthest in comparison with the nearest eccentricity. In contrast, when a large cue-size enlarges the attention spotlight this gradient should be reduced or nullified because the target is presented inside the focus regardless target eccentricity (i.e., zoom-out mechanism; e.g., LaBerge, 1983; see LaBerge and Brown, 1989 for a review).

We predict that typically developing (TD) participants will be able to zoom-in their attention, generating a gradient effect, only when a small cue anticipates the target onset. On the other hand, with a large cue, they should be able to zoom-out their attention, nulling the gradient effect of the target

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