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Visual feedback increases postural stability in children with autism spectrum disorder

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ABSTRACT

Autism spectrum disorders (ASD) are often associated with poor motor control, which depends greatly on postural stability. Firstly, this study examined postural stability in young children with ASD, as little is known about early postural skills in this population. Children with ASD are known to depend considerably on visual cues when maintaining balance. We therefore wished to explore whether visual stimuli would in turn improve postural stability. We recruited 18 children with ASD (aged 6–11) and also 12 age-matched typically developing (TD) children. We measured their baseline postural stability and their ability to maintain balance when provided contingent visual feedback of the movements of their center of pressure. Postural performances were measured with a force platform. Baseline postural stability of children with ASD was significantly reduced compared to TD children, as indicated by higher sway scores. When provided visual feedback, children with ASD improved their balance significantly. We conclude that although deficient postural control in ASD is present in childhood, this may be improved in facilitating settings where children with ASD can rely on visual cues.

1. Introduction

The beneficial effect of training on the motor functioning of children with autism spectrum disorders (ASD) is well documented (Lang et al., 2010; Sowa & Meulenbroek, 2012). Still, the mechanisms that underlie this effect are rarely targeted by empirical research. In the current study, we wished to capture ability of children with ASD to use visual cues for improving their postural control, an important component of gross motor development.

1.1. Autism spectrum disorders and motor function

From the first clinical descriptions of ASD, poor motor skills have been commonly reported (Kanner, 1943). Empirical studies confirm that children with ASD experience both gross and fine motor delays and show atypical motor patterns (Ghaziuddin & Butler, 1998; Green et al., 2009; Ming, Brimacombe, & Wagner, 2007; Miyahara et al., 1997;

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Provost, Lopez, & Heimerl, 2007, for reviews see: Gowen & Hamilton, 2013). Motor function depends greatly on postural control, the fundamental and early-developing ability to maintain equilibrium by keeping or returning the center of body mass over its base of support (Horak, 1987). This was shown for instance in a sub-analysis conducted by Whyatt and Craig (2012) of the motor performance of children with ASD on the Movement Assessment Battery for Children (Henderson & Sugden, 1992), which assesses manual dexterity, ball skills and balance. They found that the motor skill deficits indicated by this test were specifically apparent in activities demanding core balance ability, such as static balance and catching a ball. A recent study (Mache & Todd, 2016) directly comparing motor skills and postural control in children with ASD has confirmed that a significant predictor of fundamental motor skill performance (locomotion and ball skills) in ASD is postural control.

1.2. Autism spectrum disorders and postural stability

Indeed, studies that have assessed postural stability in ASD by measuring balance time have generally found difficulties sustaining a posture for longer periods of time (Ghaziuddin, Butler, Tsai, & Ghaziuddin, 1994; Green et al., 2009; Jansiewicz et al., 2006; Noterdaeme, Mildenberger, Minow, & Amorosa, 2002; Papadopoulos et al., 2012, though see: Weimer, Schatz, Lincoln, Ballantyne, & Trauner, 2001 for diverging results). Research that used force plates to record the exact amount of movement made by participants when trying to hold a posture have also consistently reported increased sway in children with ASD during quiet stance (Fournier et al., 2010; Gepner & Mestre, 2002; Kohen-Raz, Volkmar, & Cohen, 1992; Memari et al., 2013; Minshew, Sung, Jones, & Furman, 2004, though see: Molloy, Dietrich, & Bhattacharya, 2003 for opposite results).

Balance is regulated through the afferent signals from the somatosensory, the vestibular and the visual systems (Peterka & Benolken, 1995). Experiments that manipulated afferent inputs show abnormal compensatory functioning between the three subsystems in ASD. For example, in Weimer et al.'s study (2001), while children and young adults with Asperger Syndrome (AS) balanced on one leg with eyes open for a similar amount of time as controls, they balanced for significantly less time when standing on one foot with eyes closed. Similarly, Molloy et al. (2003) found that when their vision was occluded, children with ASD had significantly more difficulties in maintaining balance than controls, whether or not somatosensory input was also modified, which suggests an overreliance on visual cues. Two recent studies have further confirmed this visual dependency by showing that children with ASD show more postural sway than controls when their eyes are closed (Stins, Emck, de Vries, Doop, & Beek, 2015) or while performing a visual searching task as compared to sway during an auditory digit span task (Memari, Ghanouni, Shayestehfar, Ziaee, & Moshayedi, 2014).

Minshew et al. (2004) compared how individuals with ASD (children and adults) and controls compensate for disrupted visual, vestibular or somatosensory inputs and found the relative importance of the latter to be the greatest. In this study, the postural stability of individuals with ASD was significantly reduced compared to controls when somatosensory input was disrupted alone or in combination with the disruption of the visual input. The authors also revealed a specific developmental trajectory for postural stability in persons with ASD. Postural control did not begin to improve until the age of 12 years in children with ASD and never achieved adult levels, whereas in controls, it improved steadily from 5 to 15–20 years, before it plateaued.

An alternative hypothesis put forward by Gepner, Mestre, Masson, and de Schonen (1995) and Gepner and Mestre (2002) is that atypical postural function in ASD does not derive from basic motor impairments but from a deficit in visual-motion integration, which can be captured in reduced reactivity to fast moving visual stimulation. They reported that children with ASD were posturally hyporeactive to visually perceived environmental motion in comparison with typically developing (TD) controls (Gepner et al., 1995). Greffou et al. (2012) further explored the question by assessing postural response in fully immersive dynamic virtual tunnels. Similarly to Gepner et al. (1995) and Gepner and Mestre (2002), they also found abnormal postural reactivity in participants with ASD, but only in the younger group (aged 12–15 years) and for specific oscillation frequencies.

Although the role of postural reactivity remains uncertain, the above studies underscore the relative importance of visual cues for maintaining balance in ASD.

1.3. The effect of IQ

Postural stability seems to be linked to IQ (Minshew et al., 2004) and level of functioning in ASD (Gepner & Mestre, 2002; Kohen-Raz et al., 1992; Memari et al., 2013). Children with ASD who have intellectual disability are more likely to show reduced postural stability even in static conditions with a stable floor and normal visual input (Kohen-Raz et al., 1992; Memari et al., 2013; Minshew et al., 2004). Cognitively able children with ASD on the other hand seem to catch up with TD children from the age of about 12 years, after which abnormal functioning has been found only for challenging conditions where afferent inputs were modified (Greffou et al., 2012; Minshew et al., 2004; Weimer et al., 2001). Only few studies, however, have explored postural skills in children with ASD below the age of 12, with some confirming prolonged delay until this age (Fournier et al., 2010; Memari et al., 2013; Minshew et al., 2004), but not others (Molloy et al., 2003; Price, Shiffrar, & Kerns, 2012). Inconsistent findings may be due to the variability of assessment methods and sway measures as well as to samples often covering a wide age range.