

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Human Movement Science

journal homepage: www.elsevier.com/locate/humov

Full Length Article

Receptive language is associated with visual perception in typically developing children and sensorimotor skills in autism spectrum conditions



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ARTICLE INFO

Keywords:

Autism
Sensorimotor
Receptive language
Visual perception
Balance
Embodied cognition
BA 37

ABSTRACT

A number of studies have evidenced marked difficulties in language in autism spectrum conditions (ASC). Studies have also shown that language and word knowledge are associated with the same area of brain that is also responsible for visual perception in typically developing (TD) individuals. However, in ASC, research suggests word meaning is mapped differently, on to situational sensorimotor components within the brain. Furthermore, motor coordination is associated with communication skills. The current study explores whether motor coordination and visual perception are impaired in children with ASC, and whether difficulties in coordination and visual perception correlate with receptive language levels. 36 children took part: 18 with ASC and 18 TD children, matched on age and non-verbal reasoning. Both groups completed the Movement ABC, Beery-Buktenica Developmental Test of Visual-Motor Integration, British Picture Vocabulary Scale and Matrices (WASI). Results showed that ASC children scored significantly lower on receptive language, coordination and visual motor integration than the TD group. In the TD group receptive language significantly correlated with visual perception; in the ASC group receptive language significantly correlated with balance. These results imply that sensorimotor skills are associated with the understanding of language in ASC and thus the relationship between sensorimotor experiences and language warrants further investigation.

1. Introduction

The ability to communicate effectively is a fundamental milestone in development and is critical to learning, socialising, behaviour and emotional well-being (Lindsay & Dockrell, 2012). However, children with an autism spectrum condition (ASC) find it difficult to communicate and interact with others from infancy (Dawson, Osterling, Meltzoff, & Kuhl, 2000). Consequently, current diagnostic criteria for ASC (DSM-5, APA, 2013) include social communication and interaction difficulties, in addition to unusual sensory responsivity and motor movements. (Current DSM-5 criteria (APA, 2013) refer to autism as a “disorder”, the current study uses the less stigmatising term “condition”; acknowledging both strengths and weaknesses in autism, whilst still being a medical condition for which individuals need support).

A number of studies have demonstrated impaired language in ASC, and although not a universal characteristic of ASC is well recognised, with some prevalence rates observed at 57% (Loucas et al., 2008), and 76% (Kjelgaard & Tager-Flusberg, 2001). Moreover, by using a number of standardised assessments to measure the quality of functional language in ASC children, such as the

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Clinical Evaluation of Language Fundamentals (CELF-3; Semel, Wiig, & Secord, 1995), indistinguishable weaknesses in receptive and expressive language, and grammar have been demonstrated (Jarrold, Boucher, & Russell, 1997; Kwok, Brown, Smyth, & Cardy, 2015). Studies have also compared functional language ability in children with ASC to Speech and Language Impairment (SLI), demonstrating greater impairment in receptive language in ASC (Loucas et al., 2008). This finding was reiterated in a longitudinal study that showed children with a receptive language disorder are often difficult to distinguish from those with an ASC in terms of their language outcomes (Howlin, Mawhood, & Rutter, 2000). Other studies that demonstrate differences in language include Dunn, Gomes, and Gravel (2008), Dunn and Bates (2005), Bishop and Norbury (2002), Norbury (2005), Lloyd, Paintin, and Botting (2006), Ungerer and Sigman (1987) and Luyster, Kadlec, Carter, and Tager-Flusberg (2008). Moreover, language difficulties are considered a possible requisite to a diagnosis of ASC according to the current DSM-5 criteria (APA, 2013).

Difficulties in language have been shown to affect social communication skills in individuals with and without ASC. For example: when measuring social confidence, preschool children preferred playmates with similar linguistic skills (Brighi, Mazzanti, Guarini, & Sansavini, 2015); using a longitudinal study on children from 2.5 years to 5.5 years of age, ASC children who had deficits in receptive and expressive language growth had persistently high trajectories using calibrated severity scores (Venker, Ray-Subramanian, Bolt, & Weismer, 2014); and the social functioning in two groups of individuals, one with ASC and one with SLI, from initial studies at age 7–8 to a follow-up study at 23–24 years of age, had similar and significant difficulties in stereotyped behavioural patterns, social functioning, jobs and independence (Howlin et al., 2000). Therefore, identifying possible causes behind such language and communication difficulties in ASC would be an important advancement in understanding the symptoms.

Previous research has associated language and communication with sensorimotor skills. For example, the emergence of sitting skills has been linked to receptive language development (Libertus & Violi, 2016), fine motor skills in infants are related to expressive language development (LeBarton & Iverson, 2013) and impairments in motor abilities have been identified in SLI (Iverson & Braddock, 2011). More specifically, in ASC, early gross motor abilities have been found to predict language development (Bhat, Galloway, & Landa, 2012; Bedford, Pickles, & Lord, 2016) and have also been associated with the development and severity of social skills in ASC (Green et al., 2009; Hannant, Cassidy, Tavassoli, & Mann, 2016; MacDonald, Lord, & Ulrich, 2013; Ming, Brimacombe, & Wagner, 2007). This finding is further substantiated by research showing that deaf children with ASC also had receptive language skills that correlated with praxis performance (Bhat, Srinivasan, Woxholdt, & Shield, 2016). More specific observations demonstrate that significant impairments in motor skills also appear to result in limited gesture in ASC (Mostofsky et al., 2006): in turn, this restricted gesture has been identified as a significant predictor of receptive language in pre-schoolers with ASC (Luyster et al., 2008). Difficulties with speech pronunciation due to oral motor difficulties could also impact on social acceptance and interaction in ASC (Gernsbacher, Sauer, Geye, Schweigert, & Hill Goldsmith, 2008; Page & Boucher, 1998). Moreover, children who have fine motor difficulties in early childhood (from 7 months old) are considered to be more at risk of developing an ASC by 3 years old (Landa & Garrett-Mayer, 2006).

Any link between the ability to coordinate movement and language impairment could be deemed unusual and disparate, however a theory that extraordinarily connects these two dimensions together is the ‘embodied cognition hypothesis’. This theory suggests conceptual information is represented within the sensorimotor systems (Mahon & Caramazza, 2008), where it is thought ‘cognition depends upon the kinds of experience that come from having a body with various sensorimotor capacities’ (Rosch, Thompson, & Varela, 1991: p. 172–173). Such a theory can be observed in the ‘action-sentence compatibility effect’ (Borreggine & Kaschak, 2006), where sentence meaning interacts with movements made during oral sentence presentation. A further example is where olfactory anchors stimulate memory (Engen, 1991). Moreover, a systematic lag between the age of the earliest memory and the age of acquisition of the associate word has been observed (Morrison & Conway, 2010), which is thought to reflect the formation of the conceptual knowledge required from details in the episodic memories and situational contexts. This could also account for the relation between coordination and language in infants, such as the link between sitting and language (Libertus & Violi, 2016). Thus, there appears to be a rationale for a sensorimotor and language relation.

In addition to sensorimotor skills correlating with language, visual perception also appears to be directly associated with receptive language. Both receptive language acquisition and the visual representation of auditory linguistic information occur in the same area of the brain, area BA 37. This area of the brain is within the Wernicke’s area, which is thought to be linked to the semantic/lexical system (Ardila, 2011) and appears to not only have language but also visual perception functions (Ardila, Bernal, & Rosselli, 2015; Milner & Goodale, 2008; Pammer et al., 2004; and Stewart, Meyer, Frith, & Rothwell, 2001). Moreover, recent research has identified that the verbal labelling of objects augments visual input (Souza & Skóra, 2017), providing more evidence for coaction within this area. However, this association seems to differ in individuals with developmental disorders such as ASC and SLI. By analysing a number of imaging studies of BA 37 activation during sentence comprehension, Glezerman (2013) found that instead of mapping words on to the categorical and empirical components of the left hemisphere (LH), individuals with ASC and SLI would primarily match word meaning to the situational-experiential contexts of the right hemisphere (RH). Moreover, Glezerman (2013) suggests that only in ASC is word meaning mapped onto the situational sensorimotor level in the RH BA 37. Therefore, the Broca’s area may well be important in linking difficulties in visual perception and/or sensorimotor skills to receptive language difficulties.

Additionally, it is important to consider any link between visual feedback and motor control as visual information is essential to the planning and performing of motor movements (Brooks, 1983; Wolpert & Flanagan, 2001). For example, an individual needs to be responsive to where items are visually in order to grasp, reach or avoid them. Consequently, any perceptual or underlying cognitive difficulties in visual guidance are likely to affect the ability to acquire and modify a motor command for effective motor coordination. Adults with ASC have difficulty coordinating hand/eye movements (Glazebrook, Gonzalez, Hansen, & Elliott, 2009). Additionally, by measuring both form and motion coherence in ASC, a link between visual motion responsivity and fine motor control has been observed (Milne et al., 2006). Difficulties integrating visual cues from the environment with motor movements have also been

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