Predicting the rate of language development from early motor skills in at-risk infants who develop autism spectrum disorder

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A B S T R A C T

The aim of the current paper was to use data from a prospective study to assess the impact of early motor skills on the rate of language development in infants with an older sibling with autism spectrum disorder (ASD), who are at increased risk of developing ASD themselves. Infants were tested prospectively at four points (7, 14, 24 and 36 months), and were assessed for ASD at the last visit. Latent growth curve analysis was used to model rate of language development using the Vineland Adaptive Behavior Scales between 7–36 months in infants at high and low familial risk for ASD. Motor scores from the Mullen Scales of Early Learning at 7 months were used as predictors of language growth. Gross Motor scores predicted the subsequent rate of expressive, but not receptive, language development in at-risk siblings who were later diagnosed with ASD. Although the pattern was similar for fine motor skills, the relationship did not reach significance. It seems that early motor delay impacts the rate of development of *expressive* language, and this may be of particular importance to infants at increased risk of developing ASD.

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1. Introduction

The achievement of gross motor milestones, such as crawling and walking, is widely understood to be significant in a child's life. However, the relationship between motor development and other key skills is not always recognised (Leonard & Hill, 2014). Motor development has often been viewed as a separate system to those traditionally studied by psychologists (Rosenbaum, 2005), but more recently there has been increasing interest in its effect on cognition and behaviour. The conceptualisation of motor development as part of a complex dynamic system (Thelen & Smith, 1994) has encouraged greater investigation of the constraints placed on the developing infant in terms of emerging motor skills (i.e., object manipulation, postural changes and locomotion), and the impact that relatively small changes in this component can have on other parts of the system. This approach is of particular interest in neurodevelopmental disorders, including autism

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spectrum disorder (ASD), in which it is likely that early disruptions in specific aspects of the system have cascading effects on a number of different areas of development (Bishop, 1997; Karmiloff-Smith, 1998).

The focus of the current study is on the relationship between early motor skills and the development of language in ASD. ASD is diagnosed on the basis of atypical use of language and nonverbal communication in social contexts, which interferes with typical social functioning, as well as repetitive and restricted patterns of behaviour and interests (American Psychiatric Association, 2013). An increasing number of studies have also identified motor difficulties in individuals with ASD (see Bhat, Landa, & Galloway, 2011, for a review). However, few have considered the relationship between motor and language development in those with a diagnosis. In studies of typically developing infants and children, research has suggested that increasingly sophisticated locomotion produces more social referencing and joint attention, as well as more directed gestures and social bids towards others (Campos et al., 2000; Clearfield, Osborne, & Mullen, 2008; Clearfield, 2011; Karasik, Tamis-LeMonda, & Adolph, 2011; Tamis-LeMonda et al., 2008). Other studies have reported that the achievement of key motor milestones, such as unsupported sitting and walking, is related to better expressive vocabulary (Oudgenoeg-Paz, Volman, & Leseman, 2012; Walle & Campos, 2014), as is increasingly complex object manipulation (Lifter & Bloom, 1989). As children's language level increases with age, significant correlations with gross and fine motor skills continue to be reported (Alcock & Krawczyk, 2010; Cheng, Chen, Tsai, Chen, & Cherng, 2009; Wang, Lekhal, Aarø, & Schjølberg, 2012).

Despite this apparent coupling of language and motor development in early life and the atypicalities reported in language and motor skills in ASD, relatively few studies have considered the relationships between these two developing systems in the disorder. This may be due to the fact that ASD is generally diagnosed after the age of 2 (Charman & Baird, 2002), meaning that the early motor milestones have already been achieved and must therefore be reported retrospectively by parents (e.g., Gernsbacher, Sauer, Geye, Schweigert, & Goldsmith, 2008; Kim, 2008). An alternative approach to investigating the relationship between motor and language skills in ASD is by conducting prospective studies with the younger siblings of children with a diagnosis, who are at increased risk of developing ASD themselves (Constantino, Zhang, Frazier, Abbacchi, & Law, 2010; Ozonoff et al., 2011). This approach allows researchers to compare at-risk infants to infants with no family history of ASD (hereafter, "low-risk"), and to attempt to identify early markers of atypical development in those infants who go on to develop ASD (see Elsabbagh & Johnson, 2010). A number of prospective studies have identified early motor differences in at-risk infants compared to low-risk infants (e.g., Landa & Garrett-Mayer, 2006; LeBarton & Iverson, 2013; Leonard, Elsabbagh, & Hill, the BASIS team, 2013; Toth, Dawson, Meltzoff, Greenson, & Fein, 2007; see Bhat et al., 2011, for a review). Although few have directly assessed the relationship between early motor skills and language development, a study by Bhat, Galloway, and Landa (2012) suggested an association between motor delay at 3 months and communication delay at 18 months in at-risk infants. Furthermore, LeBarton and Iverson (2013) reported that fine motor skills (from a composite score of these skills between 12 and 24 months) significantly predicted expressive language outcomes in at-risk infants at 36 months. Given the range of motor difficulties and atypicalities now reported in ASD, as well as the studies that have been conducted in this area that suggest a link between motor and language skills in at-risk infants, a more detailed analysis of the relationship between early motor skills and language development is required.

The current paper addresses this issue, using statistical modelling to assess the relationship between developing motor skills and the rate of language development in a prospective study of infants at risk of developing ASD. This is the first study, to our knowledge, that presents an analysis of the *rate* of language development in relation to motor skill in a prospective design. This is an important distinction, as it allows an analysis of the impact of motor ability on the *development* of language, not merely the language outcome. Understanding the way in which a key skill develops over time in neurodevelopmental disorders is vital, as individuals may reach a particular outcome through a number of atypical developmental trajectories, and these alternative trajectories could provide vital insight into the language and communication difficulties in ASD (e.g., Karmiloff-Smith, 1998, 2009). The data presented here were collected as part of a larger prospective study of at-risk and low-risk infants. Specifically, the current paper focuses on data extracted from the Vineland Adaptive Behavior Scales (VABS-II; Sparrow, Cicchetti, & Balla, 2005), which is a parent report measure of communication, daily living, socialisation and motor skills, and from the Mullen Scales of Early Learning (MSEL; Mullen, 1995), which is a standardised assessment of motor, language and cognitive abilities. Data were collected at 7, 14, 24, and 36 months for both measures, and the participants were assessed for ASD at 36 months. In the current analyses, motor skills from the MSEL at 7 months were used to predict the *rate* of expressive and receptive language development (assessed by the VABS-II between 7 and 36 months), which was modelled using latent growth curve analysis. The age of 7 months was the earliest time point available within the current dataset, and was also considered likely to provide some variability in the motor skills developed by different infants. Milestones such as sitting without support and crawling are achieved by some infants around this age, while others take much longer to reach this developmental stage (World Health Organization, 2006). The rate of language development was assessed using the VABS-II, as we expected parents to notice more fine-grained changes in their child's language production (expressive language) and understanding (receptive language) during this time period than might be seen through standardised assessment in an unfamiliar setting (as measured by MSEL). Moreover, this measure assesses a number of aspects of language and does not focus purely on vocabulary. Finally, correlations between the different scales on the same standardised assessment would be expected, and thus any relationships across different measures (MSEL vs. VABS-II) may provide more insight into the behaviour observed than using the MSEL for both motor and language skills.

Due to the important role of language in the social communication and interaction difficulties in ASD, and the potential significance of motor skills as an early indicator of language delay, the current paper focuses on those at-risk infants who were classified as having ASD at 36 months. These infants were compared to both the low-risk group and those at-risk infants