



Does early object exploration support gesture and language development in extremely preterm infants and full-term infants?

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ABSTRACT

Background: An increasing body of research on typically and atypically developing infants has shown that motor skills play an important role in language development. To date, however, the role of specific object exploration skills for early gesture and vocabulary development has not been investigated in extremely low gestational age infants (ELGA, GA < 28 weeks), who are at greater risk for motor and language delays than full-term (FT) infants.

Purpose: This longitudinal study examined relations between 6-month active exploratory behaviors and 12-month word comprehension, gestures and vocal production, controlling for cognitive performance and neonatal condition (ELGA vs FT).

Methods: Forty infants, 20 ELGA and 20 FT, and their mothers participated in the study. Mother-infant play interaction was video-recorded at 6 and 12 months. Oral and manual object exploration at 6 months and spontaneous gestures and vocal production at 12 months were coded. Word comprehension was evaluated with the Italian version of the MacArthur-Bates CDI parent questionnaire at 12 months. Cognitive performance was examined with the Griffiths Mental Developmental Scales at 6 months and the Bayley-III Scales at 12 months.

Results: Regression analyses showed that after accounting for cognitive performance and neonatal condition, oral exploration was related to word comprehension, and manual exploration to gestures and vocal production in the overall sample.

Conclusions: Cascading effects of specific object exploration skills on gestures and language comprehension and production in preterm infants and FT infants are discussed. Clinical implications for early assessment of and interventions involving object exploration skills, which may affect language development, are considered for the preterm population.

1. Introduction

From neuroconstructivist and dynamic systems perspectives, language development is an experience-dependent process, resulting from complex interactions among multiple different abilities, including motor skills (D'Souza, D'Souza, & Karmiloff-Smith, 2017; Hockema & Smith, 2009). Along these lines, Iverson (2010) argued that the achievement of specific early motor skills, such as the acquisition of independent upright sitting, independent locomotion, and the ability to explore objects provides infants with

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opportunities to practice skills relevant for general communicative development and the acquisition of language. In recent years, empirical evidence for this theoretical view has been growing.

Much of the current literature has focused on relations between early gross motor attainments (e.g., sitting, walking) and communicative and linguistic abilities (e.g., gestures, vocalizations, receptive and expressive vocabulary; LeBarton & Iverson, 2016; Libertus & Violi, 2016; Oudgenoeg-Paz, Volman, & Leselman, 2012; Walle & Campos, 2014). By contrast, less attention has been paid to the relations between fine motor skills (e.g., object exploration) and communicative and language development, with a few studies suggesting that active object exploration plays a key role in language development both in typically developing (TD) children (Ruddy & Bornstein, 1982) and children with autism spectrum disorder (ASD) and other developmental delays (Hellendorn et al., 2015). These relations have been relatively unexplored in extremely low gestational age preterm infants (ELGA, GA < 28 weeks of gestation), who often show difficulties in communicative, linguistic and motor skills (Benassi et al., 2016; de Kievet, Piek, Aarnoudse-Moens, & Oosterlaan, 2009; Sansavini et al., 2014; Stolt, Makila et al., 2014; Stolt, Matomaki et al., 2014; Zuccarini et al., 2016, 2017). Two studies have found relations between active exploratory behaviors in the first year and global cognitive and linguistic skills at 2 years of age in preterm infants (Ruff, McCarton, Kurtzberg, & Vaughan, 1984; Zuccarini et al., 2017). However, developmental relations between active exploratory behaviors in the first year and early communicative-linguistic skills (word comprehension, gestures, vocal production) remain undocumented and poorly understood, both in preterm infants and TD infants. The present study intends to address this issue.

1.1. Motor development and communicative-language skills in typical and atypical development

A growing body of evidence has highlighted the existence of relations between early motor skills and communicative-linguistic abilities. The central claim of these studies was that changes in motor skills provide infants with opportunities for acting in the world, gathering information and learning (Gibson, 1988). According to this theoretical perspective, developing motor skills shape the dynamic interactions between infant and environment in the first years of life (Smith, 2005) and have cascading effects on a wide range of domains, including language (Iverson, 2010). Among early motor skills, specific gross motor milestones, such as unsupported sitting and walking, appear to play a critical role in communicative and linguistic development in TD infants (Libertus & Violi, 2016; Oudgenoeg-Paz et al., 2012; Walle & Campos, 2014) and in infants at risk for developmental disorders (e.g., for ASD; LeBarton & Iverson, 2016; West, Northrup, Leezenbaum, & Iverson, in press).

Research has also documented concurrent and predictive associations between global fine motor skills and language development. These relations have been observed in TD children (Houwen, Visser, van der Putten, & Vlaskamp, 2016), in children with intellectual disabilities (Houwen et al., 2016), developmental disorders (Hellendorn et al., 2015) or language impairments (Estil, Whiting, Sigmundsson, & Ingvaldsen, 2003; Hill, 2001; Iverson & Braddock, 2011; Leonard & Hill, 2014, and in infants at risk for ASD (LeBarton & Iverson, 2013).

Among early fine motor skills, active object exploration via mouthing and manipulating, has turned out to be particularly relevant for later development (Bornstein, Hahn, & Suwalsky, 2013). Active object exploratory behaviors allow infants to detect and extract a range of information about objects' features (such as shape, texture, weight) and functions (Baumgartner & Oakes, 2013; Lederman & Klatzky, 1993; Lobo, Kokkoni, de Campos, & Galloway, 2014; Ruff, 1984). Through early object exploration experiences, infants can create categories and build semantic representations of objects (Antonucci & Alt, 2011) that are foundations of complex functions such as cognition and language (Bornstein et al., 2013; Ruff et al., 1984). Long lasting effects of active exploration on psychological functioning in TD children (Bornstein et al., 2013) have been documented, confirming its pivotal role in development. Detecting objects' characteristics through active object exploration allows infants to gradually learn to perform actions with objects, combine actions, and relate objects functionally (Lockman, 2000). Evidence for this exploration-action pathway comes from work showing that delays in active object exploration were related to difficulties in constructing sequences of functional actions with objects in infants at HR for ASD and infants with ASD (Christensen et al., 2010; Landa, Holman, & Garrett-Mayer, 2007).

Despite this evidence, only few studies have examined the impact of active object exploration on communicative-linguistic development. Ruddy and Bornstein (1982) found positive correlations between active object exploration in the first year of life and expressive vocabulary at 12 months in TD infants. In addition, actions with objects were reported at the MB-CDI toward the end of the first year of life, before their corresponding gesture or word (Capirci, Contaldo, Caselli, & Volterra, 2005; Caselli, Rinaldi, Stefanini, & Volterra, 2012), and they predicted word comprehension at the end of the first year and word production at the end of the second year (Bavin et al., 2008; Sansavini et al., 2010). Similar results have been reported for atypical populations. For example, Hellendorn et al. (2015) showed that active object exploration and actions with objects were a mediator of relations between fine motor skills and receptive and expressive vocabulary in preschool children with ASD and other developmental delays. Moreover, production of functional actions with objects at 10 months was associated with word comprehension at 12 months and with word production at 24 and 36 months in infants at risk for ASD (Sparaci, Northrup, Capirci, & Iverson, 2018).

These findings demonstrate the existence of relations among active object exploration, functional actions with objects and language development; however, the relations between active object exploration, that precedes functional actions with objects, and early communication skills, i.e. gestures and receptive vocabulary, besides expressive vocabulary, have not been deeply investigated.

1.2. Motor development and communicative-language attainments in preterm infants

Several studies have shown that preterm birth is a risk factor for motor, communicative, and language delays (Sansavini, Guarini, Savini et al., 2011; Sansavini, Guarini, & Caselli, 2011) with a greater risk associated with very and extremely preterm birth (de

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