



## Visuo-manual coordination in preterm infants without neurological impairments



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### ABSTRACT

The extent of and reasons for visuo-manual coordination deficits in moderate and late preterm born infants without neurological impairments are not well known. This paper presents a longitudinal study on the visuo-manual development of twelve preterm infants, born after 33–36 weeks of gestation without neurological complications, between the ages of 6 and 12 months. Visuo-manual integration and grasping were assessed using the Peabody Developmental Motor Scales, along with bimanual coordination and handedness tests. Visual function was examined once prior to the beginning of the study. Gross motor development was also evaluated every month. Preterm infants were compared to a control group of ten full-term infants according to corrected age.

Compared to full-terms, the visual perception of preterm infants was close to normal, with only a measure of visual fixation lower than in full-terms. In contrast, preterm infants had delayed development of visuo-manual integration, grasping, bimanual coordination, and handedness even when compared using corrected age. Tonicity and gestational age at birth were the main variables associated to the delays. These results are discussed in terms of the possible factors underlying such delays. They need to be confirmed on a larger sample of preterm born children, and to be correlated with later development. This would allow developing markers of future neuropsychological impairments during childhood.

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### What this paper adds

- New insights on development of visual-manual development in preterm infants without severe neurological impairments.
- New insights in underlying mechanisms of delays in visual-manual development in preterm infants.
- New insight on development of handedness and bimanual coordination in relation to visual-manual development in preterm infants.
- New insight on relation of visual-manual development with visual development in preterm infants.

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## 1. Introduction

The World Health Organization (WHO) defines preterm infants as those born before 37 weeks of completed pregnancy. The risks of disabilities in adulthood increase with decreasing gestational age at birth. Infants born after 34–36 weeks of gestation (late preterm), and infants born after 32–34 weeks of gestation (moderate preterm), without major neurological complications such as intraventricular hemorrhage (IVH) grades III and IV, are often referred to as “healthy” preterm infants (Volpe, 2009; Moster, Lie, & Markestad, 2008). However, there is a growing body of cross-sectional and longitudinal research showing that even these preterm infants have poorer intellectual and neuropsychological performance than full-term children (Sansavini, Rizzardi, Alessandrini, & Giovanelli, 1996; Vicari, Caravale, Carlesimo, Casadei, & Allemand, 2004; Linnert et al., 2006; Baron, Ahronovich, Erickson, Gidley, & Litman, 2009a; Baron et al., 2009b; Sansavini et al., 2010, 2011, 2014; Caravale, Mirante, Vagnoni, & Vicari, 2012; Gonzalez-Gomez & Nazzi, 2012; Nepomnyaschy, Hegyi, Ostfeld, & Reichman, 2012). It is not known yet to what extent early visuo-manual delay could predict later neuropsychological deficits.

Visuo-manual coordination has been well studied in preterm infants free of severe neurological impairments, both as preschool and as school-age children (Luoma, Herrgard, Martikainen, & Ahonen, 1998; Baron et al., 2009a,b; Crowe, Deitz, Bennett, & TeKolste, 1988; Herrgard, Luoma, Tuppurainen, Karjalainen, & Martikainen, 1993; Foreman & Fielder, 1997; Goyen, Lui, & Woods, 1998; Caravale, Tozzi, Albino, & Vicari, 2004; Goyen et al., 2008; Schneider et al., 2008; Geldof, van Wassenaer, de Kieviet, Kok, & Oosterlaan, 2012). For instance, Baron, Erickson, Ahronovich, Baker, and Litma (2011) observed deficits in 3-year-old preterm infants on visual-spatial manual tasks (block construction, puzzle assembly), and executive functions, but not on pure dexterity (see also the study of Vicari et al., 2004, on 3 and 4-year-olds). Preterm infants have also been found to have significantly lower performance on paper-and-pencil components of the Visual-Motor Integration Test (Beery & Buktenica, 1997).

Much less studies on visuo-motor development of preterm infants free of severe neurological impairments have concerned preterm infants in the first or the first two years of life. One study used kinematics and showed some motor impairment during reaching in 6- to 7-month-old preterm born infants, who reached with lower mean and final velocities compared to full-term infants (Rönnqvist & Domellöf, 2006; Toledo & Tudella, 2008). Other studies have shown weaker motor skills in preterm infants (Pin, Eldridge, & Galea, 2010; Lundqvist-Persson, Lau, Nordin, Bona, & Sabel, 2012; Formiga & Linhares, 2011). O'Sullivan, Goubet, and Berthier (2012) found that the reaching development of 8-, 10-, and 12-month-old preterm infants were similar to those of their full-term peers after correction for gestational age at birth. Finally, other studies on infants and children have shown that preterm infant's handedness is less well established than that of full-terms (Fox, 1985; Rose & Feldman, 1987; Marlow, Roberts, & Cooke, 1989; Schafer, Lacadie, & Vohr, 2009; Soria-Pastor et al., 2009; Domellöf, Johansson, & Rönnqvist, 2011).

Some studies aimed at disentangling the influence of visual versus motor deficits that bear on visuo-motor impairment in preterm children. For instance, according to Teplin, Burchinal, Johnsonmartin, Humphry, and Kraybill (1991) and Goyen et al. (2008) preterm infants visuo-manual deficits are due more to a fine motor deficit than to low visual perception. However, there is still a need to understand how visual deficits and visuo-motor disabilities interact in preterm children. No studies on preterm infants free of severe neurological impairments have evaluated on the same infants visuo-manual and visual functions.

Whether the preterm infant has normal **visual function** is an important question to be investigated when considering its visuo-manual development. A number of studies on preterm infants in their first year of life have shown visual functions to be affected (Rose, 1983; Rose, Feldman, Wallace, & McCarton, 1989; Ricci et al., 2010; Romeo et al., 2012). While much attention has been given to ophthalmological problems after premature birth such as retinopathy of prematurity (ROP) (Mataftsi, Dimitrakos, & Adams, 2011), cerebral visual impairments (CVI) have also been reported in preterm children. CVI can be defined as deficient visual function (but not visual acuity) resulting from damage or malfunction of the retrogeniculate visual pathways (optic radiations, occipital, temporal, and parietal cortex) and may include deficits in central oculomotor control as well as in visual and spatial cognition (Dutton, 2014; Philip & Dutton, 2014). CVI is a prominent sequela of preterm birth, particularly in cases of extreme prematurity, but it is also associated to moderate prematurity (Dutton, 2014; Philip & Dutton, 2014). Although it is frequently associated with cerebral palsy and intellectual disability, it can also occur in isolation (Dutton, 2014; Cavézia et al., 2010). In addition to obvious CVI, some authors have also hypothesized that the development of visual function may be delayed in preterm children. For instance, in the first year of life, visual attention as assessed through fixation shifts (measured by tracking the direction and latency of saccadic eye movements in response to a peripheral target—black and white stripes) is less mature in preterm than in full-term infants (Ricci et al., 2010). In the same vein, preterm infants have a lesser proportion of smooth pursuit eye movements as tested by their tracking of a small happy face (Grönqvist, Brodd, & Rosander, 2011). Preterm infants require more exposure time to recognize a visual stimulus after familiarization (Rose, 1983), showing less visual recognition memory (Rose, Feldman, & Jankowski, 2001).

In summary, the extent of and reasons for visuo-manual coordination deficits in moderate and late preterm infants free of severe neurological impairments in early infancy remain open questions. Answering these questions might help identifying possible markers of later neuropsychological deficits, such as DCD and ADHD (Hemgren & Persson, 2007; Faabo Larsen, Hvas Mortensen, Martinussen, & Nybo Andersen, 2013), as well as other learning disabilities, reported in these children at school age. Thus, the goal of the present study was to investigate the development of visuo-manual coordination, bimanual coordination and handedness in preterm infants born after 33–36 weeks gestation between the postnatal ages of 6 and 12

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