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The effect of a short bout of practice on reaching behavior in late preterm infants at the onset of reaching: A randomized controlled trial

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ABSTRACT

The purpose of this study was to examine the effects of a short bout of practice on reaching behavior in late preterm infants at the onset of goal-directed reaching. The study was designed as a blind, three-arm parallel-group, randomized controlled, clinical trial. Thirty-six late preterm infants were recruited from a maternity hospital and allocated according to computer generated randomization into groups that received reaching practice based on either a blocked schedule, a serial schedule, or no practice. Practice consisted of a 4 min session of induced reaching using a toy in three activities guided by a physical therapist. The activities were elicited in separate blocks for the blocked practice group and in a pre-established order for the serial practice group. The control group stayed in the physical therapist's lap but was not stimulated to reach. The infants were assessed 3.3 ± 1.4 days after the onset of goal-directed reaching in three tests: pre-test (immediately before practice), post-test (immediately after practice), and retention test (24 h after post-test). During assessments, the infants were seated in a baby chair and a toy was presented at his/her midline within reaching distance for 2 min. Changes in the number of reaches, proportions of uni/bimanual reaches and kinematic parameters of reaching were main outcome measures. From pre- to post-test, the amount of reaches and bimanual reaches increased in the serial practice group, but the increase was not maintained in the retention test. Kinematic parameters were not affected by practice. Changes in the reaching behavior of late preterm infants can be triggered after the first few minutes of toy-oriented experience based on a serial practice schedule. These changes are not consolidated one day later.

1. Introduction

Infants are naturally interested in the world around them and are constantly discovering new ways to interact with it. As goal-directed reaching emerges, around 3–4 months of age (Thelen et al., 1993; von Hofsten, 1979), the possibilities for exploring the environment enlarges dramatically (Lobo & Galloway, 2013a). Hence, infants increasingly improve their ability

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to act upon and experience objects. This developmental path, however, may not always be typical for infants at risk for developmental delays, such as infants that are born preterm.

There is growing body of evidence that preterm infants show differences in comparison to typically developing infants in the amount of reaching and their organization. There are indications that preterm infants show different developmental patterns in proximal (e.g., the distribution of uni- and bimanual reaches) and distal control (e.g., the changes in hand opening) and reaching kinematics (e.g., movement velocity, movement units, etc.) (see Guimarães, Cunha, Soares, & Tudella, 2013, for a review). For example, relative to typically developing infants, preterm infants born at less than 33 weeks of gestational age show a delayed reaching onset (Fallang, Saugstad, & Hadders-Algra, 2003; Heathcock, Lobo, & Galloway, 2008) and perform less reaches and reaches with more nonfunctional hand postures (i.e., closed) once they acquire reaching (Heathcock et al., 2008). In addition, preterm infants with less than 32 weeks of gestation use more bimanual than unimanual reaches when reaching for moving objects at 8 months corrected age. This prevalence of bimanual reaching may be a strategy for maximizing reaching range and thus suggestive for preterm infants being less skilled reachers than full-term infants (Grönqvist, Strand Brodd, & von Hofsten, 2011). Yet, it is still unknown which proximal strategy preterm infants adopt to reach for stationary objects at or shortly after reaching onset. These infants also reach with less velocity and more movement units compared to full-term infants at 4–6 months corrected age. This may reflect a dysfunction in the ability to modulate the movement (Fallang et al., 2003; Fallang, Øien, Hellem, Saugstad, & Hadders-Algra, 2005). It is unclear yet how this kinematic control in preterm infants is characterized at or shortly after reaching onset.

Also the reaching in late preterm infants (i.e., born at 34–36 6/7 weeks of gestation) shows differences with full-terms. Although it is not known if reaching is delayed or less frequent compared to typically developing infants, they do show differences in the control of fingers and hand movements at 6 months corrected age by more often reaching with an open hand. Late preterm infants reach with lower velocities and spend more time decelerating their arm movement prior to contact with the object (Toledo, Soares, & Tudella, 2011; Toledo & Tudella, 2008). Again, at present, the organization of reaching at onset is unclear, but these differences relative to full-term infants might present a constraint for further learning and the acquisition of fine manipulative skills that may only become apparent in later years (Fallang et al., 2005). Hence, exploring early reaching interventions to minimize these constraints is evidently of relevance.

Interestingly, as far as we know, there is only one study that investigated the role of movement practice in an early preterm population (born $<$ 33 weeks of gestation; Heathcock et al., 2008), but none that examined practice in late preterm infants. Heathcock et al. (2008) found that after 4–8 weeks of daily practice of hand–toy interaction applied by parents and initiated before reaching onset, the preterm infants started reaching at the toy at younger age and showed enhanced quantity and quality of reaching, in particular for distal control (i.e., more reaches with open and a ventrally oriented hand) relative to untrained preterm infants. However, Heathcock et al. (2008) did not specify the nature of practice. Hence, we raise two questions. Does a short bout of practice (i.e., a few minutes) affect the reaching behavior of newly-reaching late preterm infants as well, and if so, are these changes dependent on the scheduling of practice?

Physical and occupational therapists often experience immediate changes in the motor behavior of preterm infants after only few minutes of social and sensori-motor stimulation (e.g., enticing infants with a toy). Nevertheless, research on effects of short motor practice in preterm infants to confirm these subjective observations are lacking. In full-term infants who just started reaching, it has been recently demonstrated that 4 min of practice produced an immediate increase in the number of reaches, enhanced proximal (more unimanual reaches) and distal control (more reaches with semi-open hand) and shorter and faster reaches compared to baseline measures (Cunha, Soares, Ferro, & Tudella, 2013; Cunha, Woollacott, & Tudella, 2013). Similar to findings in adults after motor practice in the order of magnitude of minutes (Karni et al., 1995), these immediate effects are likely granted by the plasticity of the infant brain (e.g., Kolb & Gibb, 2011; Mackey, Whitaker, & Bunge, 2012), although this has not been confirmed for motor behavior.

Practice is often scheduled in blocked (e.g., 111–222–333), random (e.g., 213–123–132) or serial (e.g., 123–123–123) sequences of similar movements or tasks (Schmidt & Wrisberg, 2008). In adults, random and serial schedules generate higher contextual interference than blocked schedule, that is, they disrupt the performance of an activity, but paradoxically results in better retention (Battig, 1979; Shea & Morgan, 1979; also see Magill & Hall, 1990, for a review). In children, studies are relatively scarce and the results ambiguous (e.g., Pigott & Shapiro, 1984; Ste-Marie, Clark, Findlay, & Latimer, 2004; Zetou, Michalopoulou, Giazitzi, & Kioumourtzoglou, 2007). However, some have argued that contrary to adults, in children, whose motor and cognitive abilities are still maturing (Bell & Wolfe, 2007; Zipp & Gentile, 2010), low contextual interference would be more advantageous for learning (Jarus & Goverover, 1999; Pigott & Shapiro, 1984). This is based on the idea that low contextual interference adds less extrinsic variability and, therefore, requires less effort to assemble suitable movement patterns (Zipp & Gentile, 2010) and to elaborate memory representations for the to-be-learned task (Battig, 1979; Magill & Hall, 1990) compared to higher contextual interference. In this sense, the learning of motor skills in young children and children with compromised memory processes seems to be favored by practice techniques that require less use of cognitive demands. As preterm infants can present difficulties in working memory and learning processes early in infancy (Gekoski, Fagen, & Pearlman, 1984; Heathcock, Bhat, Lobo, & Galloway, 2004; Jongbloed-Pereboom, Janssen, Steenbergen, & Nijhuis-van der Sanden, 2012) and later acquisition of motor skills may be related to such difficulties (Lobo & Galloway, 2013b; Steenbergen, van der Kamp, Verneau, Jongbloed-Pereboom, & Masters, 2010), contextual interference in the motor behavior of preterm infants is an issue that deserves research.

In this study, we investigated the role of late prematurity and contextual interference on early reaching behavior. Specifically, we assessed immediate and delayed (i.e., after 24 h) effects induced by few minutes of reaching practice under