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Toy-oriented changes in early arm movements II—Joint kinematics

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Abstract

Our recent work suggests that infants begin to change their hand and joint kinematics in the presence of a toy months before the onset of purposeful reaching. Moreover, these 'toy-oriented' changes in hand kinematics cluster into Early, Mid and Late phases. The purpose of the present study was to test hypotheses regarding toy-oriented changes in joint kinematics in the same infants.
Methods: Thirteen infants were observed every other week from 8 weeks up to the first week of reaching around 20 weeks. At each session, a high-speed motion analysis system recorded infants' arm movements with and without a toy present.
Results: *During the Early phase*, infants scaled down their movements. *In contrast, during the Mid phase* infants scaled up their movements and did not change the relationship between the shoulder and elbow for speed and smoothness-related variables. In addition, infants showed toy-oriented changes such as increase in shoulder flexion and adduction. *In the Late phase*, infants continued to produce toy-oriented changes in shoulder orientation, and increased shoulder excursion and speed relative to the elbow. Thus, the toy-oriented changes in hand kinematics in the Mid and Late phases [Bhat, A. N., & Galloway, J. C. (2006). Toy-oriented changes in early arm movements of young infants: Hand kinematics. *Infant Behavior and Development*, *29*(3), 358–372] more closely followed changes in shoulder kinematics. Lastly, results are discussed in terms of shoulder–elbow dissociations, speed–amplitude relationships, and the key role of spontaneous movements in the development of reaching.

Keywords: Infant; Motor development; Joint coordination; Reaching; Arm movement; Shoulder; Elbow

1. Introduction

The ability to reach for and contact objects typically emerges around 4–5 months of age (Thelen et al., 1993; von Hofsten, 1984). Throughout the period before reach onset, termed the 'prereaching period'[1] (von Hofsten, 1984; Zaal, Daigle, Gottlieb, & Thelen, 1999) infants move their arms with or without an object or other people present (Thelen, 1981). Understanding how purposeful reaching emerges from these early non-reaching arm movements represents a significant gap in both developmental psychology and the neuromotor sciences. This understanding is especially pertinent to the neurorehabilitation assessment and intervention in young infants born at risk for reaching-related coordination impairments such as those born preterm and with low birth weight (Fallang, Saugstad, Grogaard, & Hadders-Algra, 2003), with intrauterine drug exposure (Tronick, Fetters, Olson, & Chen, 2004), or with brachial plexus birth palsy (Pondaag, Malessy, van dijk, & Thomeer, 2004).

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[1] By 'prereaching period', we mean the postnatal months between birth and reach onset. In contrast, 'prereaching' has also been used to denote arm movements in the first 2 months (Trevarthen, 1990).

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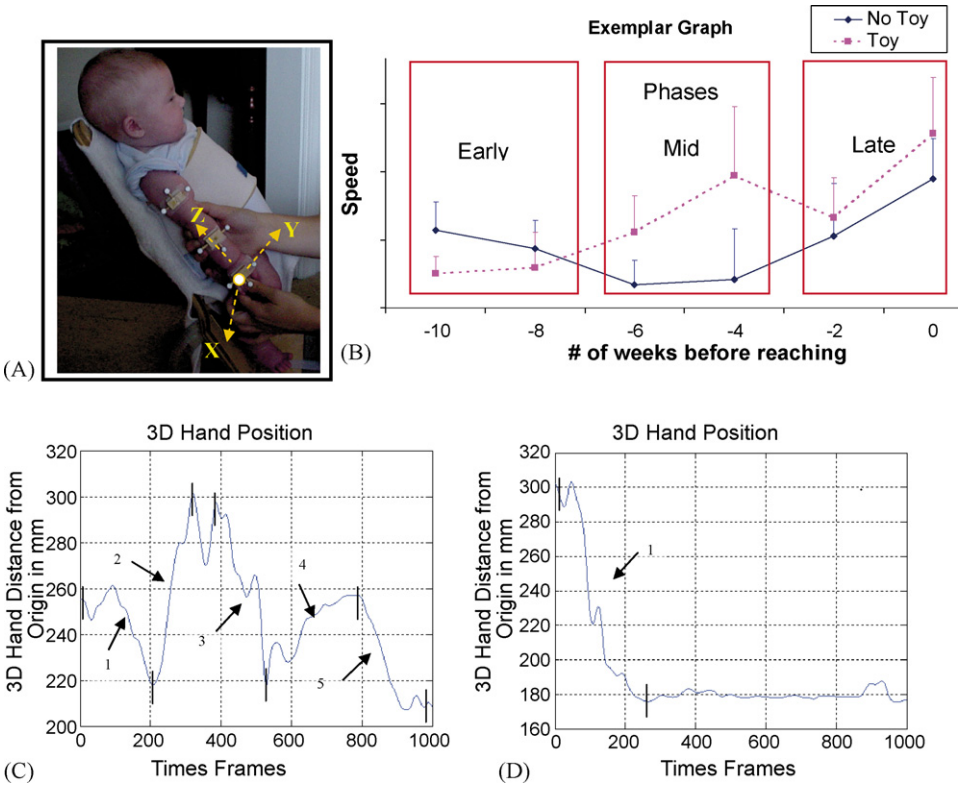

Fig. 1. Experimental set up and movement identification (C and D). (A) Shows an infant in the custom made chair with a schematic of shoulder, elbow, and hand kinematic model with the sign conventions for joint motions. (B) Shows how the Early, Mid and Late phases relate to the number of weeks before reach onset. (C and D) Shows the identification of separate movements from the ongoing prereaching arm motion.

What are the potential roles of these early arm movements in the development of reaching? Both neurobiological studies (Eyre, Miller, Clowry, Conway, & Watts, 2000; Eyre, Taylor, Villagra, Smith, & Miller, 2001; Martin, 2005; Martin, Choy, Pullman, & Meng, 2004) and behavioral studies (Kawai, Savelsbergh, & Wimmers, 1999; Lobo, Galloway, & Savelsbergh, 2004; Out, Savelsbergh, van Soest, & Hopkins, 1997; Out, van Soest, Savelsbergh, & Hopkins, 1998; Thelen, 1979; Thelen et al., 1993; Turvey & Fitzpatrick, 1993; von Hofsten, 1993) have suggested that infants gain important experiences through their early arm movements. The general thought being that infants learn to reach for and contact objects through the social, cognitive, perceptual, and motor benefits of moving their arms within the various physical and social contexts typical of their daily life. The initial emergence of reaching in turn impacts more global development as reflected in the influence of skilled reaching on an infant's future motor (Corbetta & Bojczyk, 2002; Goldfield, 1990), social (Fogel, Dedo, & McEwen, 1992; Fogel, Messsinger, Yale, Disckson, & Hsu, 1999), perceptual (Corbetta, Thelen, & Johnson, 2001; Eppler, 1995; Rochat, 1989), and cognitive development (Diedrich, Highlands, Spahr, Thelen, & Smith, 2001; Thelen, Schöner, Scheier, & Smith, 2001).

Our recent cross-sectional and longitudinal work has focused on understanding the details of how infants, during the prereaching period, move their arms when a toy is presented as compared to without a toy present, and how infants adapt these 'toy-oriented' changes over the weeks leading up to the first reach (Bhat & Galloway, 2006; Bhat, Heathcock, & Galloway, 2005; Galloway & Thelen, 2003). In terms of hand kinematics, our results suggested that infants produce complex, yet tractable toy-oriented changes many weeks before reaching (Bhat & Galloway, 2006). These changes clustered into three phases (Fig. 1B): Early phase (8–10 weeks before reaching), Mid phase (4–6 weeks before reaching) and the Late phase (within 3 weeks of reaching) (for details on phases see Bhat & Galloway, 2006). Interestingly, each phase had both toy-oriented changes that were unique to that phase, as well as changes that overlapped other phases. *The purpose of the present study was to test specific hypotheses regarding toy-oriented changes in joint kinematics in the same infants during the same three phases of the prereaching period.*