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Hand preference status and reach kinematics in infants

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ABSTRACT

Infants show age-related improvements in reach straightness and smoothness over the first years of life as well as a decrease in average movement speed. This period of changing kinematics overlaps the emergence of handedness. We examined whether infant hand preference status is related to the development of motor control in 53 infants ranging from 11 to 14 months old. Hand preference status was assessed from reaching to a set of 5 objects presented individually at the infant's midline; infants were classified into 'right preference' or 'no preference' groups. Three-dimensional (3-D) recordings were made of each arm for reaches under two distinct conditions: pick up a ball and fit it into the opening of a toy (*grasp-to-place task*) or pick up a Cheerio® and consume it (*grasp-to-eat task*). Contrary to expectations, there was no effect of hand preference status on reach smoothness or straightness for either task. On the grasp-to-eat task only, average speed of the *left* hand differed as a function of hand preference status. Infants in the no preference group exhibited higher left hand average speeds than infants in the right preference group. Our results suggest that while behavioral differences in the use of the two hands may be present in some infants, these differences do not appear to be systematically linked to biases in motor control of the arms early in development.

1. Introduction

Reaching in adults is characterized by two major movement patterns (Jeannerod, 1988). First, adult reaches are very *straight*. The straightness of the reach refers to the ratio of the path traveled by the hand over the distance between the hand and its target, with values closer to 1 indicating straighter movements. Second, adult reaches are very *smooth*. The smoothness of the reach refers to the number of peaks in the hand-speed profile, and similar to straightness, values closer to 1 indicate smoother movements. Adult reaches consist of a single acceleration and deceleration in hand speed, what von Hofsten (1979) termed a single 'movement unit'. Visually, a movement unit has a speed profile resembling a bell curve with a single rise and fall.

By contrast, infant reaches are typically comprised of a sequence of movement units, or multiple accelerations and decelerations in the hand speed profile. The hand path is also less straight. This pattern has largely been attributed to the protracted postnatal development of the cerebellum and corticospinal system, and to a lesser extent, the mechanical properties of the arm (for a discussion, see Berthier, 2011). Despite individual differences observed in infants studied longitudinally, many

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investigators who have quantified reaching using two-dimensional (2-D) and three-dimensional (3-D) motion analysis systems in infants have reported age-related improvements in reach straightness and smoothness over the first years of life as well as a decrease in average speed (Berthier & Keen, 2006; Corbetta & Thelen, 1996, 1999; Konczak & Dichgans, 1997; Konczak, Borutta, Topka, & Dichgans, 1995; Mathew & Cook, 1990; Rönnqvist & Domellöf, 2006; von Hofsten, 1979 but see Fetters & Todd, 1987).

In an effort to understand the origins of handedness, research has begun to explore left-right side differences in the kinematics of these infant arm movements, particularly for reach straightness and smoothness. Prior to and immediately following the onset of successful reaching at around 16 weeks of age, there are no detectable kinematic differences between the two arms (Lynch, Lee, Bhat, & Galloway, 2008; Souza, de Azevedo Neto, Tudella, & Teixeira, 2012). Kinematic arm differences seem to emerge once the infant has acquired some reaching experience. In a study that examined infants every two weeks from 20 to 32 weeks of age using 2-D recordings, the path of the right arm was straighter and had a shorter movement time compared to the path of the left arm (Morange-Majoux, Peze, & Bloch, 2000). In a study of 6-month-olds using 3-D recordings, Hopkins and Rönnqvist (2002) found that the right arm was smoother than the left arm. Rönnqvist and Domellöf (2006) reported that the right arm was smoother than the left arm in children assessed longitudinally at 6, 9, 12, and 36 months of age. The right hand also had a straighter hand path than the left hand at 9 and 12 months, but not at 36 months of age. At this last timepoint of 36 months, hand preference was assessed separately from reach kinematics and all children exhibited a right hand preference for throwing, drawing and hammering. These findings are of particular interest because the direction of asymmetry (favoring the right side) matches the group-level right hand preference observed in both adults (e.g., Annett, 1985, 2002) and infants (e.g., Fagard, 1998; Ferre, Babik, & Michel, 2010; Hinojosa, Sheu, & Michel, 2003; Jacobsohn, Rodrigues, Vasconcelos, Corbetta, & Barreiros, 2014; Ramsay, 1980).

A limitation of prior work is that infants' hand use preference has not consistently been measured separately from kinematic recordings. If developing hand preference and developing arm control are related, the classic kinematic approach may miss hand-by-hand-preference interactions. With respect to arm control in infants, motor development follows a proximodistal pattern such that control of the upper (proximal) arm develops before control of the (distal) hand (Berthier, Clifton, McCall, & Robin, 1999). Furthermore, the development of the corticospinal tract, which is responsible for reaching and grasping, is dependent on activity and experience (Martin, 2005). The development of hand preference could therefore be conceptualized in terms of experience as an accumulation of skill with one hand (preferred) over the other hand. In this view, the proposed developmental link between hand preference and motor control acquisition in infants is *experience*. Thus, infants with a hand preference should exhibit greater control of the preferred hand because the infant has more experience using that hand. Likewise, the hands should not differ in motor control for infants with no hand preference, who have presumably equal experience using both hands.

We measured hand preference in 11- to 14-month-old infants for reaching to 5 objects presented individually at the midline, and collected 3-D recordings from both arms on two separate reaching tasks. Following the naming convention of Flindall and Gonzalez (2013), infants reached to and picked up a ball to fit into the opening in a toy (*grasp-to-place task*) and reached to a cup and picked up a Cheerio® to consume it (*grasp-to-eat task*) on different trials. The testing range was chosen based on Touwen's (1976) observation that the pincer grasp develops between 11 and 14 months of age, and our own observations that the tasks were too difficult to be used reliably with younger infants. We hypothesized that the hands would differ systematically in infants exhibiting a hand preference at the time of testing, and that any differences would favor the preferred hand. We were particularly interested in the effect of hand preference on the reach properties of straightness and smoothness, for which left-right side differences have been previously reported in infants (Hopkins & Rönnqvist, 2002; Morange-Majoux et al., 2000; Rönnqvist & Domellöf, 2006). In addition, we examined biases in average speed with the hypothesis that lower average speeds would indicate more advanced motor control, given the developmental pattern for average speed (e.g., Berthier, 2011). Conversely, we predicted that the hands would not differ systematically for infants characterized as having no hand preference at the time of testing.

2. Method

2.1. Participants

53 healthy, full-term 11-month-old (15 males, 13 females, $M = 336 \pm 6.4$ days) and 14-month-old infants (10 males, 8 females, $M = 419 \pm 8.3$ days) participated in this study. Seven infants did not contribute useable kinematic data either due to fussiness or equipment error. Of the remaining 46, four infants were excluded on the basis of left hand preference status and therefore insufficient group size for analyses. By task type, data from 26 infants were analyzed for the grasp-to-place task and from 42 infants for the grasp-to-eat task. Infant names were acquired through public birth records or a commercial source. Parents first received a letter in the mail describing the study, and were later contacted by phone. A lab visit was scheduled within two weeks of the child's target monthly birthdate. All infants received a small gift as a token of our appreciation. The University of Massachusetts Amherst Institutional Review Board approved the following procedure.