Journal of Experimental Child Psychology 133 (2015) 57–71

Contents lists available at ScienceDirect

Journal of Experimental Child Psychology

journal homepage: www.elsevier.com/locate/jecp

Children's bilateral advantage for grasp-to-eat actions becomes unimanual by age 10 years

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ARTICLE INFO

Article history:
Received 8 October 2014
Revised 23 January 2015
Available online 10 March 2015

Keywords:
Kinematics
Development
Bimanual
Left-hand
Hand-to-mouth
Grip aperture

ABSTRACT

Studies have shown that infants tend to develop a lateralized hand preference for hand-to-mouth actions earlier than they do a preference for many other grasp-to-place or grasp-to-manipulate tasks, years even before direction of hand preference can be reliably determined. This observation has led to a series of studies contrasting the kinematics of grasp-to-eat and grasp-to-place actions in adults. These studies have described a robust kinematic asymmetry between left- and right-handed grasp-to-eat maximum grip apertures (MGAs) that has been interpreted as a right-hand advantage for feeding that may have led to right-handedness as observed on a global scale. The current study examines grasp-to-eat and grasp-to-place kinematics in two groups of typically developing children aged 7 to 12 years. It was found that the previously described task difference is present in both hands among younger children and that the effect does not become lateralized until the end of the first decade of life. Additional kinematics of both the dominant and non-dominant hands are described in detail to augment a growing catalogue of reach-to-grasp action descriptions for typically developing children. The maturation of the right-hand advantage for grasp-to-eat actions is discussed in terms of an inherent right-hand/left-hemisphere bias for such actions that may have influenced the development of population-level right-handedness in humans.

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http://dx.doi.org/10.1016/j.jecp.2015.01.011

Introduction

The hand-to-mouth movement is among the earliest developing goal-directed movements (Piaget & Cook, 1953). Fetuses demonstrate a right-hand preference for hand-to-mouth movements before birth (Hepper, McCartney, & Shannon, 1998), and infants as young as 1 year demonstrate a right-hand preference for self-feeding actions (Sacrey, Arnold, Whishaw, & Gonzalez, 2013). Although some have argued that degree of handedness is not fully stable until later years (Coren, Porac, & Duncan, 1981; McManus et al., 1988; Michel, Babik, Sheu, & Campbell, 2014; Rönnqvist & Domellöf, 2006), these observations regarding hand-to-mouth movements have led some researchers to posit that the direction of handedness is established during the pre- and perinatal periods (Levy, 1976). In fact, multiple studies have documented a lateralized hand preference for grasping in infants as young as 6 months (Claxton, Keen, & McCarty, 2003; Ferre, Babik, & Michel, 2010; Hopkins & Rönnqvist, 2002; Michel et al., 2014; Morange-Majoux, Peze, & Bloch, 2000; Nelson, Campbell, & Michel, 2013; Rönnqvist & Domellöf, 2006). They have shown that, when presented with a solitary object (most often a small plush toy), infants will more often prefer their right hands for unimanual grasps. Although this early development of right-hand preference for simple object acquisition has been reported by some researchers (Nelson et al., 2013; Rönnqvist & Domellöf, 2006), others have reported that hand preference for reach-to-grasp actions is not present (or at least not consistent) until much later in development (Fagard & Marks, 2000; Nelson et al., 2013; Sacrey et al., 2013). For instance, a right-hand preference for grasping rings to remove them from a column is not apparent until a child is 21 months old (Fagard & Marks, 2000), and a robust hand preference for other grasp-to-manipulate tasks does not appear until up to several months later (McManus et al., 1988; Sacrey et al., 2013; Vauclair & Imbault, 2009). Because the initial mechanical requirements of grasping actions are virtually identical (Karl & Whishaw, 2013), it must be the end goal (or action intent, i.e., what the child is going to do with the object after acquiring it) that dictates the difference in the two sets of findings.

Action intent has been shown to modulate kinematics of the reach-to-grasp actions in adults (Ansuini, Giosa, Turella, Altoè, & Castiello, 2008; Ansuini, Santello, Massaccesi, & Castiello, 2006; Armbrüster & Spijkers, 2006; Marteniuk, MacKenzie, Jeannerod, Athenes, & Dugas, 1987; Sartori, Straulino, & Castiello, 2011) and in young children (Chen, Keen, Rosander, & Von Hofsten, 2010; Claxton et al., 2003). These studies have focused primarily on the kinematics of the reach rather than those of the grasp, however, and have not investigated whether asymmetries exist between the hands. Given the preference for right-hand use during grasping actions, one might speculate that kinematic asymmetries favoring the right hand would be clearly observable. However, studies in adults have demonstrated that left-handed movements are carried out with the same precision, timing, and preparation as their (more common) right-handed equivalents (Grosskopf & Kuhtz-Buschbeck, 2006; Tretriluxana, Gordon, & Winstein, 2008). Perhaps a way to investigate kinematic differences in reach-to-grasp actions is to use an ecologically relevant task. The previous studies have used grasp-to-lift or grasp-to-place actions, which one might argue have little ecological relevance. Because the hand-to-mouth movement has been presented as a potential archetype for all grasps (Iwaniuk & Whishaw, 2000; Whishaw, Sarna, & Pellis, 1998), investigation into this movement may prove to be effective in revealing manual asymmetries.

Kinematic investigations on the hand-to-mouth movement are seldom performed (Castiello, 1997; Desmurget et al., 2014; Ferri, Campione, Dalla Volta, Gianelli, & Gentilucci, 2011; Flindall & Gonzalez, 2014). The few studies that have investigated the kinematics of hand-to-mouth/grasp-to-eat movements showed that adults produce smaller maximum grip apertures (MGAs) when grasping an item with intent to eat than when grasping the same item with intent to place (Ferri, Campione, Dalla Volta, Gianelli, & Gentilucci, 2010; Flindall & Gonzalez, 2013). This task-dependent behavior is limited to movements performed with the right hand; left-handed movements show no kinematic difference between grasp-to-eat and grasp-to-place actions (Flindall & Gonzalez, 2013, 2014; Flindall, Stone, & Gonzalez, 2015). Smaller MGAs for the grasp-to-eat task may be considered as a kinematic advantage for two reasons. First, larger MGAs have been described as a mechanism used to compensate for uncertainty regarding the size, location, or stability of a target (Berthier, Clifton, Gullapalli, McCall, & Robin, 1996; Flindall, 2012; Gentilucci, Toni, Chieffi, & Pavesi, 1994; Harvey et al., 2001; Jakobson