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Grip selection for sequential movements in children and adults with and without Developmental Coordination Disorder[☆]



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ABSTRACT

When generating a movement adults favor grasps which start the body in an uncomfortable position if they end in a comfortable position (the end-state-comfort effect). In contrast, children with Developmental Coordination Disorder (DCD) select grasps which require little initial hand rotation even though they result in an uncomfortable end position. The current study considered grip selection of individuals with DCD when asked to make simple one step movements and when making more complex multi-staged movements. Adults with DCD ($N = 17$, mean age 24:09, SD age = 52 months) and children with DCD ($N = 20$, mean age 9:00, SD age = 20 months) and age and gender matched controls rotated a disc so an arrow pointed toward a specific target(s). Task complexity was increased by increasing the number of targets from 1 to 3. Planning for end-state-comfort was seen in all groups albeit to a lesser extent in children versus adults. The children with DCD showed fewer grips for end-state-comfort compared to their peers and this was explained by a propensity to select minimal initial rotation grasps. This result was mirrored in adults with DCD but only for the longest movement sequence. These results suggest some changes in ability from childhood to adulthood in individuals with DCD.

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1. Introduction

Every action is composed of a string of movements, for example pouring water into a coffee cup consists of a number of sub-actions: reaching to grasp the kettle; lifting and moving the kettle; tipping the kettle to pour and; placing the kettle back down. The way in which the kettle is grasped and where the hand is placed needs to allow both lifting *and* pouring, if the kettle was grasped in such a way that meant lifting was impossible that grip would need to be re-assessed before continuing. One example of how grasps are selected is that adults will choose an uncomfortable start position if it means ending a movement in a comfortable end position. For example, if reaching to an upturned glass with the intention of righting it, adults will rotate the hand and grasp it with their elbow pointing upwards so that in turning the glass their hand and arm returns to a neutral position. This phenomenon is known as achieving end-state-comfort (Rosenbaum, 1980; Rosenbaum, Vaughan, Barnes, & Jorgensen, 1992).

The developmental trajectory of end-state-comfort has been investigated in typically developing children with mixed results. Manoel and Moreira (2005) asked children aged between 2.5 and 6 years to pick up a wooden bar and insert it into a hole in a box. In some conditions, the way in which the bar was grasped determined whether the movement could be completed comfortably. Results showed very little evidence of planning for end-state-comfort but instead indicated a possible preference for start-state-comfort (although the authors do concede that this could simply be a result of no motor planning). Similarly Adalbjornsson, Fischman and Rudisill (2008) found that as a group 6 year olds showed no consistent selection of grasp for end-state-comfort during a glass turning task. However, when considering each child individually, 25% did exhibit the end-state-comfort effect. In contrast, several studies have demonstrated group effects of end-state-comfort planning in children. For example, McCarty, Clifton, and Collard, (1999) found some evidence for end-state-comfort planning in 19 month-olds when they were asked to reach for and eat from a spoon. Smyth and Mason (1997) also found that children between the ages of 4 and 8 years showed some evidence of selecting grips for end-state-comfort when rotating a dowel 180°, however, this was still far from a fully developed skill (Smyth & Mason, 1997). These results, although mixed, suggest that planning for end-state-comfort is present in primary aged children but that this may be very task dependent.

A distinct group of children present with difficulties in the coordination of movement which cannot be accounted for in terms of an intellectual impairment or identifiable physical disorder, this condition has been termed Developmental Coordination Disorder (DCD; sometimes referred to as Dyspraxia in the UK). A recent UK population study found that approximately 2% of children have DCD (Lingam, Hunt, Golding, Jongmans, & Emond, 2009). Problems manifest in difficulties with fine motor tasks such as tracing, writing and fastening buttons, and/or in gross motor tasks such as jumping, hopping and catching a ball (Sugden & Wright, 1998), these difficulties effect all aspects of daily living. Children with DCD continue to exhibit problems throughout adolescence and do not simply grow out of their coordination problems (Losse et al., 1991). Despite an increasing number of studies focusing on DCD very little is known about the underlying cause of the movement problems (see Visser, 2003, for a review). However, a number of findings have highlighted poor motor planning (e.g., Schoemaker, Schellekens, Kalverboer, & Kooistra, 1994), which may be linked to a difficulty in predicting the outcome of action prior to execution (Maruff, Wilson, Trebillock, & Currie, 1999; Smits-Engelsman, Caeyenberghs, van Rood, & Swinnen, 2007; Williams, Thomas, Maruff, Butson, & Wilson, 2006). If a difficulty in movement planning is characteristic of DCD we may expect differences in the way in which these children select grasps and whether end-state comfort is achieved.

In addition to considering end-state-comfort in a typical group, Smyth and Mason (1997) also considered end-state-comfort in children with DCD. They found no differences in how often children with DCD selected grasps for end-state-comfort compared to their peers, suggesting that this ability is unaffected in DCD (Smyth & Mason, 1997). In a more recent study, van Swieten et al. (2010) also considered grip selection in children with DCD. They used an adapted version of the Smyth and Mason task and specifically looked at whether a minimal rotation of the hand prior to contact with the object was favored over finishing a movement in a comfortable position. In their set-up a child could either maximally rotate the hand at the start of a movement and finish in end-state-comfort or start a

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