Research in Developmental Disabilities 32 (2011) 246–252

Contents lists available at ScienceDirect

Research in Developmental Disabilities

# How do object size and rigidity affect reaching and grasping in infants with Down syndrome?

Ana Carolina de Campos [a,*], Kelly Regina Francisco [a], Geert J.P. Savelsbergh [b], Nelci Adriana Cicuto Ferreira Rocha [a,1]

[a] Department of Physiotherapy, Neuropediatrics Sector, Federal University of São Carlos (UFSCar), Brazil
[b] Research Institute MOVE, Faculty of Human Movement Sciences, VU University, Amsterdam, The Netherlands

ARTICLE INFO

Article history:
Received 16 September 2010
Accepted 27 September 2010

Keywords:
Down syndrome
Kinematic analysis
Reaching movements
Grasping
Object properties

ABSTRACT

Reaching and grasping skills have been described to emerge from a dynamic interaction between intrinsic and extrinsic factors. The purpose of the present study was to investigate the interaction between such an intrinsic factor, Down syndrome, and extrinsic factors, such as different object properties. Seven infants with Down syndrome and seven infants with typical development were assessed at the ages of 4, 5 and 6 months. The findings showed that object size influenced the kinematics of reaching for the infants with Down syndrome and the grasping frequency for the typical infants. The object rigidity was shown to have a major influence on grasping frequency.



## 1. Introduction

Learning to reach and grasp for objects is central for the development of perception, action, and memory. When infants touch and manipulate objects, they can learn about their physical properties, and use this knowledge to plan future actions (Corbetta & Snapp-Childs, 2009).

Reaching and grasping entail a fit between the infant's intrinsic properties (i.e. muscle strength, hand size, arm length) and the information available from the object (i.e. its location, size, shape, and texture). In other words, the infant must perceive the objects affordances and make adaptive adjustments in reaching trajectory such as regulation of the arm velocity and deceleration, and adjustments of the hand opening (Adolph, Eppler & Gibson, 1993; Gibson & Pick, 2000). As early as 4 months, typical infants successfully perform kinematic adjustments during reaching for objects with different sizes, which demonstrates information-action coupling (Rocha, Silva, & Tudella, 2006a; Savelsbergh & Van der Kamp, 2000).

The first phase of a reaching movement consists of initial displacement of the limb towards the target. During the next phase, adjustments or corrections are made in order to increase the movement accuracy. Thus, the nearer the arm is to the target at the end of the first phase, the more potentially accurate is the movement (Beggs & Howarth, 1972). Decreasing the target size seems to influence predominantly the second phase of the reaching, as evidenced by findings of increased deceleration time (Marteniuk, MacKenzie, Jeannerod, Athenes, & Dugas, 1987) and increased number of movement units (Gentilucci, Chieffi,

* Corresponding author at: Rua Capitão Alberto Mendes Junior, 269, CEP 13566-010, São Carlos, SP, Brazil. Tel.: +55 16 91158715.
E-mail address: campos.anacarol@gmail.com (A.C. de Campos).
[1] Academic address: Rodovia Washington Luís, km 235, Department of Physiotherapy, Neuropediatrics Sector, Federal University of São Carlos (UFSCar), Brazil.

0891-4222/$ – see front matter 
doi:10.1016/j.ridd.2010.09.023

Scarpa & Castiello, 1992; Rocha et al., 2006a). These findings suggest that increasing the task demand results in more corrections at the end of the trajectory.

Although several studies have investigated the influence of object size on reaching and grasping movements, few studies have examined the influence of object rigidity. Rochat (1987) has demonstrated that, from birth, infants haptically discriminate the rigidity of objects by generating different patterns of response. Nevertheless, another study has indicated that in 4-month-old infants the object rigidity affects the macroscopic aspects of the task, such as hand opening and grasping, while kinematics is not influenced by this property (Rocha, Silva, & Tudella, 2006b).

Since complex sensory-motor skills are involved in reaching for and grasping objects with different properties, difficulties in performing these tasks may arise in the presence of developmental disorders affecting the use of sensory information, such as the Down syndrome (DS). Accordingly, Polastri and Barela (2005) have suggested that infants with DS may require more time experiencing movements in order to acquire and refine motor skills. In these infants the ability to make anticipatory hand adjustments, as well as kinematic adjustments to object properties may be impaired, as described by Kearney and Gentile (2002) in children with DS aged 3 years. Similarly, there is evidence that children with DS aged 8–10 years fail to perform the appropriate adjustments during reaching (Charlton, Ihsen & Oxley, 1996).

Previous research has demonstrated that reaches performed by infants with DS may be similar to typical infants' when the task demand is low (de Campos, Rocha, & Savelsbergh, 2010). However, no study examined how these infants adjust their reaching movements to different object properties.

Miranda and Fantz (1973) have reported that 8-month-old infants with DS may have difficulties to discriminate objects form and contour when compared to typical infants. Additionally, at 9 months their exploratory behavior is described as less complex, i.e. infants with DS tend to look longer at toys and to engage less in task-specific actions than did typical infants (Mac Turk, Vietze, McCarthy, McQuiston, & Yarrow, 1985). It may be concluded that despite the lack of kinematic data the intrinsic property DS influenced the interaction with objects.

Understanding how infants with DS adapt to different task demands is relevant to elaborate therapeutic interventions. Therefore, the purpose of the present study was to investigate the interaction between such an intrinsic factor as Down syndrome and extrinsic factors such as different object sizes and rigidities in infants aged 4–6 months.

Since infants with DS may experience difficulties to use sensory information when planning their movements (Kearney & Gentile, 2002), we predicted that their reaching movements would be less adjusted to object properties. Thus, we expected that they show difficulties in grasping the objects when compared to typical infants.

## 2. Method

### 2.1. Participants

Seven typical-developing infants (TD) and seven infants with DS participated in this study. The infants from both groups were born with a mean gestational age of 39 weeks (SD = 1.35 weeks), an Apgar score of at least 9 after 5 min, and a mean weight of 3468.33 (SD = 400.94 g), appropriate for gestational age. The infants were evaluated longitudinally at the ages of 4, 5 and 6 months, always by the same examiner. The assessments were conducted on the infants' birth date, with a tolerance of plus or minus 7 days. The DS infants were diagnosed by cytogenetic analysis as having Trisomy-21 and all of them had been participating in an early intervention program since they were 2 months. The Human Research Ethics Committee of the University approved the study and informed consent was previously obtained from the infants' parents.

### 2.2. Materials and procedures

To observe reaching movements, the infant was placed in a baby chair reclined 50° from the horizontal. Pearl-like spherical markers (Carvalho, Tudella & Barros, 2005) were affixed to the infant's wrists (dorsal carpal region) (Out, Van Soest, Savelsbergh, & Hopkins, 1998). A 10-s interval was allowed for the infant to get used to the position. Four attractive spherical objects of distinct physical properties were used in this study: two soft (anti-allergic wool pompoms) and two rigid (polystyrene balls), which were small (5 cm in diameter) or large (12.5 cm in diameter) (Rocha et al., 2006a). The objects were presented in a randomized sequence, at infant's midline, shoulders height, and arms length. Each object was presented for a period of 1 min or until the infant had performed seven reaches (Rocha et al., 2006a). The infants remained in alert state throughout the experiment. If the infant was distressed, the assessment was interrupted and resumed on another date, within the tolerance interval.

Reaching movements were recorded by using a three-camera (60 Hz) motion capture system. One camera was positioned above and behind the chair. The other two were positioned in front of and diagonally to the chair, on the right and left sides (see for further information de Campos et al., 2010).

### 2.3. Analysis system

An image capture board picked up the images from the three cameras. Adobe Premier 6.3 software was used to obtain files in AVI format. These files were opened with the Dvideow 5.0 image analysis system (Barros, Brenzikofer, Leite, & Figueroa, 1999; Carvalho et al., 2005; Figueroa, Leite, & Barros, 2003). For example, to analyze the movement of the left arm,