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Postural responses to a moving room in children with and without developmental coordination disorder

Hyun Chae Chung [a,1], Thomas A. Stoffregen [b,*]

[a] Department of Physical Education, Kunsan National University, San 63 Myrong Dong, Gunsan City, Republic of Korea
[b] School of Kinesiology, University of Minnesota, 1900 University Ave. SE, Minneapolis, MN, USA

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ABSTRACT

Children (10 or 11 years old) with and without developmental coordination disorder (DCD) were exposed to imposed optic flow in a moving room. We manipulated the amplitude and frequency of oscillatory room motion, and we evaluated the coupling of standing body sway with room oscillations. The results revealed that standing sway of both children with and without DCD was influenced by room motion. However, children with DCD responded differently than children without DCD to specific combinations of room motion amplitude and frequency. We conclude that DCD can influence a child's use of imposed optic flow for postural control and that these effects are situation-specific rather than being systemic.

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1. Introduction

There is increasing interest among researchers in the perceptual and motor characteristics of children with developmental coordination disorder (DCD). One area of concentration has been the coupling of perception and action in the context of the control of standing posture.

Several studies have examined posture in the absence of external perturbations. These studies have shown that children with DCD tend to sway more than age-matched typically developing (TD) children, and have a reduced ability to maintain unusual standing postures. Geuze (2003) evaluated standing body sway with eyes open and closed. Using measures such as the range and area of COP displacements, Geuze found "only subtle differences" between DCD and TD children. Wann, Mon-Williams, and Rushton (1998) evaluated stance without external perturbation, with eyes open or closed. They found that during eye closure, children with DCD tended to sway more than age-matched TD children. Forseth and Sigmundsson (2003) measured the duration that 10-year-old children were able to maintain several unusual stances, such as stance on one foot, or on a balance beam. Stance duration was reduced for children with eye–hand coordination problems, relative to children without such problems.

In addition to evaluating unperturbed stance Wann et al. (1998) examined the body sway of children with and without DCD when presented with imposed optical perturbations. Optic flow was generated using a swinging room (Lee & Lishman, 1975). The room oscillated at 0.17 Hz at 4.4 cm, 8.8 cm, or 13.2 cm. Wann et al. measured only movement of the head, which they used as a surrogate for overall body sway. Wann et al. reported few differences between DCD and TD children when the room was in motion; however, they did not report inferential statistics, and so it is difficult to evaluate the significance of

* Corresponding author. Tel.: +1 612 626 1056; fax: +1 612 626 7700.
E-mail addresses: hcx0001@gmail.com (H.C. Chung), tas@umn.edu (T.A. Stoffregen).
[1] Tel.: +82 634694641.

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their findings. Wann et al. noted "as a group, the children with DCD did not exhibit a stronger response to room sway than their age-match peers" (p. 509).

The absence of consistent group differences between DCD and TD children may arise, in part, from aspects of the experimental method employed by Wann et al. (1998). The amplitude of room motion exceeded the amplitude of spontaneous (i.e., unperturbed) body sway (cf. Lee & Aronson, 1974; Schmuckler, 1997; Stoffregen, Schmuckler, & Gibson, 1987). The challenging nature of these unnaturally large motions is revealed in the finding that children sometimes stepped or staggered in response to room motion (cf. Lee & Aronson, 1974; Stoffregen et al., 1987). Results obtained with such stimuli may not generalize to the smaller amplitudes of motion that typify ordinary body sway. Another issue with the method is that trials were brief (16 s), with only 12 s of data being analyzed per trial. Such short exposures make it difficult for participants to establish stable coupling with stimulus motion (and for experimenters to compute coupling). Studies relating optic flow to stance in adults typically employ trial durations of 60 s or more (e.g., Dijkstra, Schöner, Giese, & Gielen, 1994; Freitas Junior & Barela, 2004; Oullier, Bardy, Stoffregen, & Bootsma, 2002; Prioli, Cardozo, Freitas Junior, & Barela, 2006; Stoffregen, 1985, 1986; Stoffregen, Hove, Schmit, & Bardy, 2006). Finally, Wann et al. measured only head movement, which they used as a surrogate for overall body sway. Research with adults typically features direct measurements of torso motion (e.g., Stoffregen et al.) or of the forces used to control stance (e.g., Wade, Lindquist, Taylor, & Treat-Jacobson, 1995).

Research with adults has sometimes included imposed optic flow that mimicked the amplitude and frequency of ordinary standing body sway (e.g., Dijkstra et al., 1994; Freitas Junior & Barela, 2004; Oullier et al., 2002; Prioli et al., 2006; Stoffregen, 1985, 1986; Stoffregen et al., 2006). In general, these studies have shown that adults exhibit stable, precise coupling of body sway with imposed optic flow when the imposed flow has frequency below approximately 0.4 Hz. In the present study, we used smaller amplitudes of room motion, which we co-varied with the frequency of room motion. These motions allowed us to compare TD and DCD children in terms of more subtle aspects of coupling between imposed optic flow and postural activity.

We exposed TD and DCD children to a room that oscillated along the line of sight. Across conditions, we varied the amplitude and frequency of room motion. The amplitudes and frequencies of room motion were within the ranges that commonly are observed in spontaneous (i.e., unperturbed) body sway. We computed several measures of coupling between room motion and body sway, and we predicted that coupling would be stronger among TD children than among children with DCD.

2. Method

The study protocol was approved by the Kunsan National University IRB. Participants or their parents gave informed consent for their participation.

2.1. Participants

Children were recruited from five elementary schools in Kunsan City, Republic of Korea. Children were screened using the M-ABC test (movement assessment battery for children; Henderson & Sugden, 1992), with the test administered in the school. Children scoring below the 5th percentile for total impairment were included in the DCD group. Age-matched TD children were selected from those scoring above 32nd percentile for total impairment. The DCD group comprised 10 children, and there were 10 children in the TD group. All children were 10 or 11 years old (mean = 10.7 ± 0.5 year). Descriptive data are provided in Table 1.

2.2. Apparatus

The experiment was conducted in a moving room (e.g. Lee & Lishman, 1975; Stoffregen, 1985), which was an enclosure, 1.3 m high, 1.2 m wide, and 1.8 m long, mounted on wheels that traveled along rails. The room was moved by an electronic servo-motor under computer control. The interior walls of the room were covered with a high-contrast pattern of black and white squares (2 cm).

Data on body sway were collected using a force plate (Kister, Piezo-Messtechnik 9281A11, Germany), which was sampled at 100 Hz.

2.3. Procedure

The force plate was positioned 0.6 m from the front wall of the moving room. In all conditions, participants were asked to stand still with their hands at their side and their feet on marked positions on the force plate. A picture of a cartoon character

Table 1
Demographic data and M-ABC scores.

	Gender	Age	Manual dexterity	Ball skill	Balance	Total impairment	Percentile
TD (n = 10)	F = 3, M = 6	10.9 ± 0.6	3.6 ± 4.6	1.5 ± 1.7	3.5 ± 2.8	7.2 ± 2.7	32.4 ± 17.5
DCD (n = 10)	F = 7, M = 4	10.4 ± 0.5	6.5 ± 3.3	6.4 ± 2.1	5.6 ± 3.2	18.6 ± 3.6	1.87 ± 0.8

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