LEARNING TO THINK BY LEARNING TO MOVE: Effects of Self-Produced Locomotion on Executive Functioning During Infancy

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Abstract

To test the effects of self-produced locomotion on executive functioning development, we randomly assigned five-month-old infants to either a locomotor or a non-locomotor condition. The locomotion was made possible by using a robotically-assisted device. At seven months of age, attention was measured on a variety of executive functioning tasks. The data were produced by an eye-tracking system.

Introduction

Executive functioning involves regulatory processes associated with cognitive flexibility, planning and initiation of voluntary actions, and inhibitory control (Diamond, 2000). Koziol and Lutz (2013) have suggested that the development of executive functioning depends on self-produced locomotion. While other studies have examined the link between self-guided locomotion and cognitive development, these studies tend to be limited by the use of a correlational design and are dependent on motor skills to assess cognition.

In order to avoid these issues, we randomly assigned 5-month-old non-crawling infants to a locomotor or non-locomotor condition. Participants came for 12 play sessions. In the locomotor condition, infants could locomote towards a toy using a robotic-controlled device; sessions were identical for the non-locomotor condition except that infants did not locomote. At seven months, following the 12 play sessions, participants watched a video consisting of five segments designed to analyze executive functioning skills. Two of these tasks are reported here - a Means-End Task and a Rule-Switching Task. The data were produced through an eye-tracking system from Applied Science Laboratories and GazeTracker software from Eye Response Technology, which recorded the eye gaze and pupil diameter during the tasks.

Hypothesis: Infants in the locomotor condition will show more surprise during the Means-End Task when there is an unexpected event. In the Rule-Switching Task the locomotor infants will show more anticipation than the non-locomotor infants when a puppet's location switches from left to right.

Methodology

Participants

45 infants

- 22 in the locomotor and 23 in the non-locomotor condition
- 19 female, 26 male; 90% Caucasian, 10% other

Procedure

- 12 sessions of locomotor or non-locomotor play starting at five months old
- **Means-End Task (Fig. 3):** Infants viewed a video where a block tower was positioned on a platform; as a screen was placed in front of the tower, they could see the platform move. In Condition 1, when the screen was removed, the tower was shifted to a new location (following the movement of the platform). In Condition 2, the tower remained in the same location (despite the platform moving). Pupil diameter was recorded as a measure of surprise.
- **Rule-Switching Task (Fig. 4):** Participants viewed a video where a puppet appeared on the right side of the screen for nine consecutive trials before switching to the left side of the screen. Before each trial, a visual cue was presented to guide the infants in the direction they were expected to look. With the use of the GazeTracker software, we measured anticipatory looks to either side. Scoring for the trials following the switch was determined as follows: +2 for a correct look, 0 for no looks, -1 for looks in both directions, and -2 for an incorrect look.

Results

For the Means-End Task, a non-parametric analysis (Related Samples Wilcoxon Signed Rank Test) showed that there was no change in pupil diameter from Condition 1 to Condition 2 for the non-locomotor group (M = 30.18 vs. M = 30.29); however, there was a significant difference for the locomotor group (M = 26.62 vs. M = 29.63), p = .022. For the Rule-Switching Task, an ANCOVA test (with gender and ethnicity as covariates) revealed that infants in the locomotor condition performed better on the task, compared to those in the non-locomotor condition (M = -.14 vs. M = -1.86), F (1,40) = 4.45, p = .041.

Condition	Rule-Switching Task Mean (SD)	Means-End Task Mean (SD)	
		Condition 1	Condition 2
Locomotor (Experimental)	-.14 (3.9)	26.62 (5.65)	29.63 (4.31)
Non-Locomotor (Control)	-1.86 (5.4)	30.18 (5.03)	30.29 (5.37)

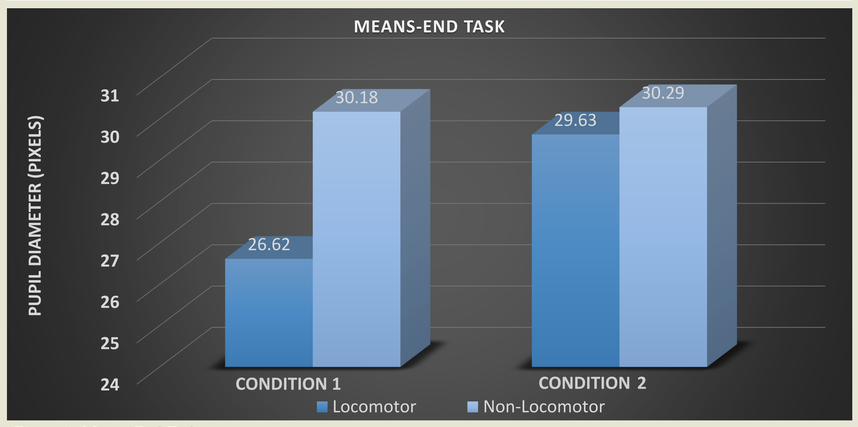

Figure 1. Means-End Task

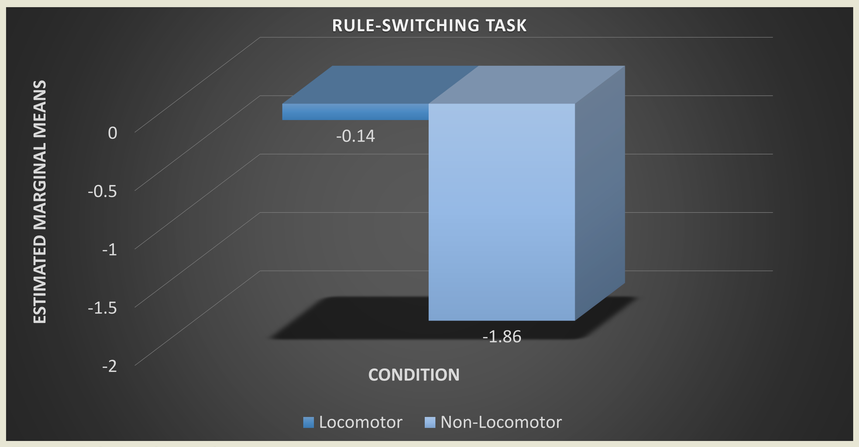

Figure 2. Rule-Switching Task

Figures

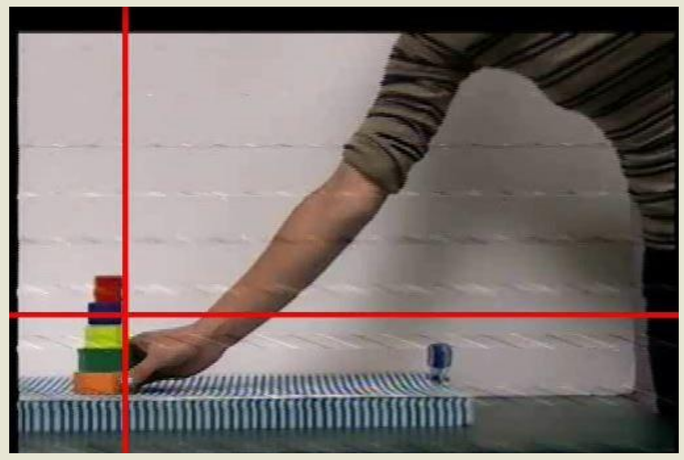

Figure 3. Means-End Task

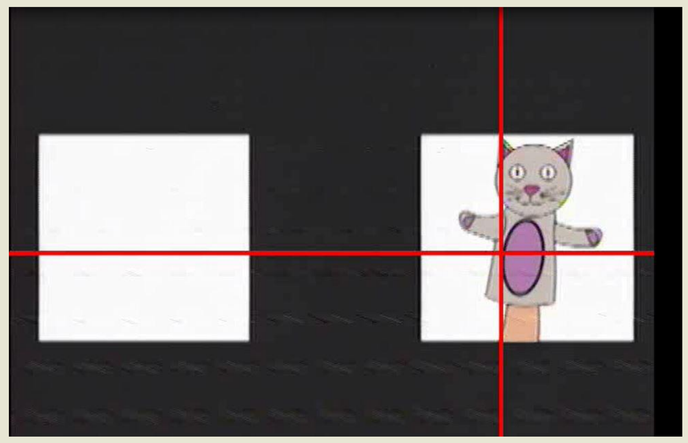

Figure 4. Rule-Switching Task

Figure 5. Control Sessions

Discussion

- Both hypotheses were supported by the data
- Infants in the locomotor condition performed better on the cognitive assessment tasks, suggesting higher levels of executive functioning than those in the non-locomotor group
- These results indicate a causal link between self-guided locomotion and the development of executive functioning skills
- These results support theories positing self-guided locomotion as a contributor to the development of executive functioning involving 1) switching from an established response to a new one and 2) anticipating an outcome
- A limitation of this research is the small number of participants
- Those working with children with impaired motor development could use these results to create an early intervention program in order to promote cognitive development, often delayed when there is a motor disorder present in infancy
- Further, the results of this study could change how we perceive the connection between movement and cognition

References

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