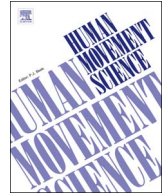




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Short Communication

Sex differences in the end-state comfort effect in pre-adolescent children

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ABSTRACT

There has been recent interest in the developmental trajectory of the end-state comfort effect (ESCE) in young children. However, potential sex differences have yet to be examined in the overturned glass task. We examined the ESCE using this task in a large sample ($N = 232$) of typically-developing elementary school children (111 girls, 121 boys) in grades 1–5 (approximately 7–11 years old). We sought to determine whether there were similarities or differences in performance between boys and girls. Children picked up an overturned drinking glass from a table, turned the glass upright, and then poured water into it from a measuring cup. Three trials were performed, and the use of an initial awkward thumb-down grip to pick up the glass was taken as evidence for the ESCE. There were non-significant main effects for sex and grade, but a significant interaction between factors. Boys increased in sensitivity to end-state comfort across the five grades while girls showed a decrease from grades 1–3, followed by an increase between grades 3 and 5. Taken together, the results indicate the presence of adult-like motor planning for the overturned glass task by the 4th grade (i.e., age 10), but also suggest the presence of a motor reorganization in girls, at around the 2nd or 3rd grade (i.e., 8 or 9 years of age).

1. Introduction

When interacting with objects in the environment, an array of movement options are available to reach for, grasp, and transport objects from one place to another. The preference to initially grasp an object using an awkward hand or arm position to end in a comfortable position has been coined the *end-state comfort effect* (ESCE, Rosenbaum et al., 1990). The ESCE has been studied for over two decades to investigate the relationship between cognitive and physical components of motor behavior (see Rosenbaum, Chapman, Weigelt, Weiss, and van der Wel (2012) for a review). Research overwhelmingly supports the presence of the ESCE in adults (Rosenbaum et al., 2012). However, the ESCE is generally not present in very young children. A systematic review by Wunsch, Henning, Aschersleben, and Weigelt (2013) identified 13 published studies on the ESCE in children from 1.5 to 14 years old. Nine studies assessed typically-developing children and 4 assessed the effect in children with various developmental disorders. Across all studies, three different tasks were used: (1) bar-transport tasks, (2) handle-rotation tasks, and (3) the overturned-glass task. Nine of

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the 13 studies reported the ESCE was present in typically-developing children, although substantial inconsistencies were found regarding age and type of task used; therefore, Wunsch et al. (2013) called for further research to assess the development of end-state comfort planning and how sensory-motor skills and cognitive factors may influence its developmental trajectory.

Since Wunsch et al. published their review in 2013, researchers have sought to further delineate the developmental course of the ESCE in children. The present study implemented the overturned-glass task, as it is a more natural task. Within this task, the ESCE is demonstrated when the overturned glass is reached for with an awkward pronated grip (thumb-down), followed by supination of the hand at the end of the movement, thus ensuring a comfortable thumb-up ending posture (Fischman, 1997). It is certainly possible to perform the task in the reverse order, but doing so would produce an awkward, uncomfortable ending posture that would make it more difficult to perform a subsequent task, such as filling the glass with water. It is important to note that previous work has demonstrated differences in motor planning abilities due to task selection. More specifically, Knudsen, Henning, Wunsch, Weigelt, and Aschersleben (2012) compared a neutral bar-transport task, to the more natural overturned glass task, and revealed young children (ages 3–5) were more proficient in the overturned glass task.

Wunsch and Weigelt (2016) recently proposed a three-stage model, using the overturned glass task to outline developmental changes in sensitivity to the ESCE. From this perspective, a child in Stage 1 will maintain a thumb-up grasp throughout the task. Stage 1 reflects the inability to anticipate movement consequences and the formation of action-effect associations are limited. With age and experience, action-effect associations begin to form, albeit slowly; therefore, children are increasingly able to anticipate future demands of the task as they progress into Stage 2. As a result, the ESCE is observed to a greater extent. Stage 3 is categorized by adult-like behavior indicated by the flexibility to modify behavior to meet the demands of the action-effect relationship; thus the ESCE is repeatedly observed (Wunsch & Weigelt, 2016).

To our knowledge, eight studies have examined children's performance on the overturned-glass task (Adalbjornsson, Fischman, & Rudisill, 2008; Jongbloed-Pereboom, Spruijt, Nijhuis-van der Sanden, & Steenbergen, 2016; Knudsen, Henning, Wunsch, Weigelt, & Aschersleben, 2012; Robinson & Fischman, 2013; Scharoun & Bryden, 2014, 2016; Scharoun, Gonzalez, Roy, & Bryden, in press; Wunsch, Weiss, Schack, & Weigelt, 2015). Although these studies have made significant contributions to our understanding of the developmental trajectory underlying the ESCE, the question of whether boys and girls perform similar or different has, to our knowledge, yet to be examined in this task.

In their assessment of typically developing children ages 3–10, Jongbloed-Pereboom and colleagues (Jongbloed-Pereboom, Nijhuis-van der Sanden, Saraber-Schiphorst, Crajé, & Steenbergen, 2013) assessed the ESCE using a sword transport task (Crajé, Aarts, Nijhuis-van der Sanden, & Steenbergen, 2010). Unexpectedly, findings revealed that girls exhibited the ESCE more often than boys. Results were attributed, in part, to differences in maturation of the prefrontal cortex, considering a report that girls (ages 5–17) performed better in measures of cognitive planning (Naglieri & Rojahn, 2001). Others (e.g., Halpem, 1997; Naglieri, 1999) also reported that girls typically outperform boys in tasks requiring frontal lobe function. Jongbloed-Pereboom, Nijhuis-van der Sanden, Saraber-Schiphorst, Crajé, and Steenbergen (2013) discussed environmental factors (Thomas & French, 1985; van Mier, 2006), sex differences in joint coordination (Piek, Gasson, Barrett, & Case, 2002) and joint mobility (Soucie et al., 2011) as other possible explanations for the proficiency displayed by girls; however, ultimately concluded that, “studies at school age on biological gender differences regarding fine manual dexterity are not available” (p. 303).

The purpose of our study was to further examine potential sex differences in the ESCE in the overturned-glass task in school-age children in grades 1–5 (approximately 7–11 years old). In consideration of recent work (Jongbloed-Pereboom et al., 2016; Knudsen et al., 2012; Stöckel & Hughes, 2015, 2016) that observed no difference in the ESCE in 7- to 10-year-old children and adults, we did not expect to see age-related differences. Building from the work of Jongbloed-Pereboom et al. (2013), we hypothesized that the ESCE would be more apparent in girls compared to boys. A secondary aim of this work was to examine hand selection tendencies in the overturned glass task. Recent work with young adults has suggested that the tendency to end in a comfortable end-state will override hand preference (Coelho, Studenka, & Rosenbaum, 2014); however, work with children has demonstrated hand preference influences motor planning skills, particularly left handers (Scharoun & Bryden, 2014). Considering the study set up, whereby the glass was placed at the participant's midline, we hypothesized that preferred hand selection would be displayed (Bryden, Mayer, & Roy, 2011).

2. Method

2.1. Participants and setting

School-age children (N = 232; 111 girls and 121 boys) enrolled in grades 1–5 (ages 7–11) with a mean age of 8.79 years \pm 1.49 participated in the study and attended a public elementary school in a small Southeastern U.S. city. In terms of participant demographics, 64% of the students were White and the remaining students were Black (24%), Asian (9%), and Hispanic (3%). Parental consent, children's assent, and approval from the Institutional Review Board for the Protection of Human Subjects were obtained prior to data collection. Data were collected during the children's Physical Education period in a quiet room within the gymnasium facilities.

2.2. Task, equipment, and procedures

Children were instructed to use one hand to pick up a clear drinking glass placed upside-down on a table, turn over the glass, and pour water from a plastic measuring cup into the glass (Fig. 1). The use of an awkward, thumb-down posture to grasp the glass was

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