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INTRODUCTION

Mind Your Body: the Essential Role of Body Movements in Children's Learning

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Abstract This special issue has its genesis in the recent establishment of the Early Start Research Institute at the University of Wollongong in Australia, which aims to transform lives of young people through high-quality early year education supported and informed by high-quality research and practice. The contributions to this special issue are based on a united approach to the brain and body, which holds that learning processes and body movements are inextricably bound. The mix of theoretical papers, intervention studies, and commentary in this issue indicate that part- and whole-body movements can positively affect children's learning performance, especially when movements are infused into the classroom and integrated into the learning task.

Keywords Embodied cognition · Human movement · Physical exercise · Learning · Young children

This special issue has its genesis in the establishment of the Early Start Research Institute at the University of Wollongong in Australia in 2015. The main goal of the $44-million Early Start project is to transform lives of young people through high-quality early year education supported and informed by high-quality research and practice. There is overwhelming world-wide evidence for substantive, positive long-term effects of early educational intervention on cognition, social-emotional development, academic achievement, and social behavior. The potential return to society on investments in early childhood education is high and more substantial than investments in later years of education (e.g., Barnett and Masse 2007). Substantial research also demonstrates that the effects of quality early childhood interventions reap the highest returns in disadvantaged communities (e.g., Heckman 2006; Heckman and

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Masterov 2007) but only for high-quality intervention programs that have support for the community with which they engage. Whereas well-designed programs can generate benefits 10 times greater than their costs, poorly designed programs may not generate a benefit at all (Barnett 2011; Barnett and Masse 2007).

The articles in this special issue consider the essential role that body movements can play in realizing high-quality education for young children. Numerous studies have shown that body movements can have substantive positive effects on children's cognition, learning, and academic achievement (for reviews and meta-analyses, see e.g., Bartholomew and Jowers 2011; Donnelly and Lambourne 2011; Fedewa and Ahn 2011; Erickson et al. 2015; Tomporowski et al. 2008). Based on their review study, Tomporowski et al. (2008) concluded that exercise is a simple, promising method for enhancing the aspects of children's mental functioning that are central to their cognitive development.

In the research literature, two distinct lines of research can be identified. The first line of research uses the theoretical framework of grounded or embodied cognition to study the effects of part-body movements, such as subtle gestures, on cognition and learning. The second line of research focuses on the effects of whole-body movements, in the form of physical activity or exercise, on health, cognition, and learning. Although both research lines focus on the effects of movement on cognition and learning to only recently, they have been working independently of each other. The embodied cognition researchers are mainly being interested in task-relevant part-body movements that are integrated into the learning task, while physical exercise researchers are mainly being interested in task-irrelevant whole-body movements that are not integrated into the learning task. One of the assumptions of the empirical contributions to this special issue is that integrating both research lines, by investigating task-relevant whole-body movements that are integrated into the learning task, can have additional benefits for children's learning.

Embodied cognition is based on the notion that cognitive processes develop from goal-directed interactions between organisms and their environment (Barsalou 2008; Glenberg 1997; Wilson 2002; see also Gallagher and Lindgren 2015; Hutto et al. 2015; Pouw et al. 2014). Evidence for the embodied cognition framework comes from studies showing that cognitive and sensorimotor processes are closely intertwined; while visual and motor processes in the brain are active during the performance of cognitive tasks such as reading and problem solving, semantic codes are activated during the performance of motor tasks. The positive effects of simple gestures on learning that have been found in domains as diverse as mathematics (e.g., Goldin-Meadow et al. 2009; Goldin-Meadow et al. 2001), language (e.g., Glenberg et al. 2011; Glenberg et al. 2004), and science (Ping and Goldin-Meadow 2008 2010) are explained by two mechanisms: enriched encoding and more efficient use of working memory subsystems. With regard to enriched encoding explanation, it is assumed that taking action in response to information, in addition to simply seeing or hearing it, can provide the memory with additional cues with which to represent and retrieve the acquired knowledge. With regard to the explanation of more efficient use of the limited capacity working memory, it is assumed that dividing the cognitive load imposed by a learning task across different working memory subsystems (i.e., visual, auditory, and motor) can prevent negative effects of too high load on one specific subsystem (Baddeley 1992, 2012). In addition, gestures can sometimes serve to offload working memory, thereby freeing up working memory resources that can be used to create deeper understanding (e.g., Glenberg and Robertson 1999; Goldin-Meadow et al. 2001). Using an evolutionary perspective, Paas and Sweller (2012) have argued that gesturing is a sensorimotor experience that may be a very old, well-developed skill (i.e., biologically primary knowledge) that is acquired easily and can be used with a minimal working memory load. One of its functions may be to reduce working memory load when dealing with biologically secondary knowledge such as learning mathematics and reading comprehension.

The underlying premise for the effects of whole-body physical exercise on cognition is that physical activity causes physiological changes, such as increased cerebral blood flow, increased oxygen levels to areas of the brain that support memory and learning (Hillman et al. 2008), and release of neurotrophins that enhance neuronal processes in the brain (e.g., Barenberg et al. 2011; see also Moreau 2015) which benefit cognitive performance, especially executive functions (e.g., Tomporowski et al. 2008). Based on a review of studies of physical activity on brain structure, brain function, and academic achievement, Erickson et al. (2015) concluded that fitter and more active children showed greater gray matter volume in the hippocampus and basal ganglia, greater white matter integrity, and increased and more effective brain activity patterns. In addition, the results of this review study indicated that children who are fitter perform better on tasks that require executive control and associative memory and show better cognitive performance and academic achievement. Diamond and Lee (2011) have argued that the core executive functions of cognitive flexibility, inhibition, and working memory are central to the skills it takes for children to be successful. Barenberg's et al. (2011) review of long- and short-term intervention studies on the effectiveness of physical activity on executive functions suggested that long-term interventions are beneficial for all executive functioning, whereas short-term interventions are particularly beneficial for inhibition tasks.

The multidisciplinary focus of the Early Start Research Institute (ESRI) extends across the areas of education, psychology, sociology, social work, health sciences, philosophy, arts, and creative arts. This special issue consists of a mix of theoretical papers and intervention studies across various learning domains, and a commentary. The three theoretical contributions to this special issue are reflective of the Early Start Initiative's variation across different research areas. The four empirical contributions are present interdisciplinary intervention studies covering the areas of educational psychology and health sciences, and integrate the research lines into the potential positive effects of part- and whole-body movements on learning and memory of children aged 4 to 11 years. Interestingly, three of these intervention studies investigated the effects of whole-body movements that were infused into the classroom and integrated into a normal classroom learning task.

The following sections outline the theoretical papers, intervention studies, and commentary, and introduce each article.

Theoretical Papers

Hutto et al. (2015) describe how their radical embodied and enactive approach to cognition has made a substantial contribution to understanding skill acquisition in the domain of sports. Using mathematics as an example, they argue that this contribution can be extended into learning of knowledge-rich STEM (science, technology, engineering, and mathematics) domains. In addition, the authors present empirical studies demonstrating how the radical embodied and enactive approach can contribute to the roots of STEM learning, inform instructional design, and has the potential to drive educational psychology research in promising new directions.

Investigating different styles of instruction in reading, Gallagher and Lindgren (2015) focused on the learning advantages of employing enacting metaphors (i.e., physically playing out the metaphor) rather than relying on consuming sitting metaphors (metaphors that sit on a page and require reading only). The authors link enactive metaphors as a form of embodied cognition and trace their effectiveness throughout recent empirical studies. The authors argue for approaches to learning with young people that emphasize whole-body engagement in a manner that regularly employs enacting metaphors. Interestingly, the authors argue that the benefits of enactive participation or a natural embodiment with the world has learning benefits from as young as 18 months of age. The authors argue for a natural embodied stance to learning in the world rather than mere passive observation. This stance insists that education that regularly embodies cognition and movements places the learner naturally "in the world" rather than being a mere spectator. The authors cite extensive research to support their position throughout the learning curriculum and from varying ages of learners.

The Novack and Goldin-Meadow (2015) paper from the internationally renowned Goldin-Meadow's Laboratory at the University of Chicago examines the simple power of gesture in learning and cognitive development. The authors argue that gestures can be easily and regularly employed into various educational settings even in traditionally symbolic fields such as mathematics that can significantly benefit in complex mathematics for very young children. As with Gallagher and Lindgren (2015), Novack and Goldin-Meadow (2015) cite a wide array of studies that reinforce empirically the long lasting effects of integrating gestures into education.

Intervention Studies

Mavilidi et al. (2015) investigated both the potential learning benefits of part-body movements (gestures) and (whole movements light rigorous exercise) using preschool Australian children (3–5 years old) learning a new language (Italian). Using a four-group randomized controlled study and a very tightly controlled design, the children had to learn 14 Italian words in a 4-week teaching program. Results showed that while all preschool students found learning new words difficult, more positive learning benefits were found by enacting with both physical exercise or gestures. There were two unique findings of their study. One was that physical exercise had larger effects when integrated into the learning task rather than separated. Second, the positive effect of gesturing was confirmed in the language learning domain with preschool students.

Agostinho et al. (2015) combined emerging mobile technologies and gesturing research to investigate the effects of finger tracing onto tablet devices with primary aged children (8–11 years old). Using the temperature learning materials, the authors compared students that studied materials with those that included a simple gesturing "finger tracing" component. The tracing group outperformed the control group most notably on transfer tasks, suggesting that embodying cognition tasks may have a degree of transferability beyond the original learning materials.

Toumpaniari et al. (2015) addressed one of the most current central questions of the Early Start Research Institute namely empirically investigating the positivity effects of embodied cognitive techniques and physical exercise with preschool-age children. In the similar approach to Mavilidi et al. (2015), the authors investigated the combined effects on both physical exercise and gesturing on learning. Using 4-year-old children learning lists of animals, they compared groups with various layers of gesturing and physical exercise integrated in the learning task. Over 4 weeks, the groups were compared. As in the Mavilidi et al. study (2015), this study demonstrated both gesturing and integrated physical activity-aided learning over simply studying instructions. It was also noted that combining gesturing and integrated physical body movement was a more powerful learning design than simply employing gesturing only. Both the research of Mavilidi and colleagues (2015) and Toumpaniari and colleagues (2015) demonstrate the considerable benefit of employing part- or whole-body approaches to learning from the earliest years of life.

Ruiter et al. (2015) examined the effects of task-related body movements and mirror-based self-observation of these movements on 118 first graders' (around 6 years of age) learning of two-digit numbers. Body movements can be employed into teaching two digits by employing a combination of big, medium, and small steps. For example, the number 30 would be simply translated into three big steps. Results clearly demonstrated that employing body movements can be highly beneficial for basic mathematical achievement as compared to simply studying instruction. Ruiter and colleagues (2015) also found that mirror-based self-observation of the learning task did not affect test performance.

Commentary

Moreau's (2015) work is based on the elementary and fundamental notion that the learning brain benefits greatly benefits from exercise. The author notes that brain development can be considerably enhanced by coupling cognitive stimulations with physical activities during various aspects and stages of learning. The author notes the high plasticity of brain function, especially in the younger years, and how physical activities can be employed to establish enhanced cognitive and brain function. The author notes the direct and obvious benefits to overall health and longevity. The author notes that physical activity has traditionally been isolated to an exercise for exercise sake (physical benefits). The author proposes there may be far more cognitive developments that are still to be unlocked.

In conclusion, this special issue reports on the simple and wide-reaching benefits of employing part- and whole-body movement can have in cognitive development and learning. As the papers of this special issue show, gesturing or whole-body intervention can be employed quite subtly in education yet impact learning quite powerfully. And even more critically, such interventions yield big rewards if employed in the early years of a child's life.

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