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Variable training does not lead to better motor learning compared to repetitive training in children with and without DCD when exposed to active video games

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ABSTRACT

Background: Little is known about the influence of practice schedules on motor learning and skills transfer in children with and without developmental coordination disorder (DCD). Understanding how practice schedules affect motor learning is necessary for motor skills development and rehabilitation.
Aims: The study investigated whether active video games (exergames) training delivered under variable practice led to better learning and transfer than repetitive practice.
Methods and procedures: 111 children aged 6–10 years (M = 8.0, SD = 1.0) with no active exergaming experience were randomized to receive exergames training delivered under variable (Variable Game Group (VGG), n = 56) or repetitive practice schedule (Repetitive Game Group (RGG), n = 55). Half the participants were identified as DCD using the *DSM-5* criteria, while the rest were typically developing (TD), age-matched children. Both groups participated in two 20 min sessions per week for 5 weeks.
Outcomes and results: Both participant groups (TD and DCD) improved equally well on game performance. There was no significant difference in positive transfer to balance tasks between practice schedules (Repetitive and Variable) and participant groups (TD and DCD).
Conclusions and implications: Children with and without DCD learn balance skills quite well when exposed to exergames. Gains in learning and transfer are similar regardless of the form of practice schedule employed.
What this paper adds: This is the first paper to compare the effect of practice schedules on learning in children with DCD and those with typical development. No differences in motor learning were found between repetitive and variable practice schedules. When children with and without DCD spend the same amount of time on exergames, they do not show any differences in acquisition of motor skills. Transfer of motor skills is similar in children with and without DCD regardless of differences in practice schedules.

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1. Introduction

Despite the wealth of research on differences in motor behavior and its underlying processes between typically developing (TD) children and those with Developmental Coordination Disorder (DCD), little is known about practice conditions that facilitate efficient motor skill training, and about factors that influence the course of motor learning (Wilson, Ruddock, Smits-Engelsman, Polatajko, & Blank, 2013). There is no doubt that children with DCD are able to learn new motor skills or improve upon existing ones when given adequate training (Miyahara, Hillier, Pridham, Nakagawa, & Miyahara, 2014; Zwicker, Missiuna, Harris, & Boyd, 2012). However, investigations of how to effectively manipulate practice conditions to create optimal learning experience are still lacking.

Motor learning refers to the processes that allow individuals to acquire new motor skills and to adjust their movements to changes of the physics of the body and the world (Kroemer, Burrasch, & Hellrung, 2016). Though there is a general consensus that motor learning leads to improvement in motor skills beyond baseline levels, these improvements are not seen as indication of learning (Shmuelof, Krakauer, & Mazzoni, 2012). Rather, improvements observed in retention of acquired skills over time and transfer (ability to apply acquired skills in novel situations) are used as key determinants of motor learning in human subjects (Shea & Morgan, 1979). Also, motor learning is described as a set of internal unobservable processes that occur with practice or experience resulting in permanent changes in movement capacity (Schmidt & Lee, 2011). Acquisition of skilled movements is influenced by various factors such as attention focus, type and frequency of feedback, amount of practice and practice schedules (Wulf, Shea, & Lewthwaite, 2010).

Practice schedules refer to the ways practice and/or training sessions are designed and structured to optimize learning outcomes (Muratori, Lamberg, Quinn, & Duff, 2013; Vera, 2008). Generally, two forms of practice schedules are described in the motor learning literature: repetitive (or constant) and variable practice (Shea, Kohl, & Indermill, 1990). Repetitive practice is the continuous repetition of one skill during an episode of training, whereas variable practice involves the execution of a wider variation of skills (Lage et al., 2015). It is now known that training the task to be learned repetitively (constant practice) leads to improved practice performance but results in poor retention and transfer (Battig, 1966; Shea & Morgan, 1979). The advantage of repetitive practice may be that performing many repetitions leads to automatization of that skill, and enables temporal and spatial adaptations of this specific skill (For example, the skill improves in speed, accuracy, stability and fluency). Nonetheless, variable practice leads to increased retention and transfer (Lee & Magill, 1983; Muratori et al., 2013; Schmidt & Lee, 1988; Shea & Morgan, 1979) and is widely regarded as superior to repetitive practice in terms of enhancing skill learning.

The idea that motor learning benefits more from practicing tasks in a variable rather than repetitive practice context is known as contextual interference (CI) effect (Feghhi, Abdoli, & Valizadeh, 2011; Magill, 2004; Shea & Kohl, 1990). From a neurocognitive perspective, sensorimotor learning involves learning new mappings between motor and sensory variables. Such mappings are termed internal models, as they represent features of the body and the environment. When we learn new movements, we must be able to link them to appropriate contextual cues such as objects, tasks or environments (Wolpert, Diedrichsen, & Flanagan, 2011). For example, expert video game players develop an extraordinary ability to extract information and spread their attention over a wide spatial frame without any apparent decrease in performance (Green & Bavelier, 2003).

One of the prominent hypothesis for the poor motor control in DCD concerns deficit in the internal modeling of movements (Wilson et al., 2013). According to this hypothesis, children with DCD have significant limitations in their ability to accurately generate and utilize internal models of motor planning and control. Since learning is strongly determined by the neural representations and influences how learning generalizes to novel situations, deficits in internal representations will not only hamper skill acquisition but also transfer of motor learning. As an example; when playing a new or untrained computer game on a balance board, after playing many other active computer games during 5 weeks, the relevant inputs stay comparable (the moving and stationary images on the screen) and the task relevant output will be similar, namely rapid weight shifts. It is hypothesized that by playing many different games (variable training), the child extracts general rules for how to control the coveting parameters for different games (Braun, Aertsen, Wolpert, & Mehring, 2009). What differs between the various computer games are the parameters of inputs and outputs, such as the path through which the children have to steer round the obstacles that have to be avoided, and the amount and timing of the weight shifts. Given these comparable task constraints, we can expect transfer of learning, which can be evaluated by the more rapid learning of other comparable tasks. On the other hand, if the child plays one game over and over again, it will become better at that game. However this creates relatively less contextual interference during training because it involves executing the same motor task repeatedly. The child playing many different but comparable games, may also have improved performance on the games played, but will likewise have learned the basic structure of a balance steered computer game and transfer. By playing multiple motor tasks, contextual interference (CI) effect is assumed to create relatively high interference throughout practice because of the rapid changes in task demands from game to game (Shea & Morgan, 1979). In short, it is expected that high levels of CI (variable practice) would result in poorer performance but increased retention and transfer compared to low levels of CI. This is because during acquisition stage of learning, variable practice creates opportunities for more effortful cognitive processing (Lin, Sullivan, Wu, Kantak, & Winstein, 2007) and structural learning (Braun et al., 2009). Previous motor learning research in children with DCD focused on a Serial Reaction Time paradigm (Gheysen, Van Waelvelde, & Fias, 2011; Lejeune, Catale, Willems, & Meulemans, 2013; Wilson, Maruff, & Lum, 2003). To date, no study has examined the impact of practice schedule manipulation in children with DCD. Recent studies have introduced active video games (exergames) in children