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# The Relation between Motor Learning and Executive Function in Kindergarten Children

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## Abstract

The term motor learning refers to a series of processes that lead to relative and permanent changes in the capability for skilled movement. This change happens as a result of motor learning processes that incorporate cognitive aspects. Effective motor lead to the formation of procedural memory (memory for skills and habits).

The term executive functions relates to cognitive processes that are needed in order to complete a task which includes complexity and innovation (Hughes & Graham, 2002) i.e. one that is unfamiliar and challenging. These processes are the foundation for goal oriented behavior which is managed by the cerebral cortex in the frontal lobe.

Research literature has pointed to a neurological link between executive functions and motor learning, whereby executive functions play a significant role in learning new skills in what is known as the fast learning phase, characterized as learning through trial and error. (Brookman, McDonald & Bishop, 2014; Cameron et al., 2012)

To objectives of the current study were two-folded. The first objective was to examine motor learning processes and long term memory formation among typically developping kindergarten-age children at intervals of 2 hours and 4 hours after training. Recent studies on the subject have demonstrated the occurrence of long term memory consolidation within 24 hours of training, whereas children ages 9-12 showed improved performance within few hours of training (Ashtamker & Karni, 2013). We hypothesized that the consolidation of procedural memory would also occur in younger children within two and four hours of training.

The second objective was to examine the relationship between executive functions and motor learning among kindergarten-aged children. Previous studies on motor

learning have pointed to a link between the executive functions and improvements in the fast learning phase, characterized by trial and error (Doyon & Benali, 2005).

The study employed a graphomotor task, appropriate for the participants' age, in which participants were asked to repeatedly connect three dots with line to draw a simple shape, which was an "invented" letter, termed Boomerang. The study group was comprised of forty children from six public kindergartens in Israel's center region, who performed a series of tests, among them the executive functions test. Participants were divided into two groups, each of which trained in the graphomotor task, the Boomerang task, on which they were tested two hours or four hours after training and two weeks later. The execution of the Boomerang shape created by participants was evaluated at the block level (12 during training, 4 after two or four hours, 4 more two weeks after training) for speed and accuracy, which are measures of the quality of procedural memory. Assessment was made collected at four time intervals: at the start of training, at the end of training, two/four hours after training and two weeks after training.

Our results show that both groups demonstrated the expected motor learning phases, i.e. improvement in the speed of performance during training and additional improvements during the memory consolidation phase, which remained two weeks later without changes to the level of performance. Moreover, no significant differences were observed between the two groups – the group tested two hours after training and the group tested four hours after training.

In addition, the results point to a correlation between the performance speed and accuracy in motor tasks at the start of training and performance accuracy in tasks that

tested executive functions, confirming the study's hypothesis. However, unexpectedly, this correlation was also found two weeks after training, which seems to indicate difficulties in retrival over time at this age.

Our conclusion is that graphomotor training leads to improvement in the speed of performance in kindergarten-aged children as little as two hours after training. Our findings support the practical implementation of an efficient test, using short time intervals, of the memory consolidation process. Moreover, our study enhances the results of previous studies by demonstrating robust procedural learning of age-appropriate tasks among kindergarten-aged children.