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**The Relation between Motor Learning and
Executive Function in Children with Language Impairment**

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Abstract

Children with specific language impairment present significant deficits in language abilities. The population in question is heterogeneous in that the characteristics, severity and causes of impairment vary widely. It is estimated that around 7% of kindergarten children are affected by specific language impairment. It would seem that impairment goes beyond language, and a significant proportion of the same children have a tendency towards slower motor function. Studies have pointed to a deficit in procedural memory as a cause in some cases. The procedural memory system is involved in acquiring both language and motor skills, which would explain why children with specific language impairment also find it difficult to acquire motor skills.

The term "motor skill learning" denotes a series of processes that bring about relative and absolute changes in the ability to move skillfully. These changes are initiated through motor learning processes that involve cognitive aspects. In order to achieve automatic motor control, the child must first learn the skill and then practice it multiple times until it becomes an automatic motion, i.e. the execution of the motion becomes fast, fluid, and does not require attention. The formation of long term memories of motor and cognitive skills is part of the concept of procedural memory.

In addition to a deficit in motor function, children with specific language impairment have been found to have weaker executive functions. The term "executive functions" relates to cognitive processes at the foundation of goal-seeking behavior. Studies indicate a neurological link between executive functions and motor learning, insofar as the ability to execute one process is affected by the ability to execute the other.

The current study evaluates the formation of long term procedural memory during the motor skill acquisition process, using a grapho-motor dot-to-dot task, in which a child creates a simple shape suitable to his or her age and expected abilities, in this case an "invented letter" called a "Boomerang". The study examined differences among children with specific language impairment and children with normal language

development in acquiring and retaining the ability. After learning the task, the child's performance on the task was tested four hours after the initial practice session and again two weeks later. This was based on a previous study, which found that children with specific language impairment did not perform as well as their normal language development pairs 24 hours after practicing the task (Adi-Japha, Strulovich-Schwartz & Julius, 2011). The study's second goal was to find an association between executive functions and motor learning patterns. This was based on previous studies that have implied an association between executive functions and motor learning during the fast learning phase, which requires significant attention resources and involves a process of trial and error.

The study included 53 kindergarten children, 25 who had specific language impairment and 28 showed normal language development. All of the participants took a series of cognitive tests, including tasks to evaluate executive functions language tests, and the "Boomerang" motor learning task. Both groups were subjected to the same tasks and the same practice method, which included the fast learning phase, in which the grapho-motor task was repeated multiple times and the delayed gains phase of the task, which was performed four hours after the practice session and two weeks later, to test the efficiency of memory formation and the preservation of the learned ability. Altogether, each participant's performance was tested at four different points in time. For each block of the boomerang shape task, quality of execution was tested using speed and accuracy dimensions, which are indicators of quality of procedural memory, which forms following the motor learning task. Additionally, participants were tested on a computerized non-motor task to evaluate executive functions.

The results showed that the motor pattern demonstrated by children with specific language impairment was similar four hours and 24 hours after practice. Among children with specific language impairment we observed slower execution of the motor learning process and low accuracy compared to the typical language development control group. However, over time children with specific language impairment tended to close the gap.

Moreover, while our results indicate a strong association between executive functions and specific language impairment during the fast learning phase, this association was not observed in the long term, in which typical language development.

The current study advances the understanding of learning and preservation abilities of newly learned skills among kindergarten children and, in particular children with specific language impairment. Our findings indicate that children who have difficulty preserving the type of learned motor skills often learned in kindergarten (e.g. drawing, cutting, threading, etc.) require multiple repetitions. In practice, the kindergarten teacher can encourage children to repeat a task over and over again to ensure their long term success. To an extent, this will improve children's ability to focus their attention and maintain concentration at expected levels.