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Cognitive Skill Acquisition among Students with Attention Deficit Hyper-Activity Disorder

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Abstract

Attention deficit hyper-activity disorder (ADHD) is defined as a neuro-psychiatric disorder, characterized by difficulties in regulating attention, hyperactivity, impulsivity (American Psychiatric Association, 2013), and in deficits in executive functions. Executive Functions (EF) are defined as a set of neuro-cognitive processes, responsible for the choice and execution of behaviors that serve a future goal (Welsh & Pennington, 1988). Executive functions include basic cognitive processes such as, attention control, inhibition, working memory and cognitive flexibility. Furthermore, executive functions include high cognitive processes such as, planning, problem solving, inferring and the simultaneous operation of multiple basic executive processes (Nigg et al., 2005).

Considering the importance of executive functions in the learning and execution of academic work, employment and routine chores, researchers claim that the executive function deficit characterizing ADHD explains to a large extent the academic, employment and day to day difficulties that children and adults with ADHD experience (Biederman et al., 2004; Weyndat, Oster, Gudmundsdottir, DuPaul, & Anastopoulos, 2016). Many important skills are cognitive in nature and their intact acquisition are vital for academic, employment and general functioning. It seems that the acquisition and consolidation processes of cognitive skills have yet to be examined among adults with ADHD.

Acquisition of a cognitive skill refers to a process in which a new skill turns through training into a skill performed with efficiency, meaning a skill performed faster and more accurately. Therefore, the goal of this research was to examine the acquisition and consolidation of a cognitive skill among students with ADHD. To examine the acquisition of a cognitive skill, students with ADHD

and students with typical neurological development, were asked to solve a cognitive task known as the Tower of Hanoi Puzzle ten consecutive times. The tower task is considered a complex task that requires the operation of multiple executive processes (such as, planning, inhibition and working memory), simultaneously (Asato, Sweeney, & Luna, 2006). The tower task has been used frequently to examine the EF of different populations, especially when it is presented as a one-time task. When the task is presented several times, it is known to measure procedural acquisition of a cognitive skill (Beaunieux et al., 2006) .

The influence of EF on the acquisition process of a cognitive skill has been estimated in this paper through four measures; the number of moves required for solution; total time required till solution; average time per move; average time till execution of first move. These four measures were used to compare the initial performance of the students in task solution and their overall learning across ten trials of practice. In this research, a significant difference was found in the initial performance in the task, when the total time for solution and the number of moves to solution were significantly higher among students with ADHD. This result correlates with the results of previous research that found that in tasks that examine EF, the performance of participants with ADHD is not as good as that of students without ADHD (Boonstra, Oosterlaan, Sergeant, & Buitelaar, 2005; Miyake et al., 2001; Murphy, 2002).

In contrast, in all measures, no differences were observed regarding the acquisition of the cognitive skill during training. These results suggest that among students with ADHD, the initial performance is impaired when the task demands are high on the EF. However, given additional training, the speed and accuracy improve with learning, as seen among typically developed students.

To understand how it is possible to improve the proficiency obtained by a learner during the acquisition of a cognitive skill, participants were divided into two groups. The first group underwent constant training, in which participants solved the same configuration of the task in each practice. The second group underwent alternating training, which means that the participants practiced five different configurations of the task. The level of proficiency was estimated through a procedure known as Skill Transfer. Transfer is the application of knowledge acquired in one setting, in another. It is said that the ability to transfer can be a good indication of learning, even more than the learning process itself (Schmidt & Bjork, 1992) .

In this research it was found that participants that underwent alternating training exhibited better transfer in three measures: number of moves to solution, average time per move and total time to solution. This result reinforces Schmidt and Lee's (2011) theory and correlates with the results found in Vakil & Heled's (2016) paper, who also observed the beneficial influence of alternating training. In addition, it was observed that ADHD does not inhibit the ability to benefit from alternating training and transferring the skill acquired in one context to another.

Finally, this research wanted to examine the memory consolidation process of a cognitive skill among students with ADHD. The consolidation stage refers to improvements that occur during the hours and days post training. It is said that these improvements reflect continuous functional and structural changes of the neural "hardware" of perceptual, motor and cognitive representations chosen for the execution of the skill (Karni & Bertini, 1997). In this research a consolidation effect was not observed at all. A possible explanation suggests that the consolidation effect comes from research in the motor (Robertson et al., 2004) and simple perceptual skill domains (Hauptman & Karni, 2002; Karni, 1996; Karni & Sagi, 1993). In these domains it has been found that significant training leads to a consolidation effect, observed after a delay, during which there is no additional

training. It is possible that in cognitive tasks, consolidation is observed under different conditions than those that were given in this current research. For instance, in a different experiment conducted on typically developed students with the Tower of Hanoi Task, it was found that following a long training session and a delay, the consolidation effect was not observed unless additional practice was provided after the delay (Vakil, Karni, Levenscous-Erlich, 2002). Considering the possible need for additional practice following a delay, it is possible that in the current research such an effect was not found because participants were not granted additional practice following their delay.

The conclusions of this paper are that among students with ADHD, the deficit in EF hamper the initial performance in cognitive tasks. This means that when the components of a cognitive task place heavy demands on the EF of students with ADHD, the observed performance is worse than that observed among typical developed students. Nonetheless, this research has also found that the ability to acquire a cognitive skill is intact among students with ADHD. This means that given identical training, the performance and learning rate of students with ADHD is the same as that of students with typical neurological development. Furthermore, when the ability to transfer the skill was examined, there were no differences in the level of proficiency exhibited by the two groups.

Finally, it was found that following alternating training, that sets high cognitive demands due to its nature, students with ADHD achieved the same level of skill as typically developed students and higher skill than that acquired by TD students who underwent constant training.

A possible limitation of this research might be in the amount of practices assumed to be needed to pass on to the procedural stage (according to Anderson's ACT Theory (1982)). We suggest future research re-examines the distinction between Anderson's learning stages, in disc-transfer tasks. Especially, the possibility that in the first solution process of the task, the learner moves from the

declarative stage to the procedural stage. We base this recommendation on the results of this paper that show that the cognitive load characterizing the declarative stage is expressed only in the first practice. An additional limitation regards the absence of a consolidation effect in our experiment. It is recommended that future research examines the potential factors involved in the consolidation process. For example, whether it is dependent on additional practice following the delay stage, or whether it is sensitive to other factors like the length of the practice or the time in which the training takes place. Korman and her colleagues (2017), found that among students with ADHD, during a motor skill task, the time of day in which the training was performed affected skill consolidation. Therefore, suggesting that at least among students with ADHD, the time of day in which one is trained affects the consolidation of the skill. Operating different factors during training and following delay may assist in understanding consolidation processes in the cognitive domain.