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# Cognitive Neuroscience and How Students Learn: Hype or Hope

## Neurociencia cognitiva y aprendizaje

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Applied cognitive neuroscience (ACN) is a discipline that aims to relate brain functioning with cognitive processing by means of the study of neural substrates involved in mental processes. Until now, advances in ACN have allowed the tracking of certain biological and cognitive characteristics related with cognition and learning in the classroom context. Different methods of cognitive evaluation have contributed to explaining how learning is developed. Meanwhile, the challenge of neuroscience has been to analyze how the brain solves abstract problems, enables verbal dexterity and manipulates relevant ambient information to give color to learning through pathways of functional attention and memory. This in turn enables executive abilities that allow problem-solving and decision-making, among other cognitive attributes. In addition, studies in ACN have endorsed the early detection of diverse specific learning problems and promoted the development of neuropsycho-pedagogical strategies that favor the neurorehabilitation of a particular cognitive domain (Reyes & Sánchez, 2017).

Likewise, with the advances in the field of basic sciences, ACN has reached the goal of determining neurobiological and molecular processes that show distinctive correlations or associations between patterns of learning involved in executive function. In this regard, it is known that executive function can be assessed with different neurocognitive tools. An interesting approach was taken by Miyake et al. (2000), establishing that executive functioning consists in three closely related cognitive abilities: inhibitory control, working memory and cognitive flexibility. In this respect, Collins and Koechlin (2012) have suggested that these domains contribute to the development of reasoning, problem solving and planning. Up until now, there is no question that executive functions are relevant for school preparation and constitute a marker of quality of life in several domains: professional progress in adult life, getting and maintaining a job, developing healthy living habits and forming good and stable interpersonal relationships (Diamond & Ling, 2016).

Taking into account its relevance and contribution to the good academic prognosis and the development of abilities and skills that favor a successful adaptation to social and cultural surroundings, contemporary education models have the fundamental challenge of supporting the development of student executive function. In this sense, some studies in ACN and learning have suggested that executive function can be improved and even sped up through cognitive training as an alternative to school learning. Among the methods and programs that have been created for this purpose, it is important to mention the implementation of computerized tasks to train working memory, which have shown some efficacy.

Nevertheless, this type of training does not guarantee improved flexibility, nor a significant increase in attention (Rueda, Checa, & Combita, 2012). Furthermore, this relative improvement of working memory has been controversial with contradictory results (Harrison et al., 2013). Bergman Nutley et al. (2011) suggested that people improve the abilities that they practice, and this is transferred to other contexts where similar abilities are needed. However, it seems that people solely improve what they practice and this improvement does not transfer to other skills. Thus, for now, the cognitive benefits offered by computerized tasks designed to increase executive functioning demand more research in each executive domain in order to assess their reach in time and improvement potential of cognitive dexterity (Harrison et al., 2013).

Several variables can be introduced to the processes of cognitive improvement or executive training:

1. Teachers trained in pedagogical tools that favor understanding academic processes through a central component for sustained learning. This condition could significantly reshape the process of learning in the classroom.
2. Changes and modifications of study plans, which provide a constant challenge to executive function.
3. Implementing the development of tasks oriented to global executive function in school dynamics. In this respect, it has been reported that there is a greater chance of successfully transfering training effects to other behavioral and social cognitive instances if the program of cognitive function training is comprehensive. This constitutes a proposal for the development of holistic curriculums.
4. Learning by discovery, resuming Jerome Bruner's stance, which involves learning by means of a guided discovery oriented to observation, classification and problem solving, where students actively take part in the comprehension of knowledge by themselves (Metsämuuronen J, & Räsänen P. 2018).

In addition, the core of executive function could be motivation. In agreement with Epstein (2012), it is possible to suggest that the teacher can promote truly motivated behavior if three main aspects are developed: a) a flexible direction to a goal, where the teacher provides a range of possibilities that allow the student to weigh different options in order to achieve the desired objective around a learning challenge; b) Success expectation, where the instructor focuses on autoregulation for the development of learning tasks to demonstrate the effects produced by perceived competitiveness; and c), the value given to a task, where the teacher knows that the reward assigned to its execution is crucial to determining optimal learning. In this perspective, the key to positioning practice through cognitive training in specific learning tasks mediated by executive functioning is to endorse a good amount of motivation, since the interaction between motivation and cognition is likely crucial to fostering efficient learning.

Nowadays, advances in computational cognitive neuroscience have begun to explain some of the neurophysiological mechanisms that underlie the motivational state, and how it is essential for execution and learning. This points out that the use of incentives in pedagogical scenarios could increase and improve cognitive processes, such as working memory and decision making, among others.

Executive functions and their components, both those involved in planning strategies and in cognitive monitoring, prove to be of vital importance for academic success, as described above. However, it is worth mentioning the importance of emotional aspects, like the weight factor in the process of teaching-learning. Emotion and social learning have been recognized in education for a long time, yet have been relegated to educational theories for the reduced number of applicable neuroscience research methods. Hence, it has been difficult to obtain biological evidence of the impact of emotion and social processing on learning (Immordino-Yang, 2011), although several published studies support this position.

In the last scale published by John Hattie in 2018 about the effects that influence the academic achievement of students positively or negatively, a lot of the 252 variables with greater effect size were exclusively of affective-emotional nature, such as teachers' expectations of their students' learning competency. A wide consensus exists about learning disorders that result in emotional problems, like the acute effect of a psychosocial stressor (Vogel & Schwabe, 2016) or the neurocognitive aftermath of early and chronic stress situations (Nemeroff, 2004). Inversely, experiencing other type of emotions with positive valence favors the learning process. An example of this kind of situations consists in the effect of the teacher's empathic capability (Stojijkovic, Djigic, & Zlatkovicz, 2012) or style of classroom management (Djigic, & Stojiljkovic, 2011).

Paying attention to these emotional aspects is crucial to promoting learning. It is assumed then, that the interaction between motivation and cognition emerges due to the modulation of neuronal circuits in the prefrontal cortex paired with subcortical structures like the basal ganglia and the hippocampus (Daw & Shohamy, 2008). This map of cortical activation could delineate learning by reinforcement, which is sensitive to the motivational influences related to incentives. The value of the incentive is defined in terms of stimulus properties, and specifies the behavioral choices made in a particular domain of action (Berridge, 2004).

In agreement with this claim, pedagogical processes in the classroom require a dose of intrinsic motivation (associated with deeper learning and with higher levels of wellbeing) and therefore, it is the desire type of motivation. But why does some learning involve more or less motivation? The key lies in the emotions involved in learning. In consequence, the design of plans and programs, and automonitoring and planning of conducts require optimal levels of emotional excitation. Therefore, emotions are what give valence to learning and make it potentially durable (Lemoine, Nassim, Rana, & Burgin, 2018).

Consequently, emotional processing during learning has allowed for maintained, selective attention to take part in the circuit of working memory and in the access to new modules of executive functioning that guarantee the efficacy and durability of learning. Paraphrasing Francisco Mora: "all lasting learning processes and memory consolidations are emotionally colored" (Teruel, 2013). Thus, an additional challenge for modern teachers is to be able to distinguish emotions in learning by enabling ludic and innovative neuropsychopedagogical activities that promote the passion for efficient use of information for the individual and collective benefit, allowing each individual to stand out for their individual talents and contributions to society. Without a doubt, neglecting the emotional variables to focus only on intellectual and cognitive aspects of learning is a mistake since the integration between both aspects is crucial for a holistic comprehension of this always complex phenomenon.

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