Cognitive training based on modern board and card games to improve executive functions in children at risk of social exclusion.

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1. What are Executive Functions?

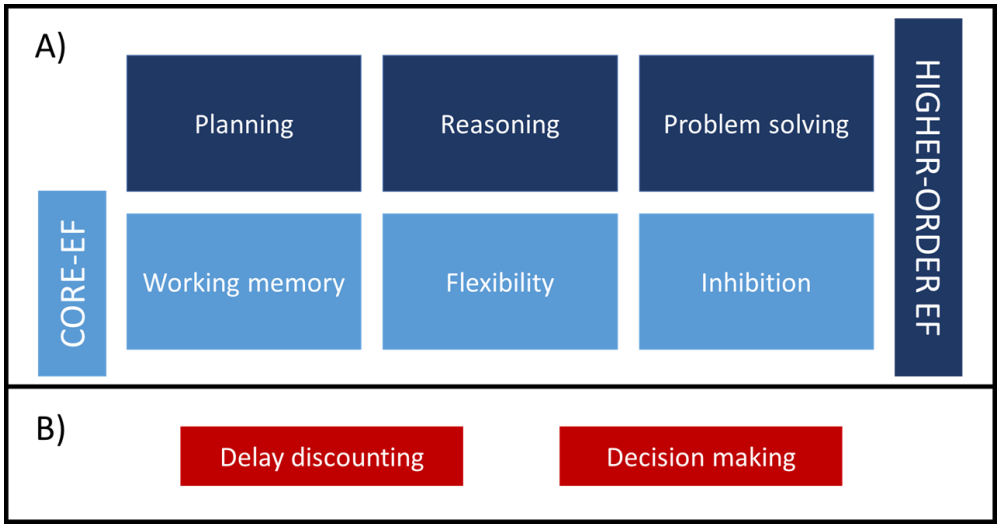
Executive functions (EFs) have been described as a set of cognitive processes that make it possible to follow a goal by controlling, directing, and coordinating other cognitive processes (Bull & Lee, 2014). EFs are important in cognitive tasks and in socioemotional and behavioral domains (Baggetta & Alexander, 2016). Thus, EFs are the "orchestra's director" that manage and control other cognitive abilities to regulate our behavior and engage in purposeful and goal-directed behaviors" (Cristofori, Cohen- Zimerman, & Grafman, 2019; Miyake et al., 2000). But, in more depth, what are these psychological processes?

2. Classification of Executive Functions

Recent reviews (Baggetta & Alexander, 2016; Cristofori et al., 2019) agreed that "executive functions" is a complex and multi-dimensional construct that includes various psychological processes. Different authors consider that the processes included in the model of Miyake et al. (2000) are the core EFs (Baggetta & Alexander, 2016; Cristofori et al., 2019; Karr et al., 2018). Miyake et al. (2000) performed an empirical study using confirmatory factorial analyses where they demonstrated that the main EFs are updating's function of working memory (WM), shifting, and inhibition. Working memory refers to the system or systems necessary to keep things in mind while performing complex tasks (Baddeley, 2010). WM includes different systems. For instance, the visuospatial sketchpad and the phonological loop hold temporal information known as Short-Term Memory (STM) (Baddeley, 2010). Furthermore, a central executive system allows the manipulation and updating of information (Baddeley, 2010). The central executive system's updating function goes beyond the simple maintenance of task-relevant information and dynamically manipulates it. Updating requires examining elements collected on WM and substitute non-relevant older information with relevant new information (Miyake et al., 2000). On the other hand, shifting has been described as the capacity of alternating tasks or mental sets (Miyake et al., 2000). Finally, inhibition is the capacity of suppressing dominant or proponent responses to perform behaviors that need more attention (Miyake et al., 2000). Other authors include higher-order EFs that need from core EFs (Miyake & Friedman, 2012), such as planning, reasoning, or problem-solving (Cristofori et al., 2019; Adele Diamond, 2013).

Other authors, such as Zelazo & Carlson (2012), have proposed another classification: cool and hot executive functions. All the EF described above would be cool functions. These executive functions are involved in analytic situations without emotional aspects (Baggetta & Alexander, 2016). Otherwise, hot EF –such as decision making or self-control- are engaged in tasks with an emotional basis (Homer et al., 2019). Moreover, considering neural studies, cool executive functions have been usually associated with dorsolateral prefrontal cortex (PFC) (Lemire-Rodger et al., 2019), whereas affective aspects of EF are generally related to ventral/medial and orbitofrontal PFC (Guo et al., 2017). Furthermore, these regions interact in neural networks (Lemire- Rodger et al., 2019).

Figure 1. Taxonomy of the psychological processes included in Executive Functions (EF): A) Cool executive functions; B) Hot Executive Functions (adapted from Cristofori et al., 2019; Adele Diamond, 2013; Miyake et al., 2000; Zelazo & Müller, 2002).



3. Development of Executive Functions

Bearing in mind the taxonomy of EFs shown in Figure 1, different developmental patterns can be considered. For instance, cool EFs develop in the first ages of life (O' toole, Monks, & Tsermentseli, 2017). These EFs continue developing in scholar-ages and to a less extent in adolescence and young adulthood (Huizinga, Dolan, & van der Molen, 2006; Linares, Bajo, & Pelegrina, 2016). On the other hand, hot EFs have their maximum development in adolescence (Poon, 2018).

4. Why are so critical Executive Functions?

As Cristofori et al. (2019) wrote in their review, "*EFs allow individuals to alter their overlearned behavioral patterns when they become unsatisfactory, allow individuals to adapt to novel and complex everyday life situations. These functions are what enable us to understand complex or abstract concepts, solve problems we never encountered before or plan our lives, among others*". Therefore, we can conclude that EFs are highly important in our daily lives. As shown in Table 1, different studies have found that EFs predict health, education, and job success, among other life domains. Hence, adequate development of EFs is essential for the person and the educative and personal development of children.

Table 1

Impact of EFs in different life domains (adapted from Cristofori et al. (2019); Diamond (2013)).

Life Domain	How is EFs relevant to this domain in life?

Mental health	Some EFs are impaired in different disorders, such as: ·Attention Deficit with/without Hyperactivity Disorder (ADHD) (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005) · Depression (Rock, Roiser, Riedel, & Blackwell, 2014) · Schizophrenia (Vöhringer et al., 2013) ·Bipolar disorder (Vöhringer et al., 2013)
Physical health	Impaired EFs have been related to obesity (Reinert, Po'e, & Barkin, 2013), unhealthy behaviors, such as low physical activity (Hall, Fong, Epp, & Elias, 2008) or poor treatment adherence (McNally, Rohan, Pendley, Delamater, & Drotar, 2010), among others.
School success	EFs predicts math (Friso-van den Bos, van der Ven, Kroesbergen, & van Luit, 2013), reading skills (Foy & Mann, 2013; Sesma, Mahone, Levine, Eason, & Cutting, 2009), and academic achievement (Best, Miller, & Naglieri, 2011; Pascual, Moyano, & Robres, 2019)
Relationships	EF dysfunctions are significant in disruptive behavior (Tsermentseli & Poland, 2016) and in solving emotional problems (Poon, 2018). EFs are also important in love relationships (Eakin et al., 2004).
Quality of life	EFs are related to quality of life (Stern, Pollak, Bonne, Malik, & Maeir, 2017).

5. What impairs Executive Functions?

Some situations can affect the development and/or impair EFs. As Diamond (2013) wrote in her review, some of these situations can be stress, loneliness, lack of sleep, or exercise. Other studies have found socioeconomic factors, such as being at risk of poverty, can also deteriorate EFs. Hackman et al. (2015) found that, in early ages, socioeconomic level predicts performance in cool EFs tasks. However, this relation was mediated by other outcomes, such as maternal sensitivity or home characteristics through environmental enrichment. Environmental enrichment is understood as a combination of inanimate and social elements that can be used to enhance individual development (Kempermann, 2019). Environmental enrichment has been demonstrated to facilitate brain neurogenesis, even in

adults. Thus, theoretically, to improve EFs in children at risk of social exclusion, it should be interesting to increase environmental enrichment.

6. How can be improved Executive Functions?

As Diamond & Lee (2011) consider, EFs can be improved through different activities, such as computerized and non-computerized training, aerobically exercise, martial arts, and mindfulness or classroom curricula.

Cognitive based interventions are treatments whose primary outcome are cognitive processes, as EFs (Bahar-fuchs, Clare, & Woods, 2013). These interventions can include cognitive stimulation, cognitive or restorative training, and neuropsychological rehabilitation/remediation (Kueider, Krystal, & Rebok, 2014; Reichman, Fiocco, & Rose, 2010).

These treatments are designed to improve cognitive functioning by combining standardized and systematic tasks, repeated several times (Tajik-Parvinchi, Wright, & Schachar, 2014). Cognitive training has been demonstrated to mainly boost trained cognitive processes or similar ones (near transfer), but also, in some cases, untrained ones (what is called far transfer effect; Tajik-Parvinchi et al. (2014).

7. Including board and card games in cognitive interventions

Gamifying or using playful cognitive training elements is an increasing trend (Lumsden, Edwards, Lawrence, Coyle, & Munafò, 2016). Lumsden et al. (2016) found that introducing game elements did not assure an improvement in task performance (though it could), but it boosted participant motivation. Other studies point out that gamifying cognitive training showed better results than non-gamified interventions (Ninaus et al., 2015).

Traditional board and card games have shown their potential as cognitive training (Noda, Shirotsuki, & Nakao, 2019). However, theoretically, modern board and card games can be better tasks in cognitive training than traditional ones. According to Sousa & Bernardo (2019), modern and traditional board games are differentiated from a scientific perspective because an identifiable author creates modern board games.

Furthermore, modern board and card games are more diverse in the type of mechanics used (not only positional or abstract, like traditional games). Besides, several game mechanics not found in traditional games (such as deck building) have been created during the last 50 years. Moreover, modern games are more aesthetical (what makes them more attractive to most the people, and especially for children), are usually more highly thematic (what facilitates the motivation of players), and some of them rely accurately on one cognitive process to play, similar to the tasks used in cognitive training.

8. Board and card games in cognitive interventions for people with low socioeconomic status

Previous studies have found some benefits of cognitive interventions based on board and card games in people at risk of social exclusion. For example, Scalise et al. (2020) found that children from low socioeconomic status improved their visuospatial STM and inhibition. In older people, Overman & Robbins (2014) a non-randomized controlled trial in which they conducted cognitive intervention based on an ad hoc working memory game and two modern board and card games that boosted reasoning. Research in children with mental and behavioral disorders associated with the risk of social exclusion has also been performed, though they are scarce. For example, Estrada- Plana, Esquerda, Mangues, March-Llanes, & Moya-Higueras, (2019) found that the short-term linguistic memory increased and the conduct problems decreased significantly after playing modern board and card

games in children with ADHD. Thus, though some studies have been previously performed with children at risk of social exclusion, well-conducted RCT are needed to demonstrate whether executive functions can be improved in children with low socioeconomic status after playing modern board and card games scheduled in cognitive intervention sessions or not.

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