# THE COMPLEX COGNITIVE SYSTEM OF EXECUTIVE FUNCTIONING: A CONCEPTUAL REVIEW

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***ABSTRACT***

*Every day we are faced with a variety of situations that require the use of cognitive processes different, such as recognizing and memorizing stimuli, understanding and producing statements, solving problems. In recent decades, cognitive psychology and neuropsychology have made considerable advances in description of these processes and how they can be disrupted as a result of an injury to the nervous system central. However, it is clear that our adaptation to the environment is not limited to perceiving, reading, and speaking. A fundamental aspect of mental life is represented by the need to continuously modulate the use of these cognitive resources to contingent needs according to our goals and goals. It is this type of problem that refers to the expression executive functions (EFs). During developmental age Efs change consistently and since age of 8 years many Efs are similar to adults.*

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## Executive Functions: a complex cognitive system

Every day we are faced with a variety of situations that require the use of cognitive processes different, such as recognizing and memorizing stimuli, understanding and producing statements, solving problems. In recent decades, cognitive psychology and neuropsychology have made considerable advances in description of these processes and how they can be disrupted as a result of an injury to the nervous system central. However, it is clear that our adaptation to the environment is not limited to perceiving, reading, and speaking. A fundamental aspect of mental life is represented by the need to continuously modulate the use of these cognitive resources to contingent needs according to our goals and goals. It is this type of problem that refers to the expression executive functions (EFs).

EFs represent the abilities allowing people to establish new patterns of behavior and the cognitive tools for thinking and reflecting on themselves[1-3]. This is important in all situations that cannot be dealt with on the basis of schemes already learned by the individual. This definition tend to emphasize the control over other cognitive processes and indicates that rather than representing distinct cognitive operations (such as memory or learning), the FE controls the unfolding of these processes.

In general, EF allow the strategic allocation of attention and the synchronization of the answers necessary for the simultaneous performance in multiple tasks; are necessary for monitoring the performance

in order to capture and correct the errors, and modify programs when ineffective; consent to maintain attention continuously for prolonged periods.

These consensus descriptions help to understand the breadth and variety of issues that they must be addressed in a scientific study perspective, on the one hand to account for the underlying processes FE and, secondly, to correctly interpret disorders that may result from lesions of the nervous system or that are effects of psychiatric disorders[1-5].

The executive functions are, therefore, cognitive functions of a higher order, consisting of six steps:

1. Analyze the task
2. Plan how to achieve the task
3. Organize the steps you need to carry out the task
4. Develop a time line to complete the task
5. Adjust or change the steps, if necessary, to complete the task
6. Complete the task in a timely manner

Therefore, EF may be identified with the different abilities such as inhibition, flexibility, planning, employment, attention, and fluency. On the other hand, working memory, inhibition and cognitive flexibility are considered as the nuclear EF and are the foundation of other higher-order EFs such as reasoning, problem solving and planning[1-5].

In recent years a further distinction of executive functions has been elaborated, which calls into question the specific characteristics of the single activities: it is the one between cool EFs and hot EFs[1-5].

The Cool EFs are exercised during cognitive, abstractive or decontextualized tasks and identified as problem solving, abstraction, planning, development and implementation of strategies and working memory. The Hot EFs are linked to an automatic and emotional processing of the stimuli, or one simple and rapid programming that intervenes in stressful situations. The hot EFS are therefore connected with phenomena such as empathy, the theory of mind, emotional regulation and decisions in affective dimension.

On the other hand, both the Cool EFs the Hot ones work in perfect sync with the purpose of guaranteeing an ideal functioning, but neuropsychological studies suggest a double dissociation between the two types of functions documenting injuries to Hot EFs in the absence of problems for the Cool executive functions and viceversa[6-24].

In summary, Efs are important for cognitive processes and motivational skills needed to achieve our daily, ordinary and extraordinary goals.

***Executive Functions in the neonatal period***

Traditionally, the first two years of life are not associated with EFs-related abilities, because described with reference to significant and evident changes in skills motor and language. Thanks to advances on the methodological side and to the conception of experimental tests with motor requests, mnestic and linguistic, it is possible to observe how the development of EFs start much earlier of what had been hypothesized in the past.

Regarding the cool EFs since 12 weeks of life, children are able to keep in memory the memory of goal structure of an event that he saw the protagonist and then be able to use it later in similar situations; from seven/eight the first signs of Working Memory and inhibitory control are also visible. Scarce are studies about development of hot EFs; and only some observations suggest difficulties in controlling this domain in the first two years of life, although development processes cortical seem to affect these regions before those involved in the cold Efs (6-24).

***Preschool Executive Functions***

The main characteristic of the child in this period of life is the curiosity towards the physical social world that it surrounds him. From the point of view of the cold EFs, in this period the child develops a good ability to inhibitory control and interference management. In particular, it is possible to observe: 1) significant development of the ability to generate concepts (3-4 years); 2) improvement of the inhibitory skills (3-4 years); 3) appearance of the attentive control (4-5 years); 4) improvement in cognitive flexibility and the ability to formulate strategies (4-5 years); 5) increasing in working memory (from 5 years); 6) appearance of behavior aimed to a goal and the ability to plan[26-39].

From the point of view of hot EFs, we can observe also 1) improvement in the ability to make decisions in situations where punishments come into play gratifications; 2) a significant change in Theory of Mind (ToM) (3-5 years)[30-35].

***EFs in school-aged children***

In the school period some executive skills reach the maturity and performance of some tests aimed at their evaluation appears to be similar adults.

Regarding the cold EFs between 8-10 years begins a significant improvement in cognitive flexibility; between 8-11 years begins an improvement in inhibitory control, vigilance and sustained attention[40-47].

In general, there is a refinement of the ability to understand emotions, intentions, beliefs and desires. Furthermore, an improvement can also be observed in some components of the ToM as the ability to understand social deceptions and to decipher metaphors[48-53].

***EFs during adolescence***

During adolescence, EFs are completely matured. In fact, the changes that occur on the cognitive and executive side that take place at this stage of life, provide adolescents with the best tools to cope with the new demands before which it is posed by the physical and social environment. The adolescent, in fact, will develop a growing sense of independence, responsibility and social awareness. More precisely, from 15 years we can see an improvement in attentional control and speed of processing, as well as reaching levels mature in the inhibitory domain. Between the ages of 16 and 19 (according to some studies even further), one can note the progress of working memory, in strategic planning and problem solving. On the part of the EFs, during this period, there are improvements in decision-making in the presence of shortcomings and losses[54-61].

***Relationships between EFs and cognition during developmental age***

The hypothesis of a relationship between EFs and cognition is explained by the awareness that a adequate executive functioning is essential for the implementation of intelligent behavior and oriented towards achieving a goal. Despite this, the evidence regarding a relationship between the performance in tests of intelligence and executive tests are not currently univocal.

A possible consequence of the aforementioned observation is that, in the face of nonexistent relations between the domains in their complexity, they can links between specific components exist. Other problems concern the methodological side. What the impact of the tools chosen on the results achieved is the most discussed; in particular, this which is stressed is the exclusive use of traditional tools for the evaluation of the executive domain by one side and the Wechsler Scale for the evaluation of intelligence (WISC) on the other.

Rarely, however, are present in literature works that have found significant relationships between intelligence and executive domains; what it becomes interesting to ask questions about how the different executive domains are related with intellectual skills[62-68] (Figure 1, Figure 2).

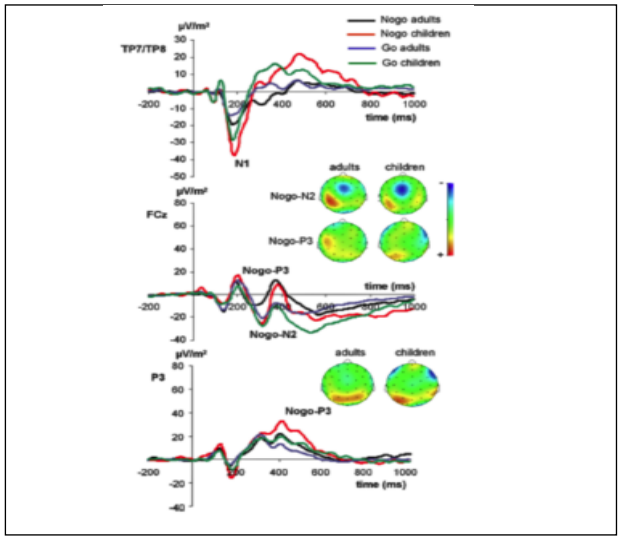


**Fig 1**: Event-related potentials (ERP) showing the N1 component at electrode TP7/TP8 for Go and Nogo trials in children and adults. In all plots time point 0 denotes the time point of Go or Nogo stimulus presentation. Electrode FCz shows the N2 and P3 ERP components on Go and Nogo trials for children and adults including scalp topography plots for Nogo trials at the peak of each component in children and adults. Positive values are coded in red, negative in blue. Electrode P3 shows the P3 component on Go and Nogo trials for children and adults including scalp topography plots for Nogo trials.

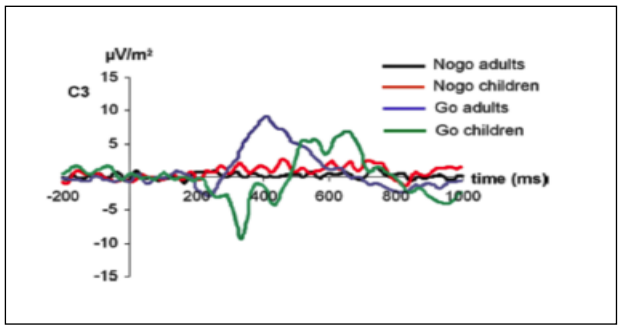


**Fig 2**: The R-cluster at electrode C3 is shown for children and adults on Go and Nogo trials. During the task the participants were required to respond using their right hand. Consequently, no activity is shown on Nogo trials, but motor activity is evident on Go trials which corresponds with differences in their reaction time.

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