



EXECUTIVE FUNCTIONS IN CHILDREN AND ADOLESCENTS: THE TYPES OF ASSESSMENT MEASURES USED AND IMPLICATIONS FOR THEIR VALIDITY IN CLINICAL AND EDUCATIONAL CONTEXTS

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The executive functions involve a wide range of processes related to the regulation of thinking, behaviour and the emotional state. Given the variety of components that fall under the umbrella of this construct, it is not surprising that its evaluation often involves some difficulties. In this sense, although numerous studies have shown the relevance of these components as determining factors in the academic achievement and social adaptation of children and young people, as well as demonstrating their usefulness in the diagnosis and intervention of several clinical problems that are typical of these stages, aspects such as the criticized ecological validity of the traditionally used assessment measures impose certain limitations on the validity and generalizability of the information obtained by means of these tools. The present paper analyses the characteristics of the most widely used assessment measures of executive functions and their applicability in clinical and educational settings. A series of practical implications arises from this analysis.

Key words: Assessment, Childhood and adolescence, Executive functions, Validity.

Las funciones ejecutivas implican un amplio rango de habilidades relacionadas con la regulación del pensamiento, el comportamiento y el propio estado emocional. Teniendo en cuenta la variedad de componentes que forman este constructo, no es sorprendente que su evaluación plantee ciertas dificultades. En este sentido, pese a que numerosos estudios han mostrado la importancia de dichos componentes como determinantes del desempeño académico y social, así como su utilidad en el diagnóstico y la intervención en diversas problemáticas durante la infancia y la adolescencia, aspectos como la validez ecológica de las medidas tradicionalmente empleadas para su evaluación, imponen hoy ciertas limitaciones a la validez y generalización de los resultados obtenidos en este ámbito. El objetivo de este trabajo es analizar las características de las medidas de evaluación más ampliamente empleadas y su grado de aplicabilidad en contextos clínicos y educativos, de lo cual se desprenden una serie de implicaciones prácticas.

Palabras clave: Funciones ejecutivas, Evaluación, Infancia y adolescencia, Validez.

The term executive function refers to a wide variety of processes, such as goal-setting, formulating hypotheses, planning, focusing and sustaining attention, generating strategies, behaviour monitoring, problem-solving, cognitive flexibility, working memory, response inhibition and emotion control. These functions involve, therefore, components of both a cognitive and emotional nature, and they play a key role in the regulation of goal-oriented behaviour (Korzeniowski, 2011; Lezak, 2004; Verdejo-García & Bechara, 2010).

These characteristics mean that the executive functions are seen as supraordinal components, which is supported by neuroanatomical studies on normative samples without pathology as the object of study (Houdé, Rossi, Lubin, &

Joliot, 2010; O'Hare, Lu, Houston, Bookheimer, & Sowell, 2008). These studies have shown the existence of a hierarchical organization of the cerebral cortex, where the prefrontal areas play a key role in integrating and responding to information from outside. Thus, the prefrontal areas of the brain have been proposed as the neurological basis of the executive functions. This relationship has also been confirmed by studies on populations of children with brain damage, the results of which have enabled associations to be made of damage to this area with certain executive deficits such as inattention, difficulty solving problems, decreased cognitive flexibility, difficulties in controlling impulses and emotions, or difficulties in planning (Stuss & Knight, 2013; Wolosin, Richardson, Hennessey, Denckla, & Mostofsky, 2009). However, this area is characterized by its dynamism and flexibility, so the functions carried out by these areas depend heavily on other brain regions

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such as the posterior cortical areas and other limbic and basal structures (Lozano & Ostrosky, 2011; Tirapu-Ustárroz, García-Molina, Luna-Lario, Roig-Rovira, & Pelegrín-Valero, 2008). In the same vein, many studies have suggested that the involvement of the frontal lobe and its connections in executive functioning may not be homogeneous, and it seems that various brain regions participate differentially in the different functions (Jurado & Roselli, 2007; Wagner, Kock, Reichenbach, Sauer, & Schlosser, 2006).

One aspect that confirms these data is the fact that these functions seem to develop progressively but asymmetrically, i.e., at different rates (Best, Miller, & Jones, 2009; Huizinga & Smidts, 2011; Korzeniowski, 2011; Roselli, Jurado, & Matute, 2008). In this sense, authors such as Cassandra and Reynolds (2005) and Portellano (2005) have pointed out the existence of different stages of development. Accordingly, the period between 6 and 8 years of age is when planning and organization skills develop more rapidly. While they do not reach optimal levels until later ages, in this period, strategic, organized and efficient behaviours appear; between 12 and 14 years of age inhibitory control develops; while other functions such as cognitive flexibility, working memory or complex problem solving continue to develop until the period between 15 and 19 years of age. However, numerous studies suggest that these components do not fully mature until adulthood (Hughes & Graham, 2008; Marcovich & Zelazo, 2009; Pureza, Gonçalves, Branco, Grassi-Oliveira, & Rochele, 2013). These periods where the executive functions have been shown to develop more quickly coincide largely with the stages of compulsory education, so evaluating these aspects in relation to the appearance of certain learning or adaptation difficulties in these stages is of particular interest, especially when these children or adolescents have specific clinical problems such as Autism Spectrum Disorder, Conduct Disorder or Attention Deficit and Hyperactivity Disorder (ADHD) (García et al., 2013; Brown, 2009; Geurts & Marlies, 2012; Robinson, Goddard, Dritschel, Wisley, & Howlin, 2009; Rodríguez et al., 2010).

All of the studies mentioned above have enabled the characterization of the executive functions as a non-unitary entity, composed of different skills or abilities. Consequently, one of the main efforts that researchers have been undertaking in recent decades has been to define these skills or abilities clearly, that is, attempting to break this construct into assessable units to facilitate its study and analyse its relationships with behaviour and

learning. In this sense, there have been numerous attempts to classify the executive functions. Some of the proposed classification systems have been based on functional criteria, such as the distinction between hot and cool functions (Brock, Rimm-Kaufman, & Nathanson, 2009; Chan, Shum, Touloupoulou, & Chen, 2007; Tirapu-Ustárroz et al. 2008), or between strategic and dynamic functions (Huettel, Misiurek, Jurkiwsky, & McCarthy, 2004), while others have placed more emphasis on the neuroanatomical aspects, differentiating between the functions performed by different brain areas (Slachevsky et al., 2005).

Numerous studies, based on these classifications, have enabled the identification of working memory, organization and planning, response inhibition, cognitive flexibility and attentional capacity as the most relevant components within this construct, and the ones for which the vast majority of assessment tools available today have been developed (Diamond, 2013; Korzeniowski, 2011; Toplak, Bucciarelli, Jain, & Tannock, 2009; Van der Sluis, de Jong, & Van der Leij, 2007; Van De Voorde, Roeyers, Verté, & Wiersema, 2010).

EVALUATION OF THE EXECUTIVE FUNCTIONS

While most of the instruments for the evaluation of executive functions were originally developed for use in adults (Burin, Dakre, & Harris, 2007; Marino & Julián, 2010), in recent years great importance has been placed on the evaluation of these components in childhood and adolescence. Given their relevance in numerous problems and/or disorders present at these ages, the need for reliable and valid evaluation measures of the executive functions has been recognized by clinical and educational professionals, which has resulted in the existence of many evaluation tools and techniques.

In order to classify the evaluation measures of the executive functions, various criteria can be followed, the most widespread being that based on the distinction between measures based on performance and measures based on the observation of behaviour, which has been the subject of much discussion (Baum et al., 2008; Bishop, 2011; Gioia, Kenworthy, & Isquith, 2010; Lezak, Howieson, Bigler, & Tranel, 2012).

Performance-based tests

Also called neuropsychological tests (Marino & Julián, 2010), these tests are generally applied in clinical and research contexts and consist of individual tests or batteries comprised of different tests that measure a series of



objective indicators related to the subject's performance. Among other indices, response times, number of errors and omissions are measured. Some of the best known individual tests that are also applicable to school age include the Stroop Test (Stroop, 1935; Martín et al., 2012) and some of its variants, such as the Five Digit Test (FDT: Lang, 2002; Rodríguez et al., 2012), the Day-Night Stroop test (Gerstadt, Hong, & Diamond, 1994), or the Animal Stroop test (Wright, Waterman, Prescott, & Murdoch, 2003) for the measurement of response inhibition; the continuous performance test (CPT) and the TOVA (Test of Variables of Attention; Greenberg, 1996), or the Conners CPT-II (Conners CPT-II; Conners, 2004) to measure inhibition and attention; direct recall of digits tests (memory capacity) and reverse recall of digits (the child is asked to repeat the digits that the evaluator presents, but this time in reverse order as a measure of working memory), and those incorporated in the WISC-IV battery (Wechsler, 2003), or measures such as the Dot Matrix within the Automated Working Memory Assessment battery (Alloway, 2007) for the visual component; the Tower of Hanoi (ToH: Goel & Grafman, 1995; Díaz et al, 2012) for the measure of planning or the Trail Making Test (TMT, Reitan, 1958; Barncord, 2002) and Children's Color Trails Test (CCTT: Llorente, Williams, Satz, & D'Elia, 2003) to assess cognitive flexibility.

With regards to the executive batteries, these commonly incorporate some of the individual measures discussed above. The most widely studied would be Neuropsychology Attention and Memory (Ostrosky-Solís et al, 2003.), the BADS-C battery (Behavioral Assessment of the Dysexecutive Syndrome for Children; Kobayashi & Kobayashi, 2007), the CANTAB battery (Cambridge Neuropsychological Automated battery; Strauss, Sherman, & Spreen, 2006), and the ENFEN battery (Battery of Neuropsychological Assessment for Executive Function in Children: Portellano, Martínez-Arias, & Zumárraga, 2009).

These tests have been widely used, fundamentally in clinical practice, generally proving to be useful in detecting changes in executive functioning. However, they have been criticized for various reasons, especially for their lack of specificity and for constructing models that are not representative of the real world. Hence they are attributed with a low "ecological validity" (Burin et al., 2007). Aspects such as the origin of the tests themselves (many of them were designed to assess different constructs other than the executive functions, such as intelligence); the multitude of functions, the capabilities and operations associated with the executive functions;

the involvement of other cognitive, verbal, perceptual or motor aspects in performing these tasks; the possible effect of practice; their quantitative character; or the highly structured evaluation of the situations are among the arguments most commonly used to question the degree of validity (Chevignard, Catroppa, Galvin, & Anderson, 2010; Gioia et al., 2010; Lee, 2011; Lezak et al., 2012).

In response to the criticism of the ecological validity of the above tests, a new type of measure has emerged in recent decades, based on instrumental activities of daily living. These tests, also performance-based, involve carrying out everyday tasks, with the aim of reproducing conditions similar to those that occur in real contexts. While such measures are less numerous and are not adjusted or adapted to the Spanish context, the best known ones, applicable to children and adolescents, would be the Assessment of Motor and Processing Skills-AMPS (Fingerhut, Madiill, Darrah, Hodge & Warren, 2002) and the Children's Kitchen Task Assessment-CKTA (Rocke, Hays, Edwards, & Berg, 2008). The latter is the most used and assesses the level of support and supervision that children between the ages of 8 and 12 need during a cooking task through the number of indications needed to complete the task. Thus, the cognitive and executive aspects in the effective realization of this task are evaluated. This test includes the components of initiation, planning/sequencing, judgment/safety, organization and completion. The child is asked to cook a dish following a recipe with images and text. The child also receives hints or clues from the examiner, although only those necessary to perform the task correctly. The clues are provided in a structured sequence and vary depending on the level of assistance provided to the child. These clues increase along a continuum, from no help to direct help or even physical guidance for completion of the task. For adolescents and adults there are another two versions available, the Kitchen Task Assessment (KTA; Baum & Edwards, 1993), and the Executive Functioning Performance Test (EFPT; Baum et al., 2008). While the former involves a cooking task, the latter extends the number of activities, adding others such as making a phone call, paying bills or managing medication.

Despite the progress offered by this new type of instrument with regards to the ecological validity of measures, many of the limitations previously discussed, such as the excessive structuring, the fact that they cover a very limited range of activities that are instrumental to daily living or ones that



are rare in our present-day context, mean that they do not currently present a real alternative to the above-mentioned performance-based measures.

Tests based on the observation of behaviour

An alternative to performance-based measures is the use of behaviour rating questionnaires, which allow us to evaluate a wide variety of components from the point of view of the behaviours observed in children and adolescents at home and at school that would be indicative of deficits in executive functions. Such measures have been widely developed in recent years, reflecting for some authors the ecological validity for which the previous measures were criticized (Egeland & Fallmyr, 2010; Huizinga & Smidts, 2011; Mares, McLuckie, Schwartz, & Saini, 2007). These authors argue the usefulness of this type of evaluation, based on the fact that the executive functions involve not only cognitive, but also behavioural and emotional aspects. In this regard, issues such as accepting other viewpoints or proposing alternatives to problem solving, self-regulating emotions and behaviour, remembering certain rules or guidelines, inhibiting our impulses, or adapting behaviour flexibly in response to changing environmental situations, are essential aspects of executive functioning, many of which are only evidenced through behaviour in real situations.

Such measures are often based on the information provided by external informants, mainly families and teachers. Among the best known standardized assessment instruments we find the Child Behavior Checklist (CBCL: Achenbach, 1991), the Children Executive Function Inventory (CHEXI: Thorell & Nyberg, 2008), the Behavior Rating Inventory of Executive Functions (BRIEF: Gioia, Isquith, Guy, & Kenworthy, 2000), and more recently the Barkley Deficits in Executive Functioning Scale - Children and Adolescents (BDEFS-CA: Barkley, 2012). However, none of the above scales are available in Spanish.

In this context, the BRIEF scale (Gioia et al, 2000) has been one of the most widely used, with numerous studies that provide data on its reliability and validity (Anderson & Reidy, 2012; Donders, Den Braber & Vos, 2010; Kenworthy, Yerys, Anthony & Wallace, 2008). This scale is applicable from the ages of 5 to 18 and has several forms, including self-report. However, the scales designed to be completed by families and teachers are the most well-known respectively. Composed of 86 items, the BRIEF scale (parents and teacher versions) explores eight key areas of executive functioning: inhibition, change,

emotional control, initiative, working memory, organization and planning, order, and monitoring. These components are grouped into two basic indices: the Behavior Regulation Index or BRI and the Metacognition Index or MI. Both indices are grouped in the Global Executive Composite (GEC). High scores on these components and indices indicate difficulties in executive functioning. A Spanish version of this instrument is currently being published in TEA Ediciones.

The problem of low correspondence between evaluation measures

Despite the advantages that the use of behaviour rating questionnaires might provide for the assessment of executive functions in everyday situations, concern for the ecological expression of the traditionally used measures remains a recurring theme in the current clinical and educational context. An example of this is the recent emergence of the Aula tool, from Nesplora (Climent & Bánterla, 2011). This is a CPT that is carried out in a virtual reality environment, seeking to reproduce conditions that are as similar as possible to the reality of a classroom. This measure would therefore present greater ecological validity than the other performance-based measures previously discussed.

One of the foremost reasons for this concern is the low correlation found between the performance of children and adolescents in the performance tests and the difficulties observed in diverse areas of daily life and the low agreement found in some cases between the information provided by different informants, mostly between families and teachers, even when parallel forms of the same questionnaire are administered (Bishop, 2011; Gioia et al., 2010; Lezak et al., 2012; McAuley, Chen, Goos, Schacar, & Crosbie, 2010; Toplak et al., 2009). These studies inform of the presence of low to moderate associations between the information obtained by different methods or informants.

With regards to the existence of a low correlation between the two types of measures (performance measures vs. behavioural observation), studies such as the one conducted by Toplak et al. (2009) support this assertion. These authors compared executive functioning in a group of adolescents with ADHD and a control group, employing performance-based measures and questionnaires administered to families and teachers. This study found that adolescents with ADHD showed significantly lower performance based on the performance task compared to the control. When the



same participants were evaluated by their families and teachers, the group with ADHD presented higher deficits in executive functioning. However, when the results obtained using the two types of measures were compared, the correlations were weak to moderate. In this sense, authors such as Lezak et al. (2012) note that this low correlation between the measures may be due to the specific conditions under which the performance tests are administered, characterized by face-to-face interaction, high levels of structuring and minimal levels of distraction. These contexts differ considerably from most everyday contexts in which children and adolescents are immersed, such as the home, the school or other leisure or relational environments. Additionally, other aspects such as the level of support or stimulation that the assessor provides to the children and adolescents, giving structure and enabling them to persist in the task, could explain these differences.

With regards to the lack of agreement sometimes found between the answers provided by different informants (mainly families and teachers) on the behavioural observation scales, this could be due to the fact that these two areas of daily life differ as to the informational spaces involved, which would also make the executive control demands different. In this sense, the demand for executive activity would be heterogeneous with regard to the different spaces, depending on factors such as how novel, structured, challenging and cognitively demanding they prove to be for the children and adolescents (Ardila, 2008; Chan et al., 2008).

Current perspectives regarding the difficulties in the study of executive functions

Within this scenario, García-Molina, Tirapu-Ustárrroz, and Roig-Rovira (2007) emphasize that the ecological validity in the assessment of the executive functions does not depend exclusively on the tests administered but rather on the adequate contextualization of the information obtained. Accordingly, these authors point out the importance of issues such as the objective of the evaluation (e.g., very different protocols are required when the assessment is clinical or more education focused), the objective of the assessment in each case (e.g., to establish a profile on the competence of the various executive components or to predict daily functioning), or the population at which it is aimed. Additionally, having a deep understanding of the reality in which children and adolescents are immersed, along with their personal characteristics would be another

essential aspect, as it would enable the delimitation and a better understanding of the findings of the investigation. All of these aspects should allow the practitioner to avoid making erroneous predictions or inferences regarding the functional capacity of the individual in their daily lives. In this sense, these authors emphasize a number of aspects relating to the administration of the evaluation tests, among which the following stand out: the need for the performance-based evaluation to be carried out by specialists whose experience and knowledge regarding the relationships between the brain and behaviour enables them to interpret the data based on a solid framework of reference; the convenience of selecting the assessment instruments based on their ability to provide information on the underlying mechanisms that are altered, their level of ecological validity and their sensitivity to detect the progress and changes that occur; and finally, the importance of having information on aspects such as premorbid executive functioning, environmental cognitive demands or the compensatory strategies that children and adolescents use. All this will serve to appraise or predict the effects that executive deficits may have on daily functioning in contexts such as the home and school.

CONCLUSIONS

The issues discussed in this study can be summarized in three main ideas or conclusions:

The first is the relevance of the executive functions as determinants of the behaviour and performance of children and adolescents in contexts as diverse as education, the family or social relationships. Hence the need for reliable and valid assessment tools that not only enable the evaluation of these components but also predict the extent to which possible deficits in the executive functions may determine the daily functioning of children and adolescents in significant contexts.

The second conclusion is the need to establish an appropriate correspondence between the information obtained from the different measuring instruments. While the information based on performance in laboratory contexts is of significant value, there is a need to extend the framework to the behaviour in real situations of daily life. However, the studies carried out to date suggest the existence of a low association between these, which limits their usefulness somewhat. Thus, other sources of information should be considered, such as the direct observation of behaviour in the contexts of home or school, or information from children and adolescents



about how they perceive their own behaviour (Barkley & Fisher, 2011; Dahlgren, Lask, Inge, and Rø, 2014; Heinonen et al, 2013). An example would be the self-report version of the Behavior Rating Inventory of Executive Function (BRIEF-SR), created by Guy et al. (2004), applicable from 11 to 18 years of age.

Finally, the recommendations derived from scientific evidence suggest the need to explore the full range of components that comprise the executive functions through indexes that represent them, looking both at the cognitive as well as the emotional and behavioural correlates of this construct. The characteristics of children and adolescents, as well as the context in which they are immersed, the determinants of their behaviour and the kind of strategies they employ to cope with the possible difficulties should also be taken into account and understood as aspects to be considered in the evaluation process.

Ultimately, making further progress in the study of the different components of the executive functions, their characteristics and expression should be understood as the first step in creating a framework for as robust and comprehensive an assessment as possible, based on which to design intervention strategies that are adapted and ecologically valid.

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