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Clinical features of brain activation deficit in children

Características clínicas de niños con déficit de activación cerebral general

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| Abstract |

Introduction: Brain activation is considered as one of the mechanisms of the brain related to the functional state of deep subcortical structures. A deficit in this mechanism may be involved in behavioral disorders during development and school learning.

Objective: To identify the clinical features of Mexican schoolchildren with general brain activation deficit, and to determine the neuropsychological tasks that help to detect this syndrome.

Materials and methods: The sample included 20 Mexican schoolchildren attending regular schools and diagnosed with behavioral and/or learning disorders. The types of errors and performance in neuropsychological tasks were analyzed by categories.

Results: The results showed that there are common clinical features in schoolchildren, particularly, executive instability, fatigue and/or slow execution, and instability in memory and perceptive graphic tasks. These features can be demonstrated through the qualitative syndromic analysis of perceptive graphic tasks, retention tasks and manual praxis.

Conclusions: Qualitative assessment is effective to differentiate this type of cases from other possible neuropsychological conditions.

Keywords: Neuropsychology; Evaluation; Diagnosis (MeSH).

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| Resumen |

Introducción. La activación cerebral general se considera como un mecanismo de trabajo cerebral relacionado con el estado funcional de las estructuras subcorticales profundas; su déficit puede subyacer a los trastornos conductuales durante el desarrollo y el aprendizaje escolar.

Objetivos. Precisar las características clínicas de escolares mexicanos con déficit de activación cerebral general e identificar las tareas neuropsicológicas que ayudan a la detección de este síndrome.

Materiales y métodos. Se incluyeron 20 casos de escolares mexicanos: alumnos de escuelas regulares con problemas de conducta o aprendizaje que solicitaron apoyo de evaluación neuropsicológica. Se analizaron los tipos de error y la forma de ejecución de tareas neuropsicológicas por categorías.

Resultados. Se demostró que existen características clínicas comunes en los escolares evaluados. Como rasgos particulares se identificó inestabilidad en la ejecución de tareas neuropsicológicas, fatiga o lentificación e inestabilidad en el mantenimiento de huellas mnésicas y durante la realización de tareas gráfico-perceptivas. Estos rasgos se evidenciaron a través del análisis sindrómico cualitativo en tareas gráfico-perceptivas, de retención en diversas modalidades y de praxias manuales.

Conclusión. Se encontró eficacia clínica de diferenciación en este tipo de casos frente a otras posibles dificultades a nivel neuropsicológico.

Palabras clave: Neuropsicología; Evaluación; Diagnóstico (DeCS).

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Introduction

According to Luria (1), the brain has three functional blocks, one of which is related to subcortical regulation levels. The author named this unit first functional block of the brain.

From a structural point of view of the first functional block, most of them are nuclei of the reticular formation located in the central part of the brainstem and in diverse parts of the thalamus (2). These nuclei have ascending and descending connections that are in charge of regulating the cortical tone, sleep and consciousness states, orientation reflex, stability, and the course of the mental processes. The literature shows that these structures are related to emotional, vegetative and mnesic regulation (3), and several opinions about their correlation with cognitive functioning can be found (4). The projections of the ascending reticular system reach non-specific nuclei in the thalamus, from where projections

are sent to the cortex (2) to activate it and regulate the status of its activity.

As stated by Luria (1), the contribution of the first functional block is fundamental for maintaining the cortical tone necessary for performing any type of cognitive activity. This takes on a particular meaning in school age, when children invest most of their time in cognitive tasks that require executive stability, continuous attention and active stay during tasks. Thus, without a specific modal influence, the first functional block makes an uncertain but fundamental contribution to successful accomplishment of this type of tasks.

Accordingly, it is useful to consider deep subcortical structures as one of the fundamental neuropsychological factors involved in cognitive task performance at school age, which can be called general nonspecific activation factor (5). This factor is implicated in cortical energy activation and in general regulation of all mental processes (1); its functional weakness generates instability in the execution of cognitive actions. Such instability can be increased or expressed more clearly in fatigue states, loss of motivation, or increased complexity for executing an action (5).

Deep subcortical structures are particularly sensitive to adverse conditions in the perinatal and postnatal period. A deficient functional status of subcortical regulation levels is considered part of almost all immature syndromes or disorders in higher mental functions (6), preventing the nervous system from maintaining an adequate alert level and causing a general failure in information processing required to perform cognitive tasks (7).

At the neurophysiological level, several investigations have performed a qualitative analysis of electroencephalographic records in preschoolers (8-10) and schoolchildren (11-14) diagnosed with attention deficit hyperactivity disorder (ADHD) or learning problems (15-19). These works have identified a immaturity state in the non-specific activation system (20,21), which is especially relevant since attentional processes fundamentally depend on the reticular formation (22). In the field of qualitative neuropsychology, several clinical studies have been carried out to identify behavioral and cognitive traits in children with these deficits; from this perspective, a neuropsychologist can identify the altered factor to understand the syndrome and provide tools for its reorganization (23-26).

Studies on preschool children diagnosed with ADHD have established that the functional weakness of the general nonspecific activation factor is one of the responsible factors. Typical errors and difficulties are related to fatigue, latency, short latencies to initiate an activity, difficulties in motor coordination activities, and executive instability in the presence of micrographs and macrographs (8,10). At school age, trace interruption, task abandonment, weak tracing and simplification have also been found (13,14). Difficulties in concentration and disturbances in attention have been described; in addition, greater fatigue caused by hyperactivity has also been observed as a compensation for the lack of stimulation of the central nervous system (6,27).

Furthermore, difficulties to evoke verbal and visual information of material semantically unrelated have also been observed in 7- and 8-year-old schoolchildren with immaturity in the nonspecific regulation system (20). The same observations have been made in the neuropsychological clinic of adults with brain lesions in deep subcortical structures (28-30). In this regard, Glozman (6) reports that the acquired information is unstable or inhibited by the interference of various influences, especially homogeneous influences, even with sufficient memory capacity.

The deficit of this neuropsychological factor can alter the performance in tasks and activities assigned during school learning,

manifesting fatigue states before the complexity or duration of an activity increase (6). However, it is still necessary to systematize behavioral and cognitive clinical evidence that may help to define the presence of non-specific brain activation in cases of students with behavioral and learning problems. In particular, there are few data on these difficulties in school age, which makes the work of specialists difficult and does not allow differentiating these cases from those with a predominance of regulation and control problems. Meanwhile, none of the neuropsychological factors mentioned above can be identified in cases with an ADHD diagnosis, which makes differential neuropsychological diagnosis difficult, as well as decision making on treatment.

The objectives of this study are to characterize the clinical performance of schoolchildren with learning or behavioral problems who present deficits in the nonspecific brain activation factor, and to identify the neuropsychological tasks that help detecting this syndrome.

Materials and methods

Subjects

Twenty records of schoolchildren between 6 and 12 years of age were selected out of 105 patients attended due to learning or behavior problems in the neuropsychology unit of the university hospital of Universidad Autónoma de Puebla, México, in the period 2012-2015. Similar clinical features were identified in the selected cases, which allowed diagnosing functional deficit of nonspecific cerebral activation.

Out of 20 cases analyzed, 18 corresponded to males and six had been previously diagnosed with ADHD. The mean age was 8, and problems in school learning or behavior were the main cause for consultation. All children were public school students in Puebla.

None of the selected cases was related to pathological history (trauma or brain tumor) or to the presence of primary hearing impairment, vision or motor problems.

Material

All the participants were given the qualitative neuropsychological evaluation protocols "Puebla-Sevilla Child Neuropsychological Evaluation" (31) and "Verification of School Success in Primary School" (32). For data analysis, the tasks of both protocols were systematized by categories: graphic-perceptive, retention in different modality, manual coordination and intellectual tasks (Table 1).

Procedure

The types of error observed were recorded per subject, as well as the characteristics and difficulties found by the evaluator at the time of the assessment.

For the qualitative analysis, the responses were recorded and the most frequent types of errors and executions were characterized in the neuropsychological evaluation tasks. In addition, a comparison between tasks that showed typical errors and those that did not show any error was made. The tasks were classified in verbal, graphic-perceptive, retention, motor coordination and intellectual tasks. For the quantitative analysis, the types of errors and the most frequent execution characteristics were determined in the whole sample and in the different tasks of neuropsychological evaluation.

Table 1. Neuropsychological and intellectual tasks analyzed.

Category	Tasks in the "Puebla-Sevilla" neuropsychological evaluation protocol
Verbal	Repetition of syllables, sounds and word pairs
Graphic-perceptive	Free animal drawing Copy of a house Copy and continuation of a graphic sequence
	Visual Retention
Retention in different modality	Reproduction of letters and figures and their evocation after homogeneous interference Reproduction of free animal drawing
	Auditory-verbal retention
	Involuntary/voluntary retention of two sets of three words and recalling them after heterogeneous interference Repetition of sentences
	Kinesthetic integration
Manual coordination	Reproduction and evocation of finger positions on the opposite hand
	Reciprocal coordination of hands Sequence of manual movements Swapping finger positions
Category	Tasks of the "Verification of success in primary school" protocol
Intellectual tasks	Writing
	Copy and dictation of sentences Independent writing
	Lecture
	Reading sentences and short texts
	Calculus
	Solving arithmetic problems

Source: Own elaboration based on Solovieva *et al.* (31) and Solovieva & Quintanar (32).

Results

A qualitative analysis of the clinical manifestations in neuropsychological tasks was performed. Table 2 shows the types of errors and the most common execution characteristics identified during the accomplishment of the tasks in each category.

The different neuropsychological tasks provided interesting data. First, perceptual graphs showed types of errors such as micrographs, macrographs and loss of horizontality that were also evident in writing. Retention tasks showed difficulties to retain visual and auditory-visual information. Manual coordination tasks showed poor fluency in the movements; however, in some cases, the help of the evaluator was important to fulfill the task with better fluency. Finally, the execution of the students' verbal tasks improved when the evaluator repeated the information, even in the presence of phonemic substitutions.

Figure 1 presents some examples of the most common error types identified in perceptual graphic tasks.

Table 2. Summary of the types of errors and execution in neuropsychological tasks.

Category	Type of error	Characteristics of execution
Verbal	Phonemic substitution	Correct execution or error overcome with the help of the evaluator Impossibility even with help Help: repetition of the series by the evaluator
Graphic-perceptive	Micrographs/macrographs Instability or interruption in trace Loss of horizontality Lack of characteristic traits	Slowing down Latency
Retention in different modality	Visual retention	
	Loss of elements Micrographs/macrography Recovery of disorder elements Lack of characteristic traits Trace instability	Slowing down Latency
	Auditory-visual retention	
	Phonemic or semantic substitution Partial loss of elements Total loss of elements Recovery of disorder elements	Correct execution Latency Help: repetition of the sentence to improve execution
	Kinesthetic retention	
	Impossibility to perform the posture	Correct execution with or without active search for posture Impossibility to perform the posture even with active search
Manual coordination	Poor fluency or impossibility even with the help of the evaluator	Correct execution Auto-correction or error overcome with the help of the evaluator Help: verbal regulation "I close the right hand and I open the left one" and slow execution of the movements

Source: Own elaboration based on the data obtained in the study.

Intellectual tasks included writing, reading and calculation. The qualitative analysis established types of errors such as substitution or omission in writing and reading tasks that arose after feeling fatigue, and improvement in the execution with the aid of the evaluator (Table 3). In addition, about 50% of the sample did not consolidate literacy and calculation processes.

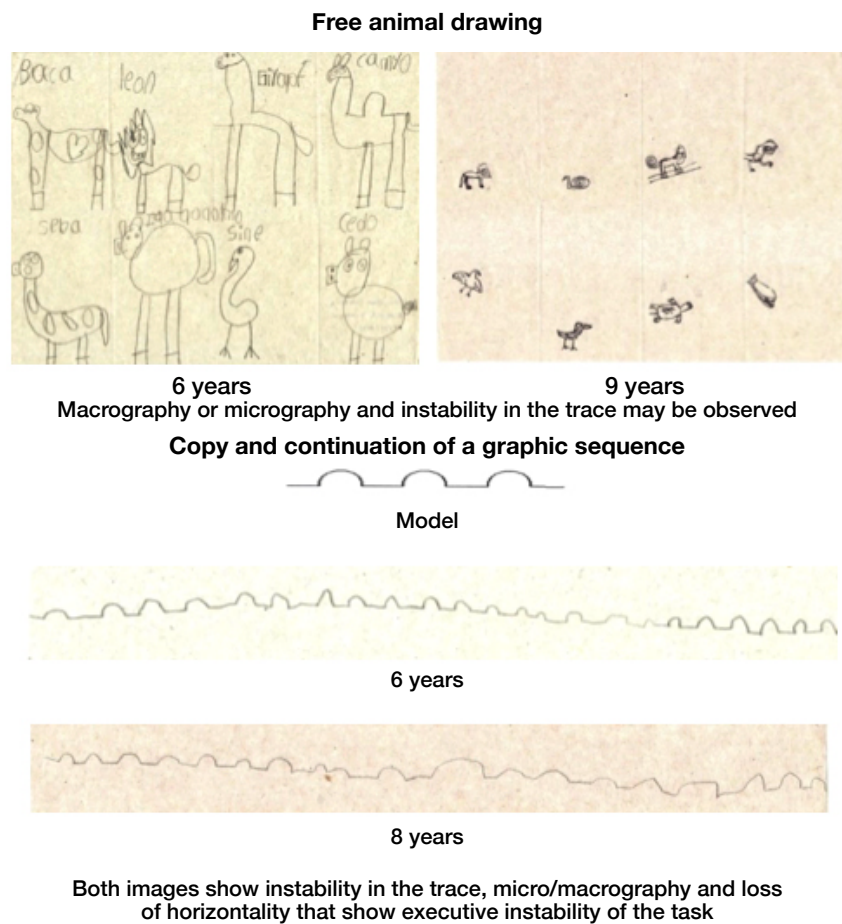


Figure 1. Examples of common error types in perceptual graphic tasks.
Source: Own elaboration based on the data obtained in the study.

Table 3. Summary of the types of errors and execution in intellectual tasks.

Category	Types of error	Execution characteristics
Intellectual tasks	Writing	
	Loss of horizontality Omission/substitution Micro/macrography Instability in trace	Unbound process Latency/slowing down Help: repetition of the sentence at dictation
	Reading	
	Substitution/omission	Unbound process Poor fluency
	Calculus	
	Rotation of a number	Unbound process Correction with the help of the evaluator Help: the operation is repeated Difficulties when the task becomes more complex

Source: Own elaboration based on the data obtained in the study.

Figure 2 presents examples of the writing task and the most representative error types in schoolchildren of different ages.

For the clinical characterization, the most frequent types of error and execution were identified in all sample individuals, which allowed obtaining a deficiency table of non-specific cerebral activation in

Mexican schoolchildren. Table 4 shows the frequency of the types of error committed in the different neuropsychological tasks.

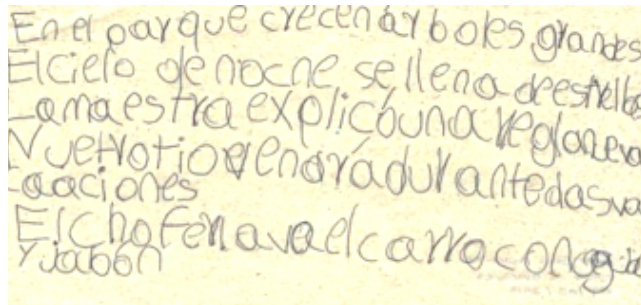
In general, qualitative characteristics were observed during the execution of the proposed tasks. In most cases, children accepted the help provided by the evaluator to improve task execution; sometimes they requested help in order to repeat the instruction or to perform the task. A slow performance was observed during task execution, as well as distraction to various stimuli, restlessness or fatigue.

Furthermore, 10 types of errors were identified in more than 50% of the sample, mostly related to visual and auditory-verbal retention tasks, as well as graphic-perceptive, manual, verbal, reading and writing coordination tasks (Table 4).

It is important to specify that each child of the sample always presented more than one type of error in the tasks. For example, it was possible to see micrographs/macrographs in graphic tasks and instability in the trace (Figure 1).

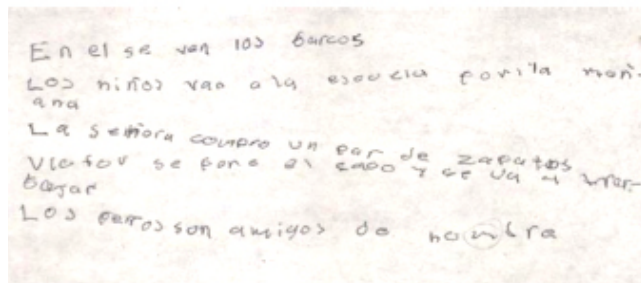
Discussion

According to Fishman (33), several causes that affect the brain in the prenatal or postnatal period may delay the maturation of brain structures and their connections, which are manifested through the discordance between the social demands on the activity and the neurophysiological possibility to guarantee an adequate level of nonspecific regulation (10). In these cases, difficulties in development and school learning can be expected, based on the non-optimal functional state of the first brain unit according to Luria’s conception (1,34).

Typing based on another text

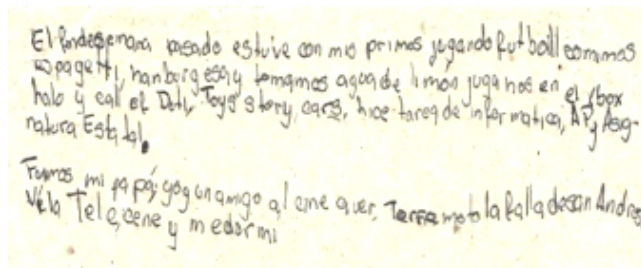
6 years

Macrographs, block writing, and spelling errors

Dictation

7 years

Loss of horizontality and omissions

Independent writing

12 years

Loss of horizontality, instability in the trace and block writing

Figure 2. Examples of the most common types of typing errors.

Source: Own elaboration based on the data obtained in the study.

The results showed that there are common clinical features in schoolchildren with functional deficits in the nonspecific brain activation factor during neuropsychological assessment, regardless of the initial reason for consultation (learning or behavior problems). Moreover, it was possible to identify sensitive tasks that help detecting this syndrome during the neuropsychological assessment based on instability, fatigue or latency during the assessment, as well as to differentiate these features from other types of errors related to functional weakness of other neuropsychological factors. In this work, such tasks were graphic-perceptive, retention in visual and auditory-verbal modality, manual coordination and writing.

The absence of these tasks in common psychometric evaluation protocols or quantitative cutoff tests, as well as the inability of specialists to detect the corresponding errors and differentiate them from other types of errors, makes it difficult to identify the state of nonspecific cerebral activation. These difficulties may be unnoticed or mistaken with problems in regulation and control factors, while

ADHD (35,36) or problems in executive functions (25) may be suspected from traditional diagnosis.

Table 4. Most frequent types of error and execution in the sample throughout the neuropsychological evaluation.

Tasks	Types of error	Frequency (cases)
General characteristic during evaluation	Accepting adult support	17
	Slowing down	15
	Requiring repetition by the evaluator	13
	Distraction to various stimuli/ restlessness	13
	Fatigue	11
Graphic-perceptive	Instability in trace	19
	Micro/macrographs	19
Auditory-verbal retention	Loss of elements in at least one mode	20
Visual retention	Loss of elements	19
Graphic sequence	Trace interruption	18
Graphic sequence and writing	Loss of horizontality	18
Verbal tasks, reading and repetition of sentences	Phonetic or semantic substitutions after fatigue	18
Writing	Slight substitutions and omissions in some of the writing tasks	15
Manual coordination	Poor fluidity in movements	11
Drawing animals	Lack of characteristic traits found in children between 6 and 8 years of age as they draw	10

Source: Own elaboration based on the data obtained in the study.

Data indicate latency and fatigue as the main characteristics, both in children with a previous ADHD diagnosis (13,14) and in cases in which a formal diagnosis is missing, only mentioning learning or behavior problems. Distraction before various stimuli and restlessness in the presence of fatigue was identified as a behavioral characteristic. In the literature, these behavioral characteristics are included under the term “hyperactivity” (35,36). In addition, it was observed that children accept the help of adults to improve their performance, as opposed to cases with primary affection of other brain mechanisms in which the external assistance is not effective (9).

Results showed that executive instability during the evaluation allowed identifying insufficiency of the activation tone of the cerebral work. Therefore, in graphic-perceptive tasks, there is instability in the trace, as well as micrographs and macrographs. These types of errors have been identified in preschoolers and school children with ADHD in which functional weakness underlies the non-specific activation factor (8-10,13,14). Furthermore, Machinskaya & Semenova (20) identified difficulties in visual and auditory-verbal retention in schoolchildren aged between 7 and 8 years. These difficulties were related to information evocation without finding variability with age, which implies instability before the deficit (6).

It is important to note that results indicated that almost 50% of the children did not consolidate school skills, which may be related to the use of pedagogical strategies in primary school in general. At the same time, it can be assumed that the lack of nonspecific activation prevents evaluated children from properly consolidating

school habits, turning them into children who manifest learning problems. The qualitative analysis of the types of errors presented by students allowed to identify phonemic substitutions that appeared due to tiredness during reading tasks (18 cases), as well as loss of horizontality and, sometimes, substitutions and omissions of consonants in writing tasks (15 cases). These characteristics imply that the deficit of this neuropsychological factor prevents adequate performance and the acquisition of the required abilities for literacy.

These data coincide with the latest publications that point out the need to consider the functionality of the first brain block during the neuropsychological evaluation and the presence of particular characteristics in the school activity, as well as the evidences during the neuropsychological evaluation. Future studies dedicated to the detailed analysis of errors in the literacy process will allow clarifying the errors related to the use of pedagogical strategies and cerebral functional weakness during the neuropsychological evaluation (37).

The obtained results may indicate a way for identifying difficulties related to the functional deficit of the first brain block, which has not been a frequent topic in neuropsychology so far. The possibility of correlating neuropsychological assessment data with electroencephalographic recordings can provide valuable information about the involvement of subcortical regulation levels at school age (38).

It is worth noting that qualitative neuropsychological evaluation and syndromic analysis allow the detection of objective clinical features. The first is a very useful tool for differential diagnosis and for the treatment of cases with learning problems and difficulties in development.

Conclusions

Qualitative neuropsychological assessment in Mexican schoolchildren provided relevant information for the detection of nonspecific cerebral activation syndrome. The syndrome was characterized by instability in the performance of neuropsychological tasks, fatigue, latency or short latencies at the beginning of an activity. Typical errors included micrographs/macroglyphs, loss of horizontality and instability in traces during graphical tasks, poor fluidity of the movements during motor tasks, as well as instability in the maintenance of the mnemonic traces in visual and auditory-verbal retention tasks. The data obtained can be useful to generate intervention strategies and neuropsychological correction of children with this neuropsychological syndrome.

Conflict of interests

None declared by the authors.

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