

## School Performance in Tests Attention and Executive Functions: Comparative Study

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### Abstract

**Introduction:** Executive functions (EF) and attention are important cortical functions to the learning process and are involved with the development of educational skills of reading, writing and arithmetic, as well as allowing the individual engaging in their daily actions.

**Objective:** This study aimed to investigate the relationship between FE, attention and academic performance of children with and without learning disabilities, of both sexes and aged between 10 - 11 years, the fifth year of a public school.

**Method:** The study included 27 children who were evaluated using the instruments for attention: Cancellation Test and Trail Making Test Part A; for executive functions; Trail Making Test - Part B, Stroop Color Word Test and Tower of London; to assess the intellectual capacity: Raven Progressive Matrices.

**Results and Conclusion:** The results indicate that children with learning disorders have underperformed the instruments that evaluate executive functions and attention when compared to children without difficulties.

**Keywords:** Attention; Executive Function; Learning Disabilities

### Introduction

The term learning disability (AD) encompasses different problems with a wide variety of causes. In functional terms, being ready for school learning means having maturation of the functions necessary to properly perform tasks and have the skills to do so. Most of the time, children who do not have the same pace of learning as their peers are seen by the school as students problems that manifest cognitive delays [1].

Regarding Learning Disabilities (AD), Fonseca [2] says that it is a subject that requires a complex interdisciplinary reflection because the subject when learning a given task presents a unique combination of talents and vulnerabilities that gives him a learning profile specific.

There is still much to study and research to better understand the intrinsic relationship between learning and the integrity of complex brain functions, with the most rapid neurofunctional transformation occurring during the first years of schooling [2].

The difficulty of learning with its multiple causes and development suggests research in the most diverse fields of knowledge to obtain a broader view on the subject. What is perceived is the interweaving of factors of organic, intellectual, cognitive and emotional origin that become responsible for its complexity [3].

Risk factors include low birth weight, malnutrition, sensory and motor problems, genetic factors, changes in the development of the central nervous system (CNS), family, psychosocial, psychiatric and pedagogical problems among others [4]. In addition to the cited factors, studies demonstrate evidence of relationship between executive functions (FE), attention and school performance [5]. Neurological studies suggest that some cognitive functions may be impaired in the context of learning difficulties, such as attention, working memory, cognitive flexibility [6-8].

Studied by different areas of knowledge such as psychology, physiology, neuroscience, biology, attention can be defined as the individual's ability to respond to certain stimuli to the detriment of others and thus ensure an efficient interaction with the environment [9]. The attention is selective and directional in nature, which maintain vigilance about what happens around us, respond to relevant stimuli, and inhibit those that are not in our immediate interests or tasks [10].

A more elementary form of attention, present in the first years of life of the individual is the "involuntary", which has a biological origin and is strongly attracted by external stimuli. The second form of attention, the "voluntary", is more elaborated and socially constructed by the school-age child, requires some degree of maturity of the nervous system and is related to the ability to respond to verbal instructions, despite distracting stimuli [10,11].

Because it is not a single process, attention can be divided into selective, sustained, divided and alternating. Selective attention is related to the ability to discriminate relevant stimuli from irrelevant ones. The sustained one is to be able to maintain the attentional focus in a specific stimulus during the execution of a task. Divided attention is the ability to divide the attention focus by performing two tasks simultaneously. The altered one consists of the capacity to alternate the attentional focus between different stimuli [11].

Executive functions are related to the skills needed to plan, initiate, perform and monitor intentional behaviors related to an environmental demand or a goal in order to interact more adaptively with the world [9,10,13]. They allow the individual to emit behaviors toward goals, to be motivated to start the day, to plan ahead, to curb inappropriate behaviors, to deal well with the stresses of everyday life, to learn from mistakes, and others.

Learning and EF are related, since such functions are shaped by educational influences, and can even be "taught" from family interactions in the different environments to more complex academic, social and leisure activities [11,14].

Studies on executive functions have developed from the technological resources of neuroimaging, however it is important to highlight the lack of research in children, due to the ethical limitations of some invasive procedures and other restrictions related to developmental patterns. For the most part, studies are conducted with adults, and there are not many specific instruments for child assessment to establish an established pattern of changes in these functions in children [15].

The executive functions involve different cognitive processing (selective attention, integration and manipulation of relevant information, impulse control, intention, cognitive and behavioral flexibility, attitudes monitoring, working memory), and these processes are called "executive functions" that will allow to initiate, plan, sequence and monitor their behaviors and cognitions [16].

Researches refer to the importance of evaluating FE not as a single construct, but to dismember it in components such as working memory, inhibitory control, selective attention, flexibility and planning, and the use of appropriate instruments is fundamental. We highlight

the development of tests used to evaluate FEs such as Stroop Test, Track Test, Tower of London Test, which assess selective attention, inhibitory control, flexibility and planning, respectively [17].

Likewise, research reports that there is evidence of the relationship between executive functions and school learning. They consider in their studies with preschool that executive skills and attentional control significantly predict success in subsequent years in both math and reading. In addition to academic success, executive functions may also be related to social and mental problems that lead to disruptive behavior and school dropout [18].

León, *et al.* [6] evaluated in their study 40 children aged 6 to 9 years, students from a public school in the greater São Paulo and concluded that, children evaluated as having better executive skills also presented better school performance.

Lima, *et al.* [19] developed a study in which 36 schoolchildren, 18 females and 18 males, ranging from 7 to 11 years of age, were studied in primary school (1<sup>st</sup> to 4<sup>th</sup> grade), where the criterion of inclusion was not learning difficulties. The Track Test, the Cancellation Test, the Tower of London Test and the the Stroop Color-Word Test.

As a result, age and performance effects were found in the performance mainly in relation to the instruments' time scores, which is an indication that the performance tends to improve according to the age group and the educational level.

Considering the importance of understanding the relationship between cognitive functions and learning, this study aimed to compare the performance of children with and without complaints of learning difficulties in instruments that evaluate aspects of executive functions and attention.

### Method

The study was carried out after approval by the Research Ethics Committee of the Faculty of Medical Sciences of UNICAMP, under Opinion No. 1,303,377. A descriptive, cross - sectional study was developed with control group and quantitative method.

### Participants

A total of 27 students from 5<sup>th</sup> grade of elementary school, aged between 10 and 11 years old, participated in the study, being 16 boys and 11 girls. The sample was divided into two distinct groups according to academic performance in the first three months of the current school year, 13 children with complaints of learning and attention difficulties and 14 children without complaints. The groups were organized by the acting teacher in the classroom.

Criteria for inclusion of the experimental group were: to present a complaint of learning difficulties; the signing of the Term of Free and Informed Consent (TCLE) by the parents and the Free and Informed Consent Form (TALE) by the children. Exclusion criteria were: to present a sensorimotor alteration; diagnosis and/or comorbidity of other neurological or psychiatric origins.

For the control group (CG), the inclusion and exclusion criteria were the same, with the exception that students should present good academic results, without complaints of learning difficulties.

The data were collected among 5<sup>th</sup> year students from a municipal school in the city of Nova Odessa/SP, which attends elementary school students.

Initially the project was presented to the coordination and direction of the school for the presentation, explanation of the objectives and procedures of the same. The consent of the school unit was effected by means of a letter of authorization. The pedagogical coordinator presented the research to the teacher and was asked to indicate the children according to the inclusion and exclusion criteria.

The children who formed the CG and GE belonged to a fifth year room of a municipal school in the city of Nova Odessa/SP, selected from the results achieved in the academic performance of the three bimonths of the year, forming the two groups: GC with the children who obtained the best results and the GE formed by the students that presented difficulties of learning and/or attention.

The project was presented to the parents and, if everyone agreed, they signed the TCLE. The evaluations were carried out at the institution where the children study in a room provided by the school. The instruments were applied individually during the regular period and during two sessions lasting approximately 50 minutes.

In order to perform this work, the subjects were submitted to the evaluation with the following instruments: Raven [20] Colored Progressive Matrix, a non-verbal intelligence test, "designed to cover the full range of intellectual development from the moment the child is able to understand the idea of finding the missing piece to complete a drawing".

Such instrument is indicated mainly for the evaluation of children with ages between 5 and 11 years and a half. It is divided into three series: A, Ab and B, each with 12 problems, which are printed with a vivid colored background in order to make them more attractive.

The evaluation of the test is done through a template or correction key, with one point assigned to each "right" response. The total score corresponds to the number of "hits". But this result does not correspond to the real potential if there has been any interference of any variable in the application. Therefore, the consistency of the score must be checked (a subtraction between the partial totals obtained in each series and the expected partial totals), none of the differences can be greater than 2 and the algebraic sum of the 3 differences obtained must be equal to zero. Otherwise, the test is not considered a valid estimate for the subject's intellectual capacity.

Finally, the significance of the score is interpreted through the percentile associated with the score, since it indicates the percentage of people who, in the standardization sample, are below a certain gross result, that is, the relative position of the person tested. After obtaining the percentile, the child's level of intelligence must be interpreted according to the classification: intellectually superior (grade I); definitely above average (grade II); intellectually average (grade III, with variation of III + and III-); (grade IV and IV) and, finally, intellectually deficient (grade V).

To evaluate the Attention, the instruments were used:

- a) Cancellation Test (TC) [21] that evaluates visual sustained attention in two versions: (1) Geometrical figures (TC-FG): composes a leaf with a random sequence of simple geometric figures and the child should mark all the circles found as fast as possible; (2) Letters in Row (TC-LF): This is a sheet with randomly distributed letters and the child should mark all letters "A" as fast as possible. For performance evaluation, the run-time criteria expressed in seconds and errors - sum of errors committed by default and addition are used.
- b) Trail Making Test (TMTA/B) [22] where Part A of this instrument is a sustained attention test and evaluates visual tracking, processing speed, visual attention and mental flexibility and is composed of a sheet with circles numbered 1 to 25, randomly distributed and the child must draw a line connecting the numerical sequence as fast as possible. Performance is evaluated in terms of time to perform the test (expressed in seconds) and the number of errors (wrong sequence connections).

In order to evaluate the Executive Functions, the following were used:

- a) Trail Making Test (TMTA/B) [22] in which Part B of this instrument is considered a mental flexibility test, composed of circles with numbers ranging from 1 to 13 and letters ranging from A to M (excluding the letter "K") on the inside. The child should draw a line connecting the circles with numbers and letters alternately (1 - A - 2 - B - 3 - C...), following the correct numerical and alphabetical orders. Performance is evaluated in terms of time (in seconds) and errors represented by the sum of sequence and toggle errors.
- b) The Stroop Color Word Test (SCWT) [23], a test that aims to evaluate the inhibitory control (ability to inhibit automatic response to controlled response) and selective visual attention (selection between relevant and irrelevant information). Four colors (red, yellow, blue and green) are used with 24 stimuli in each of the three parts: (i) "Color Card" (C): composed of squares painted in four colors arranged in random order, in which the child appoint as soon as possible; (ii) "Words Card" (P): composed of color names printed in the corresponding colors (congruent situation), in which the child must say the name of the colors as fast as possible;

(iii) "Color Word Card" (CP): composed of color names, but printed in incongruent colors, for example, the word Green printed in blue color (incongruous situation). Again the child should say the color and not name the word as soon as possible. Performance is measured by time (in seconds) and error scores for each of the cards.

- c) Tower of London (TOL) [24], a test that assesses the ability of planning and logical reasoning. The tower consists of a wooden base with three vertical pins and four colored disks of the same size, with a hole in the center for the docking on the pins. The goal is to move the discs to reproduce, in a given number of movements, the position of a target figure displayed. There are ten problems with increasing degree of difficulty, and from an initial position the child must perform the task in a specific amount of movement. Three attempts are allowed to solve the problem and the answer is considered correct when the solution is reached with the correct number of movements. The scores of each item can vary from 0 to 3 points and the total score is the sum of the scores of all items. The total score can range from 0 to 30 points.

## Results

### Sample characterization

A total of 27 students, 16 males and 11 females, were evaluated in this study. The mean age of the experimental group was 10,143 and the GC was 10,536, with no significant differences between them. Table 1 shows the frequency of the genders in relation to the study groups, a greater frequency of the masculine gender is observed in both groups. Analyzing the characteristics of the sample, we observed a higher frequency of male children in both the experimental group (67.5%) and the control group (57.1%). Similar results have been

	GE (n = 13)		GC (n = 14)	
	F	%	F	%
Male	8	61,5	8	57,1
Female	5	38,5	6	42,9
Total	13	100	14	100
Middle Ages	10,143		10,538	

**Table 1:** Sample characterization.

GE: Experimental Group; GC: Control Group; F: Frequency.

found in studies characterize childcare services and describe an overlap of the male gender associated with school complaints [26-28].

The comparison of performance between groups in the instruments used can be observed in tables 2 and 3.

The results indicated that, in relation to performance in the Attention tests, there was a statistically significant difference in time scores of the TMTA ( $p = 0.003$ ) and the TC2-T ( $p = 0.007$ ), in which the GE had a longer time in relation to GC (Table 2).

Table 3 compares the performance between the GE and GC groups in the instruments used to evaluate aspects of the FE. The results indicated that there was a statistically significant difference in the Stroop Word Color Test instrument in the Interference score in relation to the time.

## Discussion

Complaints about learning disabilities related to inattention motivate most referrals of children and adolescents for multidisciplinary evaluation as suggested by the characterization study of the cases treated at the Neuro-Learning Disabilities Outpatient Clinic of UNICAMP/São Paulo Clinic, where they found (46%) is motivated by low academic performance related to reading, writing, calculating, literacy problems and to accompanying school activities [12].

Inst.	GE (n = 13)				GC (n = 14)				Sig. (p)
	Min.	Máx.	M	DP	Min.	Máx.	M	DP	
TMTA_T	37,0	97,0	64,0	17,0734	20,0	70,0	43,071	14,1065	,003*
TMTA_E	,0	1,0	,154	,3755	,0	1,0	,071	,2673	,720
TC1_T	65,0	161,0	96,769	28,1074	29,0	111,00	81,643	21,5856	,259
TC1_EO	,0	3,0	,692	,8549	,0	4,0	,786	1,1883	,905
TC1_EA	,0	,0	,000	,0000	,0	,0	,000	,0000	1,000
TC2_T	102,0	202,0	149,154	33,2662	61,0	157,0	113,429	27,1030	,007*
TC2_EO	,0	10,0	3,308	3,1460	,0	17,0	5,286	5,3122	,458
TC2_EA	,0	,0	,000	,0000	,0	,0	,000	,0000	1,000

**Table 2:** Comparison (α) between the GE and CG groups in relation to Attention tests.

Legend: Min.: Minimo; Max.: Maximum; M: Medium; SD: Standard Deviation; TMTA: Trail Making Test Part A; TMTA\_T/E: Time/Errors; TC1: Test of cancellation of geometric figures; TC\_T/EO/EA: Time/Errors by default/Errors by addition; TC2: Test of cancellation of letters in row; (α) Mann-Whitney test; Sig: Significance - p value; We considered the significance level of p < 0.05.

Instruments	GE (n = 13)				GC (n = 14)				Sig. (p)
	Min.	Máx.	M	DP	Min.	Máx.	M	DP	
TMTB_T	64,0	250,0	152,000	46,3357	69,0	195,0	121,786	37,2500	,054
TMTB_EA	,0	5,0	1,308	1,6525	,0	3,0	1,143	1,2315	,943
TMTB_ES	,0	5,0	1,308	1,4936	,0	4,0	,571	1,1579	,128
St1_T	16,0	51,0	24,462	9,5448	16,0	36,0	21,214	6,2656	,185
St1_E	,0	2,0	,385	,7679	,0	3,0	,429	,8516	,867
St2_T	10,0	41,0	17,000	7,9791	9,0	22,0	14,857	3,7592	,650
St2_E	0	1,0	,231	,4385	,0	1,0	,143	,3631	,720
St3_T	21,0	80,0	45,462	15,4522	23,0	54,0	36,714	9,3679	,141
St3_E	1,0	5,0	3,077	1,152	,0	5,0	1,929	1,8172	,116
Fac. T	,0	21,0	7,462	5,5470	1,0	27,0	7,357	7,3234	,458
Int. T	1,0	42,0	21,154	10,0900	0,	36,0	15,500	9,7409	,076
Fac. E	,0	2,0	,462	,6602	,0	3,0	,571	,8516	,867
Int. E	1,0	5,0	2,769	1,0919	,0	4,0	1,500	1,6053	,043*
TOL	14,0	23,0	18,846	2,9111	16,0	21,0	19,214	1,6723	0,756

**Table 3.** Comparison (α) between the GE and GC groups in relation to the tests of Executive Functions.

Legend: Min.: Minimo; Max.: Maximum; M: Medium; SD: Standard Deviation; TMTB: Trail Making Test Part B; TMTB\_T/EA/ES: Time/Errors by addition/Errors by default; St1/2/3: Stroop Word Color Test color, words and color words T/Time T/Errors; Fac.T/E: Facilitation Time and Error; Int.T/E: Interference Time and Error; TOL: Tower of London; We considered the significance level of p < 0.05.

The present study had as objective to compare the performance of children in the final phase of Elementary School I (5<sup>th</sup> year), with and without learning difficulties in instruments that evaluate visual and FE components (inhibitory control, mental flexibility, selective attention visual, logical thinking, and mental planning skills).

Analyzing the characteristics of the sample, we observed a higher frequency of male children in both the experimental group (67.5%) and the control group (57.1%).

Corroborating the results of this study, other studies that have studied characteristics of childcare services describe an overlap of the masculine gender associated with complaints of students with learning difficulties [25-28].

On the performance of the groups, there were statistically significant differences in scores of the attention and FE tests, in which the group with school complaints presented time and error numbers increased in relation to the control group. Similar results were also obtained in the study by Simão, *et al.* [9] who compared the performance of groups with and without school complaints in instruments similar to those used in this study.

The Stroop Color Word Test, used as a measure of inhibitory control, showed that the groups had differences in all time scores and errors of the three cards (Color, Word and Color Word) and in the Error Interference score.

The first card (Color), has the task of quick naming of colors and the results indicate that the GE needs a longer time for the naming of colors when compared with their pairs of GC. The second card (Word) presents a congruence of the word and color, which facilitates the processing of the stimulus and the naming, thus, it is possible to observe a decrease of the time scores and errors in the two groups. This effect can be noticed because the presentation of the name of the colors printed in corresponding colors produces an effect known as facilitation [4].

In the third card (Color-Word) the "Stroop effect" or cognitive conflict is observed, that is, there is an incongruence that leads to the inhibition of the automatic word reading response to issue the correct color naming response (for example the word BLUE printed in green). Our study shows an increase in time and error scores in both groups. The fact that the complaints group presented higher values of time and errors, in all scores, when compared to the group without complaints, suggests difficulties in the inhibitory control as well as attention to the selection between relevant and irrelevant stimuli.

In the Cancellation Test-Geometric figures there were differences in time scores and errors by omission, where the GE presented the worst result. There were no difference between groups in the error scores by addition, that is, to indicate a figure other than the target.

In the Cancellation-Letters Test in Row, the groups presented a statistically significant difference ( $p = 0.007$ ) in the time score, where the GE obtained a worse performance. It can be inferred that the group with complaints presented a greater time to do the activity, however the number of errors by omission was smaller.

For Pereira, *et al.* children with higher rates of inattention and hyperactivity tend to have worse performances in the Attention Cancellation Test, a result that corroborates our findings.

In the Trail Making Test (Part A and Part B), there was difference between the two groups at all time scores and errors. In Part A, the complainant group had statistically significant increased scores ( $p = 0.003$ ).

In the Tower of London, the groups showed a difference with the highest mean score in the group without complaint, suggesting a better planning capacity.

In a study with children with no learning difficulties, significant correlations were observed between performance in attention tasks and executive functions and reading, writing and calculation scores [19]. Effects of age and series on performance were found mainly in time scores indicating that performance tends to improve according to age group and schooling. This may explain the result presented by the experimental group of this research, where the low school performance was related to poor performance in these instruments.

## Conclusion

The performance of this sample of students with and without learning difficulties in instruments that assess the attention and some aspects of the executive functions evidenced the difference found between the two groups, GE and CG and presented results in which children with complaints of learning difficulties and attention have reached a lower score in the evaluative instruments compared to their peers without complaints.

The results suggest that the instruments used were sensitive to differentiate the performance of the students. Considering the evidence, new studies are necessary to increase the sample of children with and without learning difficulties, in order to seek further clarification on how to stimulate the development of school skills that are directly related to the organization of different cortical functions such as attention and executive functions.

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