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Working memory, sustained attention and academic performance in students aged 14 to 16 at an educational institution in Valledupar

Memoria de trabajo, atención sostenida y desempeño académico en estudiantes de 14 a 16 años de una institución educativa de Valledupar

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SUMMARY

The present research seeks to analyze the relationship between the variables working memory, sustained attention, and academic performance. We worked with a population of 32 young students whose ages range from 14 to 16 years, which are part of a private institution in the city of Valledupar, Colombia. For the evaluation of the neuropsychological variables, the NEUROPSI battery was used, which used several subtests Work Memory, detection of digits in regression; Work Memory, Cubes in Regression that evaluate work memory; and attention Concentration, Successive Series, Frequency Attention and Concentration; Digit Detection sustained attention; To measure attention and to measure academic performance, the academic reports of the institution were taken into account, which is governed by the Ministry of National Education of Colombia (MEN). The results of the investigation showed that there is a significant relationship between the variables studied and the academic performance, since those students who achieved NORMAL, NORMAL ALTO results in the subtests, are those who have average HIGH grades. It is recommended to follow the proposed intervention plan, for those students who presented negative results in the evaluated tests.

Keywords: *Working memory, sustained attention, academic performance.*

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RESUMEN

La presente investigación busca analizar la relación entre las variables memoria de trabajo, atención sostenida y rendimiento académico. Se trabajó con una población de 32 jóvenes cuyas edades oscilan entre 14 y 16 años, los cuales hacen parte de una institución

privada de la cuidad de Valledupar, Colombia. Para la evaluación de las variables neuropsicológicas se utilizó la batería NEUROPSI, de la cual se usaron varias subpruebas Memoria de Trabajo, detección de dígitos en regresión; Memoria de Trabajo, Cubos en Regresión que evalúan memoria de trabajo; y atención Concentración, Series Sucesivas, Frecuencia Atención y Concentración; Detección de Dígitos atención sostenida; para medir atención y para medir rendimiento académico, se tuvo en cuenta los informes de notas académicas propias de la institución, las cuales están regidas por el Ministerio de Educación Nacional de Colombia (MEN). Los resultados de la investigación arrojaron que existe relación significativa entre las variables trabajadas con el rendimiento académico, ya que aquellos estudiantes que lograron resultados NORMAL, NORMAL ALTO en las subpruebas, son los que tienen promedio de notas ALTO. Se recomienda seguir el plan de intervención propuesto, para aquellos estudiantes que presentaron resultados negativos en las pruebas evaluadas.

Palabras clave: *Memoria de trabajo, atención sostenida, rendimiento académico.*

INTRODUCTION

Memory is a mechanism or process that allows the information transmitted by a signal to be preserved after its action has been suspended (1); which in turn enables the storage of experiences, sensations, perceptions to bring them back after a memory later. Memory is defined as "a neurocognitive function that allows to record, encode, consolidate, retain, store, retrieve and evoke previously-stored information" and for the author, learning is the ability to acquire new information, he affirms that there are different types of memory, short and long term (2). Memory is considered an important process in the daily life of the human being since its past moments or experiences are reflected, which allow the knowledge and subsequent adaptation of present and future situations. Likewise, memory directly influences the learning processes in school and/or academic training, being this the one that enables the development of knowledge and its application, hence the interest in its study, exploration, and justification to include it as a neuropsychological variable in research processes (3). This means that from the use of working memory the individual adapts the information that he is using at the moment in which he develops the task. Some authors describe that memory systematically manipulates its content and updates the information in memory to achieve the goals of the tasks, an example of this is when the subject needs to maintain the information in the short term in tasks as diverse as understanding and reasoning (4). The first measure to evaluate the capacity of working memory, which is the reading amplitude test, in the test the participant must read a series of sentences and at the same time must retain the last word of each sentence to remember it later, the qualification of the test is related to the maximum number of words that the subject can remember correctly (5). Working memory "plays a key role in fundamental processes such as learning, language comprehension, reasoning, problem-solving, planning or categorization" (6); therefore, it is stated that it is a "difficult task to think about some complex cognitive tasks that do not require the use of working memory" (6). According to the above, it is established that one of the main characteristics is that of having a limited capacity, therefore, long-term memory is used after the process and that the information contained in it is found in a state of rapid accessibility.

Another neuropsychological variable of interest is attention, which facilitates cognitive execution and the emission of behaviour in different ways since it serves both to reduce and to increase the information that is received in the brain, as well as external and internal signals. To which the student is constantly exposed. Attention couples the input of information with respect to the individual's available capacity, facilitating the selection of what is relevant and the assignment of the appropriate cognitive process for it; that is, attention functions as a door for the passage of information that reaches the brain (7). Attention, as well as working memory, plays an important role in learning since it allows making use of information at the time of performing tasks, in how that information is used, and with the data that is constantly received from the world. As well as with the responses generated regarding these data, the functioning of the learning processes and the results obtained by the student are directly related to the processes of attention and memory. So, sustained attention refers to the ability to maintain attention for prolonged periods, this type of attention is not an independent

category, since the other dimensions of attention are immersed in its functioning and are related to cognitive processes (8). The explanatory models of care have been changing over the years; The first idea that established that attention was limited has been changed, since attention is modified thanks to continuous exercise and acts as an active and constructive mechanism in the subject's cognitive processes, therefore, it could voluntarily and consciously generate greater attention span (9,10).

Contemporary neuropsychology performs a detailed and systematic analysis of cognitive processes and the relationship it has with the brain, its functions, and the tasks it performs; and it is established that the analysis process is not only to identify the concept, characteristics, and functions but must be related to the learning process, with the execution of plans, actions and the emission of the student's behavior in the case of this research. Therefore, working memory is a temporary storage mechanism, which makes it possible to store information, relate it, compare it for a short period, therefore, working memory also allows short-term storage, and in turn, manages the information necessary for highly complex cognitive processes, and it plays a fundamental role in the learning process, an important element to determine optimal academic performance by the student in their training (11). The organization and attention in academic assignments, together with the ability to link new information and knowledge with existing ones, related to reading comprehension and the ability to self-regulate learning, are elements that directly influence the academic performance of students. students (12,13). Likewise, working memory as a cognitive category allows fluidity and flexibility to be related to relational thinking; since the subject would have the ability to establish relationships between two or more events or variables; This, in turn, depends on the ability to relate what is being addressed with the reasoning to near or far events at a given moment (14). This capacity allows the individual to have more information at the same time, and that in turn allows having information in real-time that can be used to solve a task at the moment of reasoning. In this way, it can be affirmed then that there are research processes on working memory, sustained attention, and academic performance, in some of them it is proposed that working memory has implications for the functional architecture of the prefrontal cortex (15), and show that said brain region has a fundamental role in the functions of working memory and that in turn it must be conceived as a network of integration of areas, in which each one fulfills a specialized function in a specific domain. Other research, which integrates existing theories on working memory, reasoning, visual processing, language processing, and a wide variety of psychological, neurophysiological, and computational data, as well as elements related to learning (6,11,14,16).

Academic performance, as the level of knowledge shown in a specific or general area or subject, this compared with the age norm and academic level (17), so it is believed that the student's performance could be studied from processes evaluation; It was used to establish a correlation between the two neuropsychological variables and the learning process, taking into account by the results in academic performance; that in the educational institution in which the research was developed, the following rating scale and values are established against this.

In the Colombian panorama, there is evidence related to the variables studied, such as the research by Zapata et al. (16) in which they show the correlation that exists between working memory and academic performance in first semester students of different programs of a university in Barranquilla in Colombia, and to conclude they establish that correlations were found between the measures of working memory used and the academic performance of the participants, an important element compared to the effect of other variables related to academic performance, like cognition, motivation, affect, and context.

Research shows that attention problems could occur in school-age children and adolescents, and these could present a risk of suffering a deficit in academic performance, due to the relationship established between attention and the results obtained in the assigned areas; as well as a risk of emotional affectations and/or depressive symptoms (18-20). Therefore, and taking into account the analysis of the theoretical bases presented, it could be affirmed that low academic

performance in students would be a potential mediator in the relationship between attention deficit and emotional, adaptation, interaction, and self-perception problems. Similarly, some studies have found positive and statistically significant correlations between attention, but this time not with academic performance but with creative processes (21-23).

METHODS

The research carried out is of a quantitative type, of correlational design, not cross-sectional experimental, that is, the research is carried out without deliberately manipulating the study variables and the characteristics are described at a given moment (24). The following were proposed as working hypotheses: 1. The functioning of the working memory in the selected sample presents an abnormal development and 2. There will be a relationship between the working memory, the sustained attention, and the academic performance of the students. The educational institution selected for the development of the research is located north of the city of Valledupar, Cesar, Colombia, and has academic training from basic elementary to high school and vocational medium.

Population and sample

The current population of the institution is 550 students distributed in all degrees of training. The type of sample is non-probabilistic since the choice of study subjects does not depend on probability but causes related to the characteristics of the research (inclusion criteria). The group consists of 32 students, between men and women aged between 14 and 16 years of the institution.

Measurement tools

The working memory variable was measured through the regression digit detection subtest and the Regression Cubes subtest of the Brief Neuropsychological Battery in Spanish NEUROPSI (25), the sustained attention variable through the Successive Series subtest and the Detection subtest Digits of the same battery. The battery allows measuring through exercises the processes belonging to the working memory, such as Processing and storage; to evaluate working memory. It is a short, reliable, and objective instrument that allows the evaluation of a wide spectrum of cognitive functions in psychiatric, geriatric, neurological patients, and patients with various medical problems. It includes protocols and qualification profiles for the cognitive evaluation of the population with no schooling and individuals with low and high schooling. The cognitive areas that it evaluates are Orientation Attention and concentration Memory, Language Visual-spatial skills Executive functions Reading, writing, and calculation. The application can be carried out individually or collectively, the total application time of the test ranges from 25 to 30 minutes, the population to be evaluated is between 16 to 85 years old and the correction system is manual. The neuropsychological assessment instrument allows the evaluation of cognitive processes, the failure to recognize cognitive alterations has important implications for the care of the individual. The instrument has a solid base of normative data obtained in a healthy Spanish-speaking population, which serves as an objective reference to be able to carry out studies with a pathological population and to identify and diagnose subjects with subtle alterations in time. Research has been carried out in the country related to the variables in which the battery has been used (26,27).

For the measurement of academic performance, the academic performance reports provided by the educational institution were considered, which establishes a qualification relationship composed of the following ranges: Low academic performance with a grade from 0 to 3.2; basic academic performance from 3.3 to 3.7; high academic performance of 3.8 to 4.5 and superior academic performance with a range of 4.6 to 5.0. Therefore, a comparison was made of the period academic reports of each of the students selected for the test and they were compared with the standardized exams that are applied each year by the Ministry of National Education of Colombia and that measure competencies academic that students must have according to the age and the corresponding grade, these exams are national and evaluate each of the students depending on the

school grade in which each one is (5^{th} - 9^{th} - 11^{th}).

Procedure

For the development of the research, nine phases were carried out in which previously outlined work objectives were met: 1. Delimitation of the research problem, identification of the study variables, and objectives. 2. Identification of the population under study establishing inclusion criteria. A private educational institution in the city of Valledupar was selected. 3. Review of the theoretical bases and international and national research background related to the study variables. 4. Organization of the working document, methodological framework. 5. Ethical and authorization aspects. In this phase, the research was presented and the authorization letter was delivered to the educational institution, to request permission to apply the instrument, delivery of informed consent to parents, as it was the sample of minors. 6. Application of the sub-tests Work memory (Retention of digits in regression and Cubes in regression) and Attention and concentration (Detection of digits, and the Successive series) of the NEUROPSI. Attention and Memory. The scales were applied individually to each participant, considering the instructions given by the neuropsychological battery worked. Also, each participant was summoned at different times with the inattention that they did not cross information in the corridors of the place where the application of the aforementioned tests was developed. 7. Analysis of results. 8. Preparation of the final report. 9. Socialization of results with the sample and the institution.

Data Analysis

After obtaining data for each of the study variables, the statistical analysis was performed, using the correlation statistic (Pearson correlations) to analyze the contrast of the hypotheses of sustained attention, working memory, and academic performance. This information was obtained through the Excel and SPSS Statistics add-in program.

RESULTS

Next, the results of the descriptive statistics of the variables are presented, a study was carried out with 32 students from an educational institution in the city of Valledupar, Colombia, where 19 of these students were female and 13 were male, also 2 of the young people were 14 years old, 17 of these were 15 years old and 13 of them were at the age of 16. Table 1 shows the distribution of results according to the frequency statistics.

Table 1

Statistical analysis of frequency

		Age	Gender	Grade,	Average, Academic Performance	Working Memory, Digit Detection in Regression
N	Valid	32	32	32	32	32
	Lost	0	0	0	0	0
Mean		15.34	1.59	10,38		
Standard deviation		0.602	0.499	0.492		
Variance		0.362	0.249	0.242		
Rank		2	1	1		

Source: Statistical analysis, application results.

In the explanations of the results below, the frequencies of age, grade, average academic performance, Working Memory, Detection of Digits in regression, Working Memory, Cubes in Regression, Attention, Successive Series, Attention, Detection of Digits, as well as such as the correlations and the mean of each of the variables.

Within the randomly selected sample, we found that 6.3 % of the students to whom the test was applied are at the age of 14, these being the lowest population within the selection. Likewise, it is found that 53.1 % of the sample is 15 years old, this being the largest population to which the test was applied. While the remaining 40.6 % is the population with the age of 16 who participated in the application of the test.

Likewise, we found that in terms of gender, 40.6 % of the population belongs to the male and 59.4 % of the population to which the test was applied is female.

In the same way, we see that according to the ages, the grades (courses) in which the students of the selected sample are found are 10^{th} and 11^{th}. These are the last two courses of basic study before entering university.

Regarding academic performance, the students of the sample who were selected were measured with an academic aspect: which was their school average or result of grades from the period immediately before the test.

These data help us to have a starting point and to know how far we want to go with the intervention proposal. This table shows us that most of the sample is in a HIGH average of 68.8 % and that the second-highest percentage is in the BASIC level with 28.1 % of the population, and the third percentage is held by the SUPERIOR level with 3.1 % of the population. It must be borne in mind that what is sought is that most of the population reaches the SUPERIOR level, which means an improvement in the academic performance of the students.

Table 2

Frequency of subtests applied

SUBTEST	RANGE	FREQUENCY	PERCENTAGE
Working memory, detection of digits in regression	NORMAL	12	37.5
	NORMAL HIGH	20	62.5
Working Memory, Cubes in Regression	LEVE MODERADO	7	21.9
	NORMAL	11	34.4
	NORMAL HIGH	4	12.5
	SEVERE	10	31.3
Attention and Concentration, Successive Series	NORMAL	26	81.3
	SEVERE	6	18.8
Attention and Concentration, Digit Detection	MILD MODERATE	7	21.9
	NORMAL	23	71.9
	SEVERE	2	6.3

Source: Statistical analysis, application results.

Table number 2 consolidates the frequency results of the application of each of the subtests, in which we find that; of the first exercise of the test, which evaluates working memory with a

subtest called Detection of digits in regression of the Neuropsychological Neuropsi battery, which measures the capacities of working memory in 4 levels, "severe", "mild-moderate", "Normal" and "normal high". Obtaining as a result that the sample to which this test was applied are all in the ranges of "normal" and "high normal" with a percentage of 62.5 % in high normal, being an average of the representative sample. For its part, subtest 2 also assesses working memory and is called Cubes in regression, in this subtest we find 4 levels of performance and we find that, unlike the previous table, in this one there are students in the sample at all levels, the "normal" level being the highest with a percentage of 34.4 % and the "high normal" level is the lowest with an average of 12.5 %. It is also important to note that 31.3 % of the sample is at the "severe" level, which is the lowest of the subtest, and that this level in the previous exercise did not appear since no student was at it.

The analysis of the subtest called successive series, which only has 2 levels of evaluation: "severe" and "normal". With which it can be said that 81.3 % of the population to which the test was applied presents a normal level of attention, while 18.8 % presents the severe level.

In the attention subtest, detection of digits that is analyzed in table 5, we find that 71.9 of the population to which the subtest was applied is at the normal evaluation level, this level being the highest among the results obtained, and 6.3 of the population is at the severe level, this level being the lowest of the results and finally, it was found that 21.9 of the population is at the normal evaluation level.

In front of the descriptive statistics, it can be affirmed that there are alterations in cognitive function (working memory) in the tasks of detecting digits and cubes in regression since there is a deviation of 0.999 in relation to the mean which is 4 .97 in the first exercise and a deviation of 1 540 in relation to the mean of 4.63 in the second exercise. While the levels of sustained attention show significant results in the successive series tasks and digit detection attention, the first having a mean of 1.84 with a standard deviation of 1 110 and the second task presenting a mean of 8.97 and its deviation standard is similar 8.97.

Table 3

Variable's correlatives

		Average	Memory Detection Digits	Cubes in Regression	Series Successive	Attention Digit Detection
Average	Pearson's correlation	1	0.249	0.225	-0.118	0.339
	Sig. (Bilateral)	0.170	0.215	0.520	0.058	
	N	32	32	32	32	32
Memory Detection Digits	Pearson's correlation	0.249	1	0.202	0.402*	0.287
	Sig. (Bilateral)	0.170		0.268	0.022	0.112
	N	32	32	32	32	32
Cubes in Regression	Pearson's correlation	0.225	0.202	1	-0.054	0.225
	Sig. (Bilateral)	0.215	0.268		0.768	0.216
	N	32	32	32	32	32
Series Successive	Pearson's correlation	-0.118	0.402*	-0.054	1	-0.167
	Sig. (Bilateral)	0.520	0.022	0.768		0.361
	N	32	32	32	32	32
Attention Digit Detection	Pearson's correlation	0.339	0.287	0.225	-0.167	1
	Sig. (Bilateral)	0.058	0.112	0.216	0.361	
	N	32	32	32	32	32

*. The correlation is significant at the 0.05 level (2 tails).
Source: Statistical analysis, application results

In Table 3, the Pearson correlation of all the variables analyzed in the work is carried out with a bilateral significance test, with which the following results are obtained: Taking into account the results established on average, it is found that there is a significant correlation bilateral in all the developed tasks, while, in the Pearson correlation, the successive series attention task presents a negative significance. Similarly, in the digit regression memory task there is significance in both the Pearson and bilateral correlation with respect to the other tasks developed in the test. In the regression cubes memory task, there is Pearson correlation significance in all other tasks, except in the successive series attention exercise, which presents a number of negative significances. While the bilateral significance levels have a significant correlation. In the successive series attention task, it is the one with the highest levels of negative significance in Pearson's correlation, since it presents negative data with the average, the regression cubes memory task, and the digit detection attention task. While the bilateral significance levels have a significant correlation. The digit detection attention exercise shows significant Pearson and bilateral correlation with all other tasks and with the average, except for Pearson's correlation in the successive series task.

DISCUSSION

The research carried out aimed to analyze the relationship between working memory, sustained attention, and academic performance. Among the reasons why it was decided to study these variables is the direct impact on learning and education, and its probable connection of the executive functions of the brain (memory and attention) with academic performance, as stated (28) which establish that working memory is of great value in the process of learning, adaptation and school performance since it is a complex, active and linking system that allows representing and maintaining relevant information for the task to be achieved the student.

Considering the specific objectives of identifying the functioning of working memory, determining the levels of sustained attention in the development of academic activities, and the establishment of the relationship between the performance of working memory. In relation to working memory, which is a complex memory system (29), which allows to temporarily maintain and manipulate information, facilitating the achievement of complex cognitive tasks, such as reasoning, understanding, and learning. On the other, sustained attention is a type of attention that allows us to keep our mind attentive to some stimulus in the environment. That said, we can argue that, if attentional conditions are generated and executive functions are constantly exercised or, in our case, working memory, better academic results can be obtained in young people of school age. The results show that the students that of the total sample 81.3 % presented results in the category of high normal in the regression digits subscale, this shows that these students present an adequate functioning of the working memory, favoring the maintenance and manipulation of information, in the achievement of complex tasks, in this case in the execution of the subscale.

The levels of attention evidenced in the results of students aged 14 to 16 at an educational institution in the city of Valledupar, quantitatively show that 71.9 % present a normal level of attention, this being the highest value Within the three levels presented by the test (severe, normal and mild to moderate), 6.3 corresponds to the severe level, and 21.9 % to the mild to moderate level, the above can be explained by what they suggest (30), which affirm that the executive functions, defined as the set of capacities, which allow the student to independently develop their objectives, are working adequately. Likewise, it can be argued that the results found in students between 14 and 16 years old are not contradictory with the theoretical bases and the proposal developed by Franco-de-Lima (31), in the research considered as antecedent, compared to the evaluation of attention in children with and without a diagnosis of dyslexia, generating comparisons in the performance of executive functions.

In the third work objective, the need to relate the execution of working memory, sustained attention, and academic performance was established, it should be noted that the variable academic performance depends on numerous factors, and one of them is the use of strategies of learning, identifying or not the presence of difficulties in the execution of activities,

motivation, interest in the task and emotional state are other factors that can influence academic performance. Another factor may be the student's working memory capacity, it is believed that those with a more limited capacity could also perform poorly. Thus, if the first hypothesis is analyzed, it will be found that the better functioning the working memory has, or it is at the normal evaluation level, the academic results will be better, a hypothesis validated according to the results found since 81.3 % of the total sample presented results in the high normal category in the evaluation of working memory and 71.9 % normal attention, students who in turn present a high average academic performance; therefore, it is determined that for these students, the maintenance and manipulation of information are favored in the achievement of complex tasks related to the academic context.

Finally, it can be affirmed that there is a relationship between the variables studied in this research (working memory, sustained attention, and academic performance) since, as the results indicate when the executive functions are working in a NORMAL way, the academic performance of the students is high, average evidenced in the inspection of the reports of grades by period. In addition, and in relation to the fourth objective in which it is proposed to design an intervention program for neuropsychological variables, it can be established that the training of these functions will be oriented to the improvement, potentiation, and development of skills in relation to each function worked; as well as stated (32), who establish that Cognitive training, cognitive stimulation programs, together with the implementation of psycho-pedagogical actions focused on Executive Functions at School Age, intending to improve the quality of life, adaptation to the activities and tasks carried out, and in the future, attenuate pathological aging.

CONCLUSIONS

It can be concluded that there is a significant relationship between the functioning of working memory, sustained attention, and academic performance in the sample of the selected institution; which were manifested in the results evidenced after the application of the neuropsychological battery NEUROPSI; Results that show that when one or both of these variables work adequately, the grades of the students reflected in the academic performance, are presented with high averages. Different ratios with the population that presents severe functioning in the specific subscale cubes in regression and digits in regression are those that presented a basic and low academic performance.

In the same way, and according to the results of the research, it can be affirmed that the development of investigative processes and action plans focused on improving the work of the executive functions, as well as their relationship with the learning processes, will contribute with the enhancement of these functions. Therefore, it is established that by exercising executive functions through the intervention plan, academic performance is expected to change and improve progressively in each student. Within the conclusions, an element of limitation is also established, since in the development the results cannot be generalized, since the sample is small in relation to the methodological elements necessary for this purpose. One difficulty when working with a minor population is the authorization by the parents and/or guardians who, due to possible fear and/or ignorance, did not agree to participate in the research; even after having been socialized the purpose and the absence of risk when participating in it. In the same way, the need to expand the work sample to a greater number of participants is clearly established, as well as the age ranges, and check if the results are similar to those evidenced, it is also proposed to investigate the variable memory of work and other neuropsychological variables; at the same time, with variables that are not of a neuropsychological nature, such as stress, which is a function generated by the environment, and which, based on theoretical and empirical evidence, is considered a determining factor when developing activities related to cognitive functions.

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