Psychologia. Avances de la disciplina
ISSN: 1900-2386
psychologia@usbbog.edu.co
Universidad de San Buenaventura
Colombia

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Psychologia. Avances de la disciplina, vol. 9, núm. 2, julio-diciembre, 2015, pp. 85-100
Universidad de San Buenaventura
Bogotá, Colombia

ARTÍCULO DE INVESTIGACIÓN

Relationship between cognitive processes and academic performance in high school students

Relación entre los procesos cognitivos y el rendimiento académico en estudiantes de educación básica secundaria

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Fecha recepción: 22/1/2015 • Fecha aceptación: 17/5/2015

Para citar este artículo: Puerta, L. (2015). Relationship between cognitive processes and academic performance in high school students. *Psychologia: Avances de la Disciplina, 9*(2), 85-100.

Abstract

The purpose of this investigation was to determine the relationship between the cognitive processes and the academic performance by a non-experimental correlational study with a cross-sectional design. Participants were 60 students between 14 and 17 years old, who were randomly selected from high school tenth grade without a history of personality disorder or intellectual disability. Academic performance was evaluated from the school average reported by educational documents. Cognitive processes measured were: focused and sustained attention, cognitive flexibility and inhibitory control, delayed visual memory, auditory verbal learning and delayed auditory verbal memory, visual-constructive praxis, naming function of language and verbal fluency. A neuropsychological battery was used for that purpose. According to the Rho Spearman, the results indicated that there is a statistically significant relationship between the two following cognitive processes and academic performance: sustained attention ($p=0.01$) and the naming function of language ($p=0.05$).
Keywords: attention, executive functions, visual-constructive praxis, memory, language, academic performance, high school.

Resumen

El propósito de la presente investigación fue determinar la relación entre los procesos cognitivos y el rendimiento académico mediante un estudio no experimental correlacional con diseño transeccional. Participaron 60 estudiantes entre 14 y 17 años de edad, los cuales fueron seleccionados al azar de grado décimo de básica secundaria sin antecedentes personales de trastorno de personalidad o discapacidad intelectual. El rendimiento académico se evaluó a partir del promedio escolar reportado por informes educativos. Los procesos cognitivos medidos fueron: atención focalizada y sostenida, flexibilidad cognitiva y control inhibitorio, memoria visual inmediata, aprendizaje auditivo verbal y memoria auditiva verbal inmediata, praxis visuoconstructiva, función nominativa del lenguaje y fluidez verbal; para lo cual, se empleó una batería de instrumentos neuropsicológicos. De acuerdo con R de Spearman, los resultados arrojados señalan que existe una relación estadísticamente significativa entre los dos siguientes procesos cognitivos y el rendimiento académico: la atención sostenida ($p=0.01$) y la función nominativa del lenguaje ($p=0.05$).
Palabras clave: atención, funciones ejecutivas, praxis visuoconstructiva, memoria, lenguaje, rendimiento académico, básica secundaria.

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Introduction

Cognition is generally understood as the set of mental processes that occur between the reception of stimuli and the response thereto (Ortiz, 2009). Vygotsky (1978; 2009) stated that cognitive processes arise and undergo changes during the course of human development and its learning process, and that, Psychology intended to address them and understand them: origin, development and functionality. In order to define its functionality, the field of neuropsychology has focused on the study of cognitive processes, emphasizing the importance of the brain in human behavior, and the relevance of certain cognitive processes and the functions derived from them in learning (Portellano, 2005). First of all, the study of the attention process started with some works that focused on the execution or performance of subjects (Keele, 1973; Kinsbourne & Hicks, 1978 cited in León-Carrión, 1995), others on the attentional mechanisms addressing the subjective experience (Higging & King, 1981 cited in León-Carrión, 1995; McLeod, 1978; Neely, 1977; Posner, 1978), others on the filtering and selection processes (Mirsky et al., 1991) and others on finding the neural substrates (Petersen, Fox, Snyder & Raichle, 1990 cited in León-Carrión, 1995; Posner, 1991). Several types of attention are implicitly acknowledged, such as arousal, focused attention, sustained attention, alternating attention, divided attention, exclusionary attention and selective attention (Portellano, 2005). The anatomic structures related to attention are the brainstem and thalamic reticular formation, the basal ganglia, the cingulate gyrus, the primary cortices and the prefrontal cortex (Estévez-González, García-Sánchez & Junqué, 1997). The complexity of attentional processes has led to the development of several formulations of attention from different conceptual spheres of neuroscience and cognitive psychology, such as the Pribram and McGuiness model (1975), the Norman and Shallice model (1980), the Broadbent model (1982), the Mesulam model (1985), the Posner and Peterson model (1990), the Stuss and Benson model (1995) and the Mirsky model (1996), among others. For purposes of this research, the A.F. Mirsky's model has been revised. Mirsky et al. (1991) explained that the components of attention of their model might be located in different brain regions and work together as a big machine. The elements are: *focus/execution or focusing attention and efficient execution*, *sustain or sustaining attention*, *encoding* and *alternating o shift*. Castillo, Gómez and Ostrosky (2009) evaluated the effects of attention in academic performance in a group of 156 students between 7 and 12 years old applying the Neuropsi Attention and Memory Neuropsychological Test Battery (Ostrosky-Solís et al., 2007). The results suggested that selective and sustained attention improve a point every six years. Likewise did Leon (2008) and Boujon and Quaireau (2004) with the concepts of mindfulness, ability to concentrate and sustaining tasks, respectively. Lan, Legare, Cameron, Su Li and Morrison (2011) investigated the association between executive function and inhibition, working memory and attentional control, and academic achievement in reading and math in 119 Chinese and 139 American preschoolers making an intercultural analysis. It was found as results that the Chinese do better in inhibition and attentional control tasks. In both countries the relationship between the components of executive function and academic achievement were similar. Attentional control was important for all aspects of academic performance in reading and math skills.

Second, it is stated that the study of executive functions has enriched the scientific background, since they allow for and facilitate the transformation of thought into decisions, plans and actions. Stuss and Benson (1986), as well as García and Muñoz (2000) and Burgess (1997), defined executive functions (EF) as a supramodal function that organizes human conduct, which allows solving complex problems. Furthermore, the explanatory models of executive functions are the Virginia Douglas model (1983), the Schachar, Tannock and Logan model (1993), the Gray model (1994), the Barkley model (1997) and the Sergeant model (2000), among others. For purposes of this research, the self-regulation model proposed by Russell A. Barkley (1997) has been revised. He asserts that the self-regulation model is a "theory of the functions of the prefrontal lobe or, in this case, the EF system" (p.230). The model is based on the analysis of the interrelations between behavioral inhibition, EF and self-regulation. Actually, Castillo-Parra, Gómez and Ostrosky-Solís (2009), Latzman, Elkovitch, Young and Clark (2011) and Sánchez et al.

(2012) are studying the correlation between the executive function and the academic performance. Castillo-Parra et al. (2009) found that the executive functions play an important role for academic success. They evaluated a sample of 156 elementary school students by the Neuropsi Attention and Memory Neuropsychological Test Battery (Ostrosky-Solís et al., 2007). Latzman et al. (2011) used measures of cognitive flexibility, monitoring and inhibition, contrasting with academic performance on a sample of 151 boys between 11 and 16 years using instruments like KBIT-2 of Kaufman and Kaufman for CI, D-Kefs for Executive Functions and Iowa Test of basic skills education. It was concluded that executive functions predict achievement in different academic fields such as, cognitive flexibility in reading and science, monitoring in reading and social and inhibition in math and science. Sánchez et al. (2012) found any statistically significant difference between the executive function and the academic performance in mathematics. They used the Dysexecutive Questionnaire (DEX) which is a part of the Behavioral Assessment of the Dysexecutive Syndrome (BADS – Wilson, Alderman, Burgess, Emslie, & Evans, 1996).

Third, the study of visual-constructive praxis falls within the perceptive process. Perception is defined as the way in which the information grasped by the senses is understood and interpreted (Muñoz et al., 2009). At a visual perception level, human beings have cortically two main routes: the "what" route (personal and object identification) and the "where" route (spatial or positional identification) (Muñoz et al., 2009). Visual perception has been studied from several models, such as the Warrington and Taylor model (1973), Marr's Computational Theory (1982), Humpreys and Riddoch's cognitive model (1987) and Tresiman's feature integration model, among others. For purposes of this research, Humpreys and Riddoch's cognitive model (1987) was revised. They claim that there is a sensory stage prior to two types of analyses: a local (detail) analysis and a global (shape) analysis. Afterwards, perception integration, together with figure-ground segregation and the production of a representation, occurs. Some authors consider that motor development and cognitive development are interrelated, suggesting that motor development can act as a control parameter for future development (Campos et al., 2012; Piek, Dawson, Smith, & Gasson, 2008). Also, they think that some motor skills may be a prerequisite for the acquisition of other development functions, such as perceptual and cognitive ability. Machacón, Herazo and Vidarte (2012) conducted a transactional study with 389 children of 8 public institutions in Colombia. They evaluated psychomotor profile with the Vítor Da Fonseca Battery and logical-mathematical performance by the GPA finding a correlation of 0.12 ($p = 0.01$) between the psychomotor profile and logical-mathematical performance.

Fourth, the study of memory has been one of the first objects of research of psychology, because it allows registering, encoding, consolidating, relating, accessing and recovering information. It is not a unitary system, since there are several subtypes of memories that differ from each other in modes of operation, type of information managed and neuroanatomical substrates (Ortiz, 2009). Temporal lobes, particularly in their internal faces, are of great importance for the filing process of mnemonic material. The Papez circuit is an essential integrating center in such process (Kolb & Whishaw, 2006), as well as the prefrontal and parietal lobes. In turn, one of the most stable ideas throughout the development of memory models is the difference between short-term and long-term memory (Atkinson & Shiffrin, 1968 cited in Martínez-Castillo et al., 2001; James, 1980). Furthermore, the explanatory models of the mnemonic process are the Atkinson and Shiffrin multi-store model (1968), the Craik and Lockhart levels of processing model (1972) and the Baddeley and Hitch working memory model (1974), among others. For purposes of this research, the model proposed by R.C. Atkinson and R.M. Shiffrin (1968) has been revised. They stated that information processing occurs sequentially throughout three structures: sensory store, short-term store (STS or STM) and long-term store (LTS). In Colombia, Zapata, De Los Reyes, Lewis and Barceló (2009) and in México Castillo-Parra et al. (2009) are studying the relation between the memory and the academic performance arguing that memory is an important mechanism to store temporary information generating influence in learning (Etchepareborda & Abad-mas, 2005). Castillo-Parra et al. (2009) found that academic success requires more memory capacity in the early school years. Also Restrepo, Roca, Surcequia and

Herrera (2012) studied immediate auditory memory in a group of school children with normal academic performance finding significant correlations.

And finally fifth, the study of language has been of vital importance for neuropsychology, since it organizes child knowledge and experience (Vygotsky, 1979). Language is understood as "a symbolic communication system that is manifested through discourse, which is a structured system of signs that express ideas in which the word is the representation" (p.201). Two types of regulating structures can be found in language processing: cortical and extra-cortical components (Portellano, 2005). The author points out that there are two areas regulating language in the cerebral cortex: the expressive and the receptive areas. Expressive language includes syntactic and grammatical structure, the range of spontaneous speech, verbal fluency and others; with respect to comprehensive language, auditory comprehension, intonation comprehension and the comprehension of the symbolic significance of language; within repetition, word repetition and sentence repetition; within naming, the naming of real objects and of drawings and photographs; with respect to reading, reading fluency, silent reading, reading comprehension; and in writing, copying (graphomotor skills), dictation, written composition (Quintanar & Solovieva, 2005). Regarding this research, we have revised two areas in particular: one related to expressive language, which corresponds to verbal fluency, and another one referring to the act of naming in language, which represents the naming function of observed drawings about real objects. In turn, the explanatory models of language that have tried to cover the complexity of such subject matter are the Wernicke-Geschwind model (Geschwind, 1965), Patterson and Shewell's logogen model (1987), the Mesulam model (1990) and the Damasio and Damasio model (1992), among others. For purposes of this research, the model proposed by M.M. Mesulam (1990) has been revised. He argues that language depends on a neural network, which in turn contains local interconnected networks. Studies from Puyuelo and Roldan (2003) show that students who have more communication tools not only allow to relate effectively with their peers but also their language development favors the initial learning process and is part of the elements that would predict a high or poor academic performance. Rodriguez and Gallego (1992) and recent research by Barrera (2005) show differences between students with high and low academic performance in language tasks; arguing that language is a key for academic performance due to its close relationship with thought and also because it is the main learning tool in the classroom. And recent research by Ramírez (2014) exposed in a longitudinal study that language predicts academic performance specifically in reading at the end of primary school. So as did Schleppegrell (2004).

Each of the five cognitive processes described above facilitates learning in individuals, enabling the expression of their cognitive-behavioral potential, which is reflected in their tangible and measurable conduct within several spheres of human experience, such as schools and workplaces (Ortiz, 2009; Piaget, 1971; Vygotsky, 1979). Lozano, García-Cueto and Gallo (2000) discuss that if learning is conceived of as a construction of meanings, it is then the student, the core element of the entire teaching/learning process, whom has to develop goals, organize knowledge and use the proper strategies (metacognitive and emotional) that lead to a significant understanding of such material, thus rearranging her conceptual model.

Academic performance is defined as "the assessment issued by the school as a particular kind of educational evaluation specially characterized by the decisions that trigger its realization" (Rodríguez & Gallego, 1992, p. 25). It is therefore a type of special educational control with academic effects. In general terms, academic performance is classified as high, medium or low. Occasionally, such rating is quantitative and is later classified as high, medium or low for the purpose of having a hierarchical categorization of analysis (Arillo-Santillán et al., 2002). Núñez et al. (1998) indicate that the different motivations and strategies used by students when faced with learning activities has led to the identification of several types of learning approaches: deep and surface (Watkins & Regmi, 1992), strategic (Entwistle, 1988) and achievement (Biggs, 1988). There is evidence that academic performance depends on cognitive variables: intellectual ability and prior knowledge (Carroll, 1993); conative variables: cognitive and learning styles (Selmes, 1988); and affective variables: motivation and personality (Tobías, 1986).

In turn, it has been proven that there is a direct and significant correlation between the intelligence quotient, measured by standardized intelligence tests (Wechsler-R or Raven's Progressive Matrices Test), and students' brain size, measured by magnetic resonance imaging (MRI). Almeida et al. (2008) analyzed the extent to which more specific cognition factors related to verbal, numeric or figurative content complement more general factors of reasoning in predicting academic performance of students at the beginning and end of adolescence, and found a statistical significance. The results obtained through different researches suggest a moderate and statistically significant correlation between intelligence tests and academic classifications, just as has been proven in other researches (Almeida, 1988; Ackerman, 1996; Bartels et al., 2002; Gottfredson, 2002a, 2002b; Kuncel et al., 2004; Sternberg, Grigorenko & Bundy, 2001; Te Nijenhuis et al., 2004). This relationship between cognitive skills and academic performance oscillates as the student progresses through school, resulting in a lower progressive correlation between intelligence and academic performance (Almeida, 1988; Evans et al., 2002; Floyd et al., 2003). It is worth analyzing these somewhat speculative considerations with more robust studies from a methodological point of view, for instance, by improving the assessment of specific components of intelligence and cognition (Almeida et al., 2008), which refer to such cognitive processes as attention, executive functions, perception, memory and language; the latter being the theoretical and research framework of this study. Barrios and Barrios (2000) say that the extent of brain research and cognitive processes in education, give more understanding of brain functioning and this may impact on improving the ability of teachers to teach, as well as the student's ability to learn. Therefore, the general objective of this research was to determine whether a significant statistical relationship between cognitive processes and academic performance exists in a group of tenth grade students from the city of Cartagena. To fulfill this objective, it was necessary to define whether the overall score obtained by the participants in a battery of instruments selected to assess cognitive processes has any statistically significant relationship with their academic performance; the latter being their school performance. This relationship is been studying in order to observe the cognitive profile of students with high and low academic performance; which until this moment is not built to continue generating programs and strategies for effective learning.

Methods

Design

The present study was conducted from a quantitative paradigm, empirical-analytical, which was correlational and its design cross-sectional; understood as a study that associate variables through a predictable pattern for a group or population (Hernández, Fernández, & Baptista, 2010). Only once did it produce psychometric measures from a sample of students during a period of time established for the implementation of the neuropsychological tests and the analysis of their relationship with academic performance.

Participants

The sample selected for this research consisted of 60 students of tenth grade high school from Ciudad Escolar Comfenalco School in Cartagena de Indias, Touristic District, of ages between 14 and 17 years old. The participants were randomly selected of a group of students without a history of personality disorder or intellectual disability.

Instrumentation

A total of nine instruments have been used in this research: two clinical psychometric instruments to assess personality and intellectual function of participants and seven neuropsychological instruments to measure different areas of cognitive function. The independent variable of this research is the participants' grade point average, which is the cumulative number product of the sum of their grade in each course divided by the total number of courses. Ciudad Escolar Comfenalco School uses a quantitative grading system, the overall average achieved by each participant may fluctuate between 0.0 and 5.0; 0.0 being a low academic performance and 5.0 a high academic performance. In turn, the dependent variable of this investigation has been quantified based on the results obtained by the participants in the different neuropsychological research instruments used for assessing cognitive functions. For the assessment of attentional processes (Mirsky et al., 1991), such as focusing attention and effectively executing and sustaining attention, the following instruments have been respectively used: The Trail Making Test, Trial A (Reitan & Wolfson, 1993), and the Benton Visual Retention Test (1986). Taking into account the assessment of executive functions, the inhibitory control process was measured by the Stroop Color and Word Test (Golden, 1993), third administration: color / word or interference; and cognitive flexibility was measured by the Trail Making Test, Trial B (Reitan & Wolfson, 1993). Moreover, the process of visual-constructive praxis was measured by the Rey-Osterrieth Complex Figure Test, with its copy set (Rey, 1997). In turn, the memory processes were measured by the following instruments: the thirty-minute memory set of the Rey-Osterrieth Complex Figure Test (Rey, 1997) and the Rey Auditory Verbal Learning Test, lists A5 and A7 (Schmidt, 1996). Finally, the processes mediated primarily by language, such as the naming function of language and verbal fluency, were respectively measured by the following instruments: the 60-item version of the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983) and the Controlled Oral Word Association Test (COWAT) (Spreen & Strauss, 1998). The control variables consisted of two main variables. The first of which was the appraisal of four second-order personality traits using the HSPQ personality questionnaire for adolescents by R.B. Cattell and M.D. Cattell (2001). The second one was the measure of intellectual function using the Test of Nonverbal Intelligence (TONI-2) by Brown, Sherbenou and Johnsen (2000). All tests are accepted in accordance with the degree of reliability and meet Mexicans and Argentines scales.

Ethical considerations

All 60 participants were selected consecutively as the criteria required for participating was met: tenth grade students having their report cards signed by the tenth grade coordinator, absence of clinical indicators according to the HSPQ personality questionnaire for adolescents (Cattell & Cattell, 2001) and overall scores greater than 85 in the Test of Nonverbal Intelligence (TONI-2) (Brown et al., 2000). So the inclusion criteria were: being in tenth grade of high school, have no personality disorders and no intellectual disability. Parents signed the informed consent form; whose protocol was explained by a faculty team of three psychologists who administered the tests directly to the students in an individually application, receiving prior training. The seven neuropsychological instruments followed the application, correction and interpretation standards as established by the authors in their respective manuals.

Results

The data obtained from the procedure described above was analyzed under the terms of the following statistical procedure. All continuous variables were analyzed in light of the Rho Spearman correlation coefficient, which examines the relationship between ordinal variables (Hernández et al., 2010).

Table 1 below describes the means and standard deviations of the tenth grade students' demographic features of the sample, including age in years, socioeconomic stratum, and, for the nominal demographic variable, gender; and the control variables measured in the sample, which refer to the score results of the HSPQ personality questionnaire for adolescents (Cattell and Cattell, 2001) and the Test of Nonverbal Intelligence (TONI-2) (Brown et al., 2000).

Table 1. Socio-demographic features

Item	Age	Socio economic Level	Gender	HSPQ Factor QI Adjustment – Anxiety	HSPQ Factor QII Introversion – Extraversion	HSPQ Factor QIII Calmness – Excitability	HSPQ Factor QIV Dependency – Independency	TONI – 2 IQ
N	60	60	60	60	60	60	60	60

Mean	15.16	2.70	30	4.96	5.83	4.66	5.91	112.0
S.D.	0.64	0.67	30	1.86	1.47	1.11	1.16	14.66

Source: Authors (2014).

Table 1 presents that the average age of the sample was 15 years and the socioeconomic status referring 2.7 medium-low level. The sample consisted of 30 men and 30 women. The average scores for personality factors were among the range of 4.66 to 5.91 average ranking discarding mental disorders. And the IQ average was 112 refers to a score on average 100 for Intelligence Tests.

In this investigation, students were classified in different groups, taking into account the respective academic reports, whose scores range between 2.0 and 3.0 (low), and between 4.0 and 5.0 (high). Table 2 shows the grade point average scores.

Table 2. *Grade point average and academic performance concept*

Grade point average	Academic performance concept	Frequency
4.6	High	1
4.4	High	1
4.3	High	2
4.2	High	4
4.1	High	6
4.0	High	16
3.0	Low	6
2.9	Low	10
2.8	Low	4
2.7	Low	4
2.6	Low	1
2.5	Low	2
2.4	Low	1
2.3	Low	2

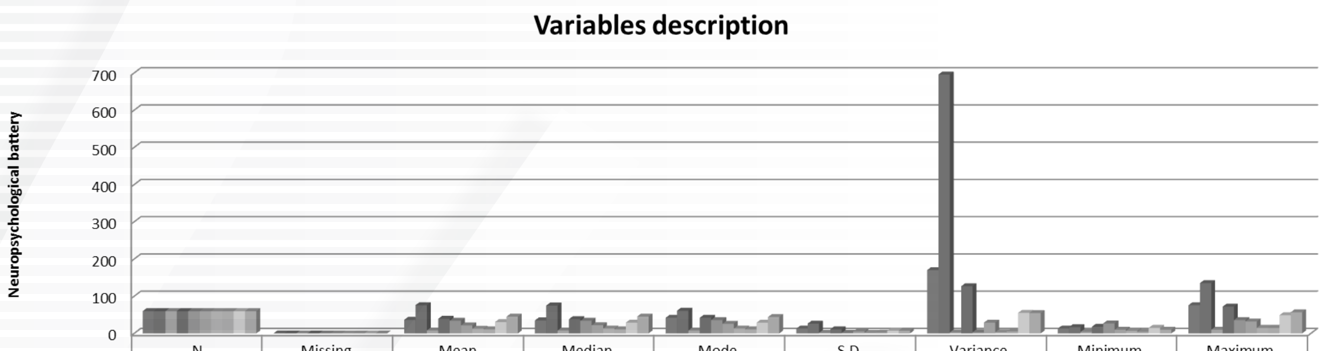
Source: Authors (2014).

Table 2 presents the grade point average and the concept of the academic performance from the educational school system. The lower academic performance is presented by the student who has average 2.3 (low) and the highest academic performance presents a student with grade average of 4.6 (high). Half of the sample (30 students) has low academic performance and half (30 students) high performance.

Table 3. *Descriptive statistics of the cognitive processes variables*

Item	TMT Time in Seconds		BVRT No. of Correct Sets	STROOP No. of Words in 45 Seconds	ROCF No. of Points Over 36		RAVLT No. of Correct Answers		BNT No. of Correct Answers	COWAT Sum of the 3 Trials
	Trial A	Trial B		Color / Word	Copy	Memory	A5	A7		
N	60	60	60	60	60	60	60	60	60	60
Missing	0	0	0	0	0	0	0	0	0	0
Mean	36.58	75.95	8.02	39.52	34.13	21.75	12.42	11.07	30.72	45.15
Median	35.00	75.00	8.02	38.50	34.00	22.00	13.00	11.00	29.00	45.50
Mode	42	61	8	42	36	26	13	11	29	44
S.D.	13.04	26.38	1.68	11.25	1.80	5.39	1.83	2.31	7.42	7.39
Variance	169.97	695.67	2.83	126.69	3.23	29.03	3.36	5.35	55.08	54.60
Minimum	13	17	4	18	27	10	7	4	15	10
Maximum	76	135	10	72	36	32	15	15	49	57

Source: Authors (2014).



	N	Missing	Mean	Median	Mode	S.D.	Variance	Minimum	Maximum
TMT A	60	0	36,58	35	42	13,04	169,97	13	76
TMT B	60	0	75,95	75	61	26,38	695,67	17	135
BVRT	60	0	8,02	8,02	8	1,68	2,83	4	10
STROOP	60	0	39,52	38,5	42	11,25	126,69	18	72
Copy ROCF	60	0	34,13	34	36	1,8	3,23	27	36
Memory ROCF	60	0	21,75	22	26	5,39	29,03	10	32
A5 RAVLT	60	0	12,42	13	13	1,83	3,36	7	15
A7 RAVLT	60	0	11,07	11	11	2,31	5,35	4	15
BNT	60	0	30,72	29	29	7,42	55,08	15	49
COWAT	60	0	45,15	45,5	44	7,39	54,6	10	57

Figure 1. *Descriptive statistics of the cognitive processes variables*
Source: Authors (2014).

Table 3 and Figure 1 present a summary of the central tendency measures with respect to the measured cognitive processes: focused and sustained attention, cognitive flexibility and inhibitory control, delayed visual memory, auditory verbal learning and delayed auditory verbal memory, visual-constructive praxis, naming function of language and verbal fluency. The scores were obtained from the seven applied instruments, with their minimum and maximum values, means, standard deviations and variances, respectively.

The results show that the mean in the TMT-A was 36.58. 50% of students are above the value 35; corresponding to the median and 50% are below this value. The most often score represent was 42 (mode). It is observed a standard deviation of 4.13 from the average of 36.58. In summary, the scores for focused attention tend to be in the range of mild severity for the performance of the group. In the TMT-B the mean was 75.95. The half of the students was above the value 75, and the other half are below this value. The mode was 61 and the standard deviation was referred to a point of 26.38. So, the scores for cognitive flexibility were located in the range of mild severity, too.

The mean in the BVRT was the same as the median with a point of 8.02. The most often score represent was 8. It is observed a standard deviation of 1.68 from the average of 8.02. In summary, the scores for sustained attention tend to be in the range of the average score according to its regulatory group. In the STROOP the mean was 39.52. The half of the students was above the value 38.5, and the other half are below this value. The mode was 42 and the standard deviation was referred to a point of 11.25. So, the scores for inhibition control were located in the range of mild severity. Likewise, the mean in the Copy ROCF was 34.13. 50% of students are above the value 34, corresponding to the median and 50% are below this value. The most often score represent was 36 (mode). It is observed a standard deviation of 1.8 from the average of 34.13. In summary, the scores for visual-constructive praxis show a superior performance according to the normative group. In the Memory ROCF the mean was 21.75. The half of the students was above the value 22, and the other half are below this value. The mode was 26 and the standard deviation was referred to a point of 5.39. So, the scores for delayed visual memory were located in the average respect to the age for this group.

For the A5 RAVLT the mean was 12.42. In this case, the median and the mode have the same value with 13. It is shown a standard deviation of 1.83. The scores for auditory verbal learning were reflected in the average range just as it was for the delayed auditory verbal memory in the A7 RAVLT which mean was 11.07. The median and the mode have the same value with 11 and the standard deviation was 2.31. Finally, the mean in the BNT was 30.72. The median was the same as the mode with a point of 29. The standard deviation was 7.42. The scores for naming function of language were in a range of severe difficulties almost like the range of severity was obtained for the verbal fluency in the COWAT with a mean of 45.15. 50% of the students was above the value 45.5, and the other half are below this value. The mode was 44 and the standard deviation was referred to a point of 7.39. The performance in the COWAT for the group of these students was moderate severity.

Table 4. *Correlation Analysis*

Item	TMT		BVRT	STROOP	ROCF		RAVLT		BNT	COWAT
	Trial A	Trial B		Color / Word	Copy	Delayed Memory	A5	A7		
Assessed Cognitive Process	Focused Attention	Cognitive Flexibility	Sustained Attention	Inhibitory Control	Visual-Constructive Praxis	Delayed Visual Memory	Auditory Verbal Learning	Delayed Auditory Verbal Memory	Naming	Verbal Fluency
N	60	60	60	60	60	60	60	60	60	60
Correlation coefficient	-0.254	-0.102	0.720**	0.204	0.050	0.041	0.196	0.226	0.612*	0.213
Sig. (2-tailed)	0.050	0.439	0.001	0.118	0.706	0.755	0.133	0.083	0.015	0.102

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).
Source: Authors (2014).

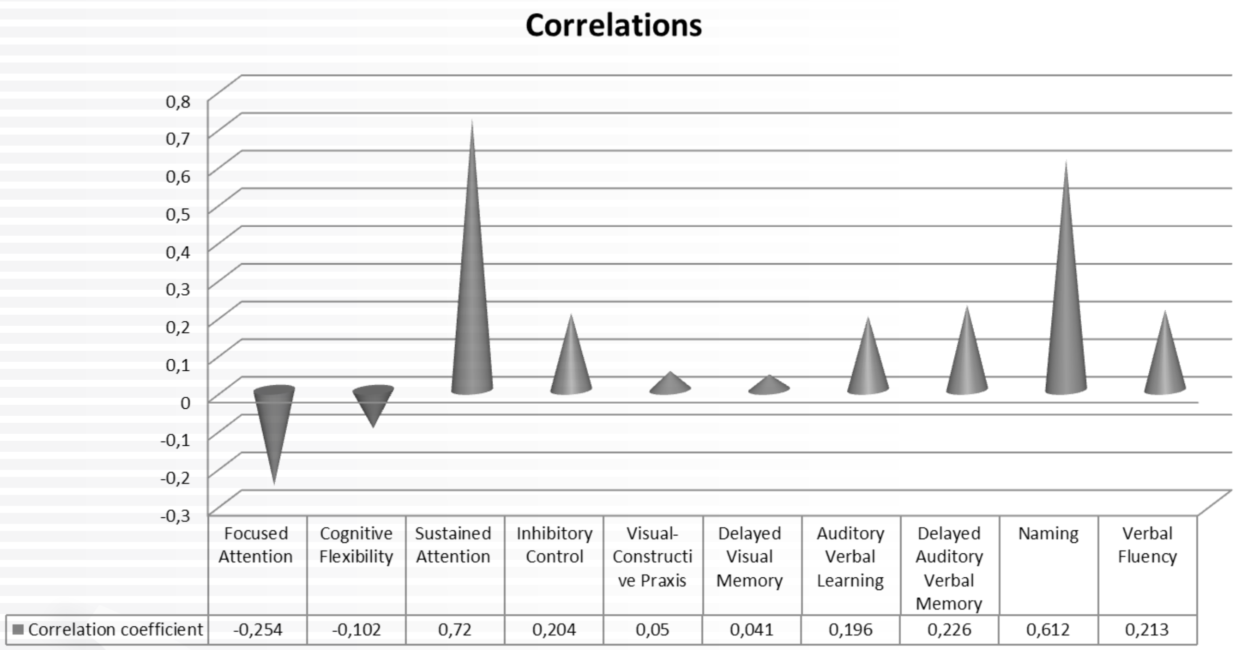


Figure 2. *Correlation between the cognitive processes and the academic performance*
Source: Authors (2014).

Tables 4 and Figure 2 provide the Rho Spearman correlation coefficient and the significance of each correlated variable pair from the seven neuropsychological research instruments. The most significant correlations between the assessed cognitive processes and academic performance were sustained attention (.720) and the naming function of language (.612). The other cognitive processes like inhibitory control, visual-constructive praxis, delayed visual memory, auditory verbal learning, delayed auditory verbal memory and verbal fluency obtained insufficient values for a positive correlation, as well as focused attention and cognitive flexibility which had negative values without positive correlation.

Discussion

The main premise of this research focuses on the correlation between cognitive processes and academic performance, and assessing such processes by a battery of neuropsychological research instruments, which consists of the Trail Making Test (Reitan & Wolfson, 1993), the Benton Visual Retention Test (Benton, 1986), the Rey-Osterrieth Complex Figure Test (Rey, 1997), the Rey Auditory Verbal Learning Test (Schmidt, 1996), the Boston Naming Test (Kaplan et al., 1983) and the Controlled Oral Word Association Test (Spreen & Strauss, 1998). Indeed, this research can show that, among adolescent students, the ability to sustain attention, assessed by Form C Administration A of the Benton Visual Retention Test (Benton, 1986) and the naming function of language, measured by the Boston Naming Test (Kaplan et al., 1983) are positive correlated with moderate significance with academic performance in such sample. The results of this study are similar to those obtained by Leon (2008) which relates the academic achievement with mindfulness, defined as the ability to concentrate. And so, it is confirmed that attention plays an important role in the activation and selection of cognitive resources, location and targeting the most relevant stimuli in their allocation according to the requirements of the task, in sustaining or the termination of its activity as well as changing the location and strength of the same as raised Boujon and Quaireau (2004). Similarly, the results of this investigation will be treated as the conceptualization built by Schleppegrell (2004) to refer the relationship between language and success in school. And thus, it can be noted that the language and its components, one of which, the naming function of language, work as predictors of academic performance as suggested by Rodriguez and Gallego (1992).

Furthermore, theoretical and clinical terms, it is worth noting that the ability to sustain attention is placed neuroanatomically on the prefrontal and parietal cortex; particularly, in the front right and bilateral parietal regions (Bartés-Serallonga et al., 2014). And the ability of the naming function of language refers to the angular region (multimodal association cortex of the parietal – temporal – occipital areas) and the back of the third temporal gyrus (area 37) of the dominant hemisphere (Vendrell, 2001). Because of this, the initial implications of the findings of this study for clinical and educational practice are handy for future neuropsychological research who wish to deepen between neuroanatomy and functionality of both processes.

Meanwhile, for such cognitive processes as the ability to focus attention and effectively executing, measured by Trial A of the Trail Making Test (Reitan & Wolfson, 1993); the cognitive flexibility, measured by Trial B of the Trail Making Test (Reitan & Wolfson, 1993); the inhibitory control of executive functions, measured by the Stroop Color and Word Test, third administration: Color/Word or Interference (Golden, 1993); the visual-constructive praxis, assessed by the Copy of the Rey-Osterrieth Complex Figure Test (Rey, 1997); the delayed memory of complex visual stimuli, assessed by the Rey-Osterrieth Complex Figure Test 30 minutes after presentation (Rey, 1997); the auditory verbal learning of words, measured by Wordlist A5 of the Rey Auditory Verbal Learning Test (Schmidt, 1996); the auditory verbal memory, assessed by Wordlist A7 of the Rey Auditory Verbal Learning Test (Schmidt, 1996); and the verbal fluency, assessed by the Controlled Oral Word Association Test (Spreen & Strauss, 1998), there was no statistically significant correlation with the academic performance variable in the sample studied under this research. For these variables is accepted in all cases the null hypothesis, which states the absence of correlation between variables and is rejected the alternative hypothesis, which postulates that there is a statistically significant relationship between the associated variables. This can be explained in terms of the limitations of this study, which point to the deficit between-groups comparisons. Is expected to continue research with other groups of different degrees in order to study the effects of attentional and linguistic ability as did Castillo-Parra et al. (2009) relating these variables in children and adults, watching his academic performance, age and education, concluding that during childhood, selective and sustained attention, working memory and executive functions have a rushed development, starting from an early age and continuing through adolescence stable, and that education plays a role important for the development of these cognitive processes. Also, it is concluded for the other cognitive processes like focused attention, cognitive flexibility, inhibitory control, visual constructive praxis, delayed visual memory, auditory verbal learning, delayed auditory verbal memory and verbal fluency that his association with academic performance can be explained by the effects of other variables such as intelligence, motivation, affect, and context, among others which are been studied by Moreno and Martínez (2010), Moreno and Chauta (2012), Moreno, Echavarría, Pardo and Quiñónez (2014), Hernández-Pozo, Ramírez-Guerrero, López-Cárdenas and Macías-Martínez (2015).

Another limitation found in this study, refers to the single measurement of academic performance taken. It is concluded that further research should be accompanied by others methodological tools such as Test-based criteria (Álvarez, 1989), Questionnaire FADE (Factors Associated with School Performance) (Timarán, Moreno & Luna, 2011) or other indicators of school performance as Additive School Performance Index (IADE) (Reyes, 2006) to obtain others measures of the variable.

In summary, regarding the literature review about academic performance, we confirm that some cognitive processes (sustained attention and naming function of language) are related to the willingness of students to make the most of school education (Caso-Niebla & Hernández-Guzmán, 2007; Castejón & Pérez, 1998). Second, once again the usefulness of several neuropsychological instruments to study cognitive processes in students without clinical disorders is confirmed. In this particular case, further use of this type of batteries is needed in other educational contexts in order to establish comparisons among groups, which would lead to the collection of more information about the subject matter. Third, the need arises in the pedagogical field to design psychopedagogical strategies aiming at the development of the prefrontal lobe functions, superior parietal and third temporal gyrus, such as planning, behavioral or inhibitory control, mental or cognitive flexibility, working memory, fluency, naming and attention (Flores, 2008). This study potentially urges the need to generate further hypotheses regarding this research. Thus, it would be of great interest to study the predictive value of these functions in academic performance of students at different education levels, such as elementary school, high school and higher education or university. Finally, it is essential to perform rigorous correlational and explanatory analyses when dealing with the academic performance variable in order to measure it adequately way when making comparisons; as well as to implement such valid and reliable neuropsychological instruments as those used in this research in order to objectively, systematically, structurally and uniformly contribute to the psychological scientific background in the field of neuroscience.

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