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Executive Functions in children of 9 and 12 years old in Montessori Method

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Abstract:

We emphasize the importance of the executive functions from an early age and how they keep developing throughout childhood.The study's main objective is to study the correlation between the time students have been in a Montessori school and sexes, with the executive functions. As for the more specific objectives, we consider the assessment of the executive functions in a Montessori school and to determine the level of the executive functions in students. This work, outlines the evaluation of neuropsycological development and the executive functions in a group of boys and girls from CCE Montessori Palau Girona school. To this end, the administration of the test ENFEN (Portellano et al. 2009) and CUMANES (Portellanoet al.2012) has been conducted and we have focused on two sub-tests from each one. Together, we have evaluated a total of 30 primary school pupils aged 9 and 12. From the results, we have analyzed the strong and weak points, and a proposal for intervention from them has been made so they can serve as a basis for the future.

No differences in the results of the executive functions evaluated have been observed between the sexes but within the different ages there have been differences. It was observed that for most of the executive functions a positive slope, although not significant, between the time the students enrolled in the Montessori methodology and a higher positive score in the executive functions, being more significant with the youngest, 9 year olds. A greater significance in males versus females was also observed.

In conclusion, no differences were found in the executive functions of students respect to sexes but a higher score in the executive functions related to a longer period of time enrolled in the Montessori methodology was observed.

Keywords: Executive functions, Montessori, Elementary, Sex, Age.

1. INTRODUCTION

For more than a century Dr. Montessori (M. Montessori, 1952) included the executive functions in her methodology and explained that the child goes through different sensitive to over development periods and at the same time, acquiresdifferent capacities. Stimulation for these periods, Dr. Montessori proposed an harmonious environment and currently, it has been shown that the acquisition of knowledge has nothing to do with memorizing or repeating the work again and again, it is learned experimenting and manipulating.

The Montessori environment is an attractive and organized environment for work and the working materials are distributed in areas. It is a space to promote freedom and autonomy for children so they can work at their own pace and depending on their needs. The adult is responsible of preparing this environment. The materials are handled and real and children can work with them whenever they want and they are never interrupted by the guide and also they have their own error control. The Montessori classroom structure allows movement freedom of movement within established rules, spaces are bright and spacious and are designed to stimulate awareness and independence for children. The prepared environment allows to bring reality to the child so the children find a meaning in their world and adapt successfully. This environment suggests a respect for the materials, the work of other colleagues, and the adult,and makes the children unfold with order and freedom.

Each material developed by Dr. Montessori requires movements led by theintelligence and allows the child the gradual realization of works. Furthermore, it is a junction point between the concrete and the abstract and takes the child to real world knowledge.

On another hand, the executive functions depend on a neuronal circuit that includes three fundamental skills: self control, working memory,keeping the information that we will use in our mind, and creativity. In addition, executive functions also include more complex activities such as problem solving, reasoning and planning.

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The first author who spoke of executive functions was Joaquin Fuster (Fuster, 2000) and the term of executive functions was due to Muriel Lezak (Lezak MD, 1982). Neuroscientific Adele Diamond (Diamond, A., 2011) has been commissioned to relate the Montessori pedagogy and the executive functions.

According toTirapu-Ustárroz (Tirapu "Ustárroz, J & Luna" Lario, 2008), Luria (Luria, 1986) was the first author who identified disorders related to initiative, motivation, formulation of goals and action plans and self-monitoring of behavior associated with frontal lesions. It was later when Muriel Lezak (Lezak MD, 1987) coined the term and defined them as essential mental abilities to carry out an effective, creative and socially acceptable behavior. Meanwhile, Mateer (Sholberg MM, 1989) distinguished the following components: direction of attention, recognizing priority patterns, formulation of intention, achievement or accomplishment plan, implementing the plan and recognition of achievement. Others like Sholberg and Mateer (Sholberg MM, 1989) refer to them as the components in the direction of care, recognizing priority patterns, formulation of intention, attainment plan and implementation of the plan. Executive functions are linked to neuroanatomical processes according Bechara et al. and Cummings (Bechara A, Damasio H, 2000).

From an educational perspective, we can say that executive functions:

• Emerge in the first year of life.

• They develop a wide range of ages, with an increase between 2 and 5 years old and from 12 years old.

We must also talk of Neuroscience and how is approached from the point of view of cognitive psychology.

Therefore, we must complete the procedural approaches with structural approaches,as the one developed by Piaget, which establishes the genesis and development of theaction structures and the subject operations and proposed the operative pedagogy, which is specific in the use of active methods of education.

Neuroscience tries to relate the mind, behavior and activity of nerve tissue, that is to say, how the brain activity is related to the psyche andbehaviors, and it is changing the way we learn, how to store information in the brain and biological processes that facilitate learning.

Therefore, through the executive functions, Montessori students:

- Have freedom to choose what and where to work.
- No times tables and they can work without interruption.
- There is only one material in each classroom so they learn to wait for the other child to finish.
- The guide observes each child and presents new challenges.
- Few activities are done with the whole group.
- Learning comes through practice.
- Tutoring between children of different ages (three ages mixed in the classroom).
- Teaching among children gives better results.
- The curiosity and interest of each student is assessed.
- The work environment is attractive.
- Classes breathe peace and calm and children are concentrated.
- Classes have many children (30-40 children) to encourage support among themselves.

2. OBJECTIVES

We propose like a general objective: To evaluate the executive functions in a Montessori school.

In addition, they have been identified as specific objectives:

Objective 1. Check whether there are high differences in executive functions depending on the time of enrollment in a Montessori school.

Objective 2. Check for differences in executive functions depending on sexes.

Objective 3. To assess whether there are differences in executive functions depending on age regarding the group evaluated.

Objective 4. Relate the values obtained by time, age and sexes in the executive functions of the group.

Objective 5. Determine the level of executive functions and propose improvements

3. METHODOLOGY

3.1. Design

The project has been considered a descriptive study, as the data obtained in the different sub-test of ENFEN and CUMANES test are measured. Descriptive statistics were used to assess the study group and to see if thereare differences between different variables (sexes). It is also a

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correlational study, as it assesses whether there is a relationship between the time students have been enrolled in the Montessori school and the results obtained in the various sub-test. Furthermore, it is a non-experimental study because the independent variables are not manipulated, that is, such phenomena are observed and as given in its natural context. Finally, it is a quantitative study, since observations are studied from numerical data.

3.2. Participants

For the study, 30 students were chosen from Elementary Education in the Montessori-Palau School in Girona (Spain), located in a high socioeconomic neighborhood (Palau). It also should be noted that most of the students come from areas close to the capital. It is the first school of Catalonia where the Montessori methodology was established 12 years ago, although this center is operational since 1967 where it worked with the traditional methodology. Currently, it holds the Montessori method from 0 to 12 years, from higher cycles, it works in a traditional methodology.In this study, 15 males and 15 females aged 9 and 12 years will be valued. They have been excluded students who have as their mother tongue a foreign language and with less than 3 courses in the country; likewise, they have been excluded students with special educational needs or students with psycho diagnostics.

3.3. Instruments

For the study we used the following instruments:

- ENFEN. Neuropsychological Assessment of Executive Functions in Children(R. M. and J. A. L. Z. Portellano, 2012). Through this test, we value the level of maturity and cognitive performance in activities related with the executive functions in children. The battery is composed of four tests that measure the different components of executive functions: verbal fluency, construction,construction with rings and resistance to interference. We will focus on the path building test that evaluates memory, prospective and work, selective and sustained attention, spatial perception,logical reasoning, mental flexibility, the ability to anticipate andmotor coordination graph. Their results allow to guide the intervention and see the strengths and weaknesses of the subjects.

- CUMANES. Neuropsychological Maturity Questionnaire for School (R. M.and R. M. A. J. A. Portellano, 2009). Through this test is carried out an overall assessment of neurodevelopment and cognitive performance in children. This test is grouped in 6 areas: Language, visoperception, executive functioning, memory, rhythm and laterality. As in the previous test, will focus on the sub test of visoperception and rhythm. Their results allow to guide the neuropsychological and educational intervention.

3.4. Procedure

Since each test follows a different design, we detail how they carried out the realization of each test. For the two tests, we use a bright room and withthe examiner and the child. They were applied on different days.

ENFEN. The paths test is formed by two parts: gray path and colour path. Gray path, we ask the child to draw a line joining the numbers from 20 to 1 that appear randomly arranged on a sheet. In the colour path, we ask the child to draw another path joining the numbers from 1 to 21 that appear randomly arranged on a sheet, but alternating the ones that are yellow and the pink ones.

CUMANES. In the visoperception test, the child presents a series of 11 geometric figures, and the task is to copy as closely as possible one at a time corresponding boxes. We ask them to do so very carefully because they cannot use the eraser. In the first 10 figures the child has the model in front. In the last one, an independent figure is presented for 15 seconds. After it is removed and they are required to reproduce the figure they just saw. In the rhythm test the children have to play 10 rhythm sets. The examiner performs a rhythmic sequence pounding on the table with the opposite end of the pen tip. Then she/he asks the child to repeat the same way. The series have an increasing complexity, so it is differentially score (1, 2 or 3 points).

3.6. Data analysis

Data analysis is done with an Excel spreadsheet, which has carried out a descriptive statistical analysis of students by sexes and age and the results obtained in the relevant sub evaluated test performed. It has also been calculated a linear regression between the data obtained in the sub test to assess executive functions and the time the students have been in Montessori methodology. For each of the regressions has been evaluated the equation of the line and its coefficient of determination (the square of the Pearson correlation R2). It has also been determined that correlations were significant from the P value for a significance level of $\alpha = 0.05$ and N-2 degrees of freedom, where N is the number of students tested. Significance was not observed under these data with the exception of executive function colour path in students aged 9 years.

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4. RESULTS

Executive Functions were evaluated in 30 Montessori school children from 9 to 12 years old. Average, Medium and standard deviation from all students was represented in Table 1. .

Table 1. *Descriptive statistical executive functions analysis.*

	GREY PATH	COLOUR PATH	PERCEP. VISION	RHYTHM
Average	7,17	6,33	9,77	7,67
Medium	7,50	6,50	10,00	8,00
Standard deviation	2,20	2,07	0,57	1,84
MALES				
Average	7,33	6,20	9,73	7,73
Medium	7,00	7,00	10,00	7,00
Standard deviation	2,29	2,37	0,59	2,12
FEMALES				
Average	6,93	6,57	9,79	7,57
Medium	7,50	6,00	10,00	8,00
Standard deviation	2,23	1,83	0,58	1,65
9 YEARS OLD STUDENTS				
Average	6,63	6,11	9,79	7,79
MediUM	7,00	6,00	10,00	8,00
Standard deviation	2,29	2,11	0,54	1,78
9 YEARS OLD MALES				
Average	6,67	5,89	9,78	7,89
Medium	7,00	7,00	10,00	7,00
Standard deviation	2,55	2,52	0,44	1,90
9 YEARS OLD FEMALES				
Average	6,67	6,11	9,78	7,67
Medium	7,00	6,00	10,00	8,00
Standard deviation	2,29	1,76	0,67	1,87

We can see in the statistical descriptive a little variation between sexes, so males have high average in grey path and rhythm and females have higher in colour path and perceptive vision. All data have the same standard deviation less vision perceptive, with a low standard deviation.

In Figure 8 is observed correlation results in different executive functions. We found the highest correlation with rhythm in colour path and less correlation with perceptive vision and rhythm. In all executive functions the evaluated slopes are positive.

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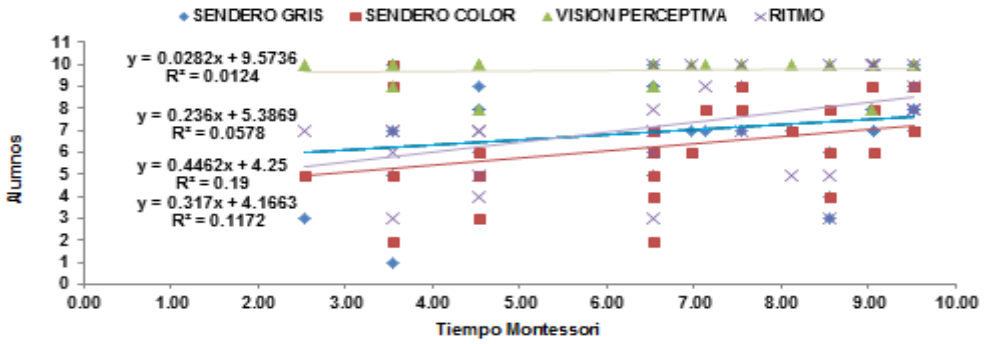

Figure 8. Executive Functions correlations (grey path, colour path, perceptive vision and rhythm) in all students evaluated how long have been in Montessori school immersion. The correlations weren't significant statistical for significance level of 0.05 and 28 degrees levels.

In Figure 9, we can see different males correlations between executive functions and time in Montessori school immersion. We found higher correlations in vision perceptive and colour path and less in rhythm and grey path. In all correlations were found positive slopes.

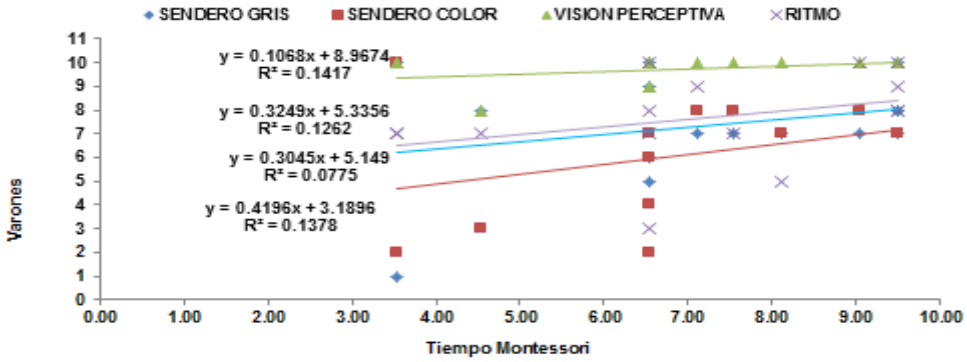

Figure 9. Functions executive correlations (grey path, colour path, perceptive vision and rhythm) in male students evaluated how long have been in Montessori school immersion. The correlations weren't significant statistical for significance level of 0.05 and 28 degrees levels.

In Figure 10 is observed female correlation results in different executives functions and time immersed in Montessori school. We found the highest correlation in colour path and rhythm and less correlation with perceptive vision in grey path. In all executive functions evaluated slopes were positive except perceptive vision.

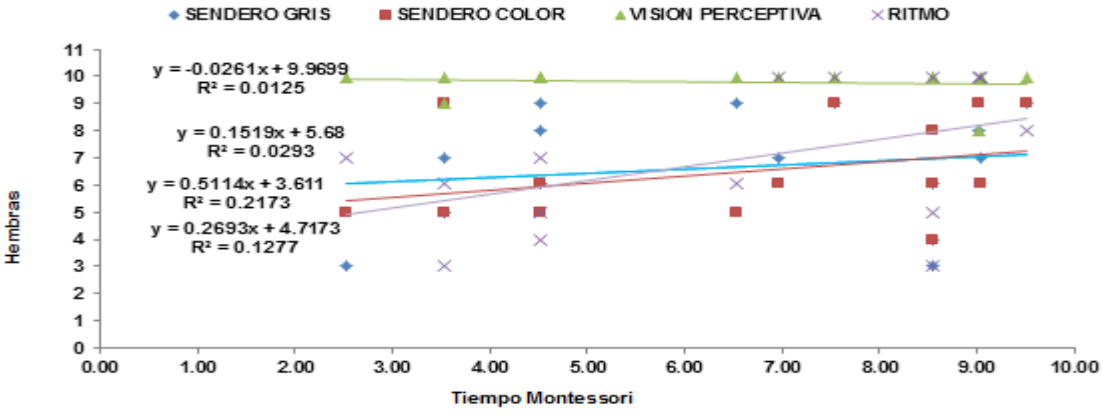

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Figure 10. Functions executive correlations (grey path, colour path, perceptive vision and rhythm) in female students evaluated how long have been in Montessori school immersion. The correlations weren't significant statistical for significance level of 0.05 and 28 degrees levels.

In the Figure 11 we can see that students with 9 years old have a higher correlation than older students (Figure 8). In students with 9 years oldwe can observe a higher correlation in colour and grey path. Rhythm and perceptive vision we can observe less correlation. All slopes are positive except vision perceptive.

In Figure 12, we found a higher correlation in colour and grey path and less in rhythm and perceptive vision. All slopes were positive.

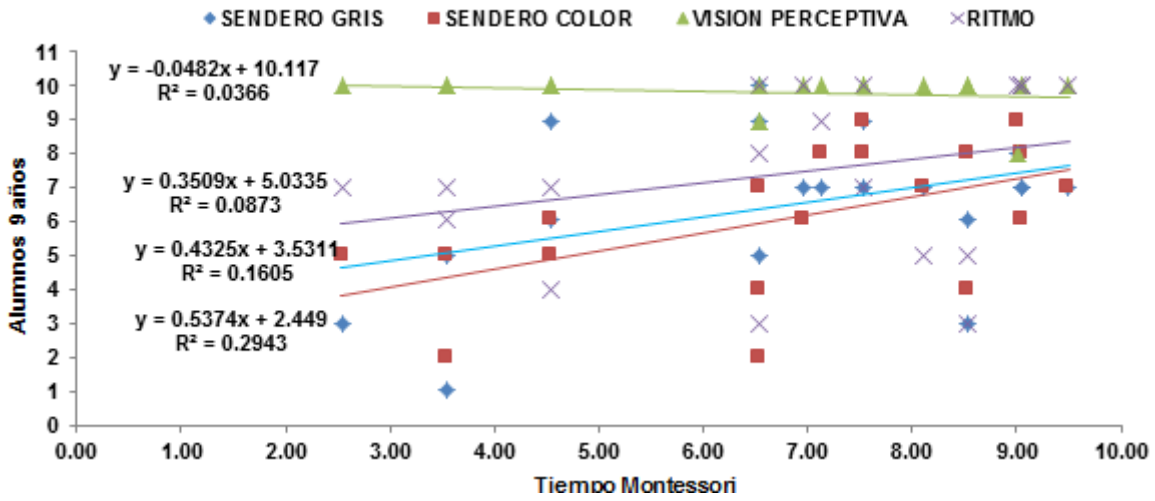

Figure11. Functions executive correlations (grey path, colour path, perceptive vision and rhythm) in nine years old students evaluated how long have been in Montessori school immersion. The correlations weren't significant statistical for significance level of 0.05 and 28 degrees levels.

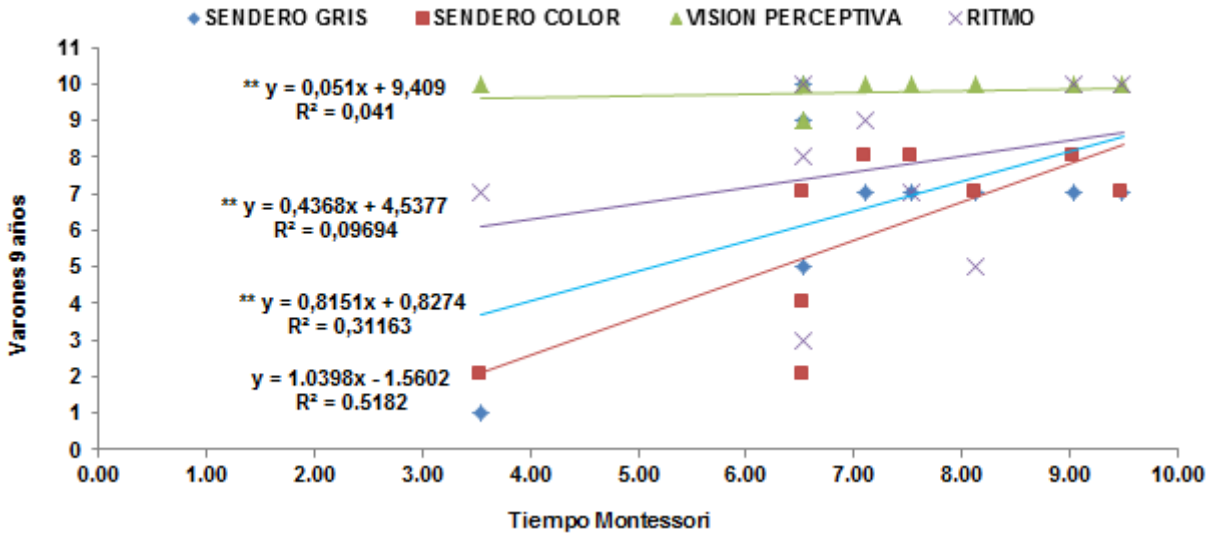

Figure 12. Functions executive correlations (grey path, colour path, perceptive vision and rhythm) in nine year old male students evaluated how long have been in Montessori school immersion. The correlations weren't significant statistical for significance level of 0.05 and 28 degrees levels.

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In Figure 13, was observed a higher correlation in colour path and perceptive vision and less in grey path and rhythm. We found a positive slope in all executive functions, except vision perceptive.

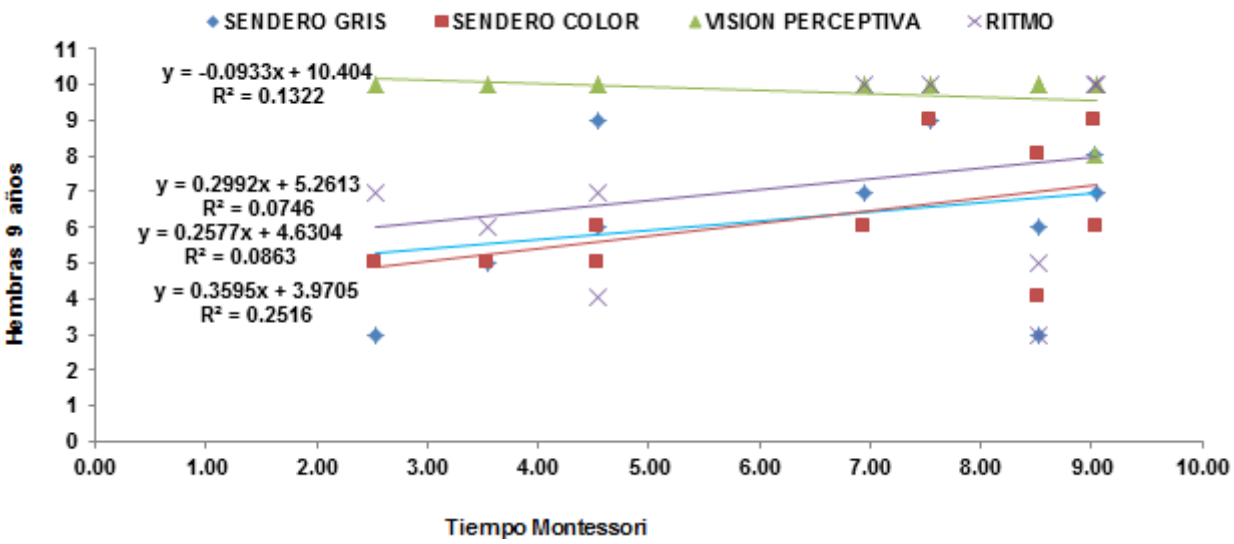

Figure 13. ExecutiveFunctions correlations (grey path, colour path, perceptive vision and rhythm) in female 9 years old students evaluated how long have been in Montessori school immersion. The correlations weren't significant statistical for significance level of 0.05 and 28 degrees levels.

5. INTERVENTION PROGRAM

5.1. Goals

The objectives to be achieved are:

- Maximize the executive functions in children of elementary education.
- Developing skills and abilities for students who may have problems in learning.
- Encourage students to develop and improve their strengths and weaknesses.

5.2. Methodology

When focusing the intervention program, we must keep in mind that not all students are at the same level as far as executive functions are concerned, so the proposal is indicated to improve and enhance those capabilities in all types of students. From here, we will work different aspects:

- Learning context: It is important that students are motivated whenworking in class. From the Montessori method, this last point is very important because the independence and autonomy of students, who are participants in their own teaching-learning process is promoted.
- Teacher role: The role of the teacher will be an active and dynamic roleto propose activities.
- Role of students: We believe that the students played the most important role in this type of intervention, because as we said earlier,he/she will be participant and responsible for his/her teaching-learning process.
- Role of the Montessori methodology: Considering the premises that Dr. Montessori gave.
- Role of activities: participation is important in proposed activities to improve learning, and these may be in small group orindividual.

5.3. Activities

The timing of the activities will be a quarter (14 classes), divided into a weekly 40-minute session, organized to enhance memory, perception, attention, logical reasoning, mental flexibility, the ability to anticipate and coordination graphomotor.

5.4. Evaluation

We will consider the continuous evaluation in which the participation, motivation and involvement of students in day to day in the classroom is very important, and on the other hand, the final

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evaluation, where aspects that are part of the competition are valued that is evaluated

6. DISCUSION

We didn't find in data, difference in average according sexes, but in younger students, we have had minor results in executive function. Those were expected results because executive function during growing up period increases.

Executive Functions, are high during childhood and it remains stable in adolescence.

Generally, correlations between executive functions and the time a student has been in a Montessori school system are not so high (no significant atα = 0,05 and N-2 degree level). The highest correlation was found in males with 9 years in colour path, with a significant relevance, and we have less correlation in all students in perceptive vision executive function.

Although majority correlations are not significant in terms of stats, in all cases, we have obtained positive correlation in almost all executive functions so when students were immerse before in Montessori school, we have had better perform in executive function test.

This fact is evident in students with 9 years (Figure 11), where students who started before in Montessori school system have had a high rank (statistical difference in Figure 12) than student with 9 years who start before.

When all students grow older, the difference in the executive functions are minor, according several studies done for Williams, Ponesse, Scharchar, Logan and Tannock (William, B., Ponesses, J., Schachar, R., Logan, G.&Tannock, 1999).

Also, we found differences between sexes, so males have had better score than female, and we found those data in all students with 9 years old. That could be happen because mental maturity female is early than males (Acosta, 2001).

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