RELATIONSHIP BETWEEN ATTENTIONAL ABILITIES AND ACADEMIC PERFORMANCE AMONG MIDDLE SCHOOL LEARNERS IN MIDDLE ATLAS OF MOROCCO

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Abstract

Introduction: Attention is one of many cognitive functions; it plays a central role in the learning process. For this reason, our study aims to determine the impact of attentional abilities on academic performance among middle school learners in Middle Atlas of Morocco.

Methods: Data were collected from a sample of 137 middle school learners. For the assessment of attentional abilities, we performed the Trail Making Test (TMT) to estimate mental flexibility. Evaluation of selective attention was done through the Stroop Test and the measurement of sustained attention was achieved via the d2-R test.

Results: Our results revealed that the attentional abilities of learners in our samples are positively correlated with their academic performance and vice versa.

Conclusion: At the end of this study, it is important to establish a thorough diagnosis of attentional disorders to identify learners with attention problems in order to implement a remedial program so as to avoid the detrimental effects of these disorders on the academic performance of learners.

Keywords: Learner, Middle School, Academic Performance, Attentional Abilities

Introduction

Research in neuroscience and neurocognition have highlighted the main pillars essential to all learning, with the prefrontal cortex playing essential roles, namely attention, active engagement, feedback and finally consolidation of learning outcomes, which is a crucial stage in the memorization process (1). In learning, the first attempts made are to associate certain patterns with particular situations, often requiring focus and sustained attention. The definition of attention seems quite clear, according to Lachaux (2011), "*The child discovers that to be attentive is to stop constantly moving from one centre interest to another to stabilise a little, to stop for a few moments on certain aspects of the world around him. If this period of mental stability is prolonged, he discovers that he is concentrated and that the involuntary break from these states is called letting himself be distracted*." (2). In clinical practice, the most frequently used taxonomy is that of van Zomeren and Brouwer, who defined five major types of attention divided into two main axis: the intensity axis (alert, vigilance and sustained attention) and the selectivity axis (selective attention and divided attention) (3).

Several studies in neuroscience have shown the association between attention and learning (4). Hence, many researchers have been interested in studying attentional skills in relations to the learning process, especially in children (5). With the development of cognitive neurosciences, the novelty of studies on cognitive functions in relation to learning and the rarity of this type of study in adolescents, particularly in Morocco, we aim to clarify the relationship between attentional processes and school performance in Moroccan adolescents.

Materials and Methods

Subjects

137 middle school learners continuing their studies in four public colleges, aged within 12 to 16 (with an average

age of 14.5±1.3), and living in two different areas [urban (n=59), rural (n=78)] in the province of Khénifra located in the Middle Atlas (Morocco) were sampled randomly.

Methodology

Before administering the attention tests to the participants, we obtained administrative authorisations from the directors of their schools and consent from the parents or guardians of the learners. Then, we proceeded to complete an information sheet for each learner, collecting socio-demographic data relating to each participant (age, school, region of origin, grade level, general average of the first semester, and parents' level of education).

Each participant were required to complete the Trail Making Test (TMT) and Stroop tests individually. For the d2-R test, the test was administered in groups of five to six learners after the two previous tests had been completed. We tried to ensure that the tests were administered under conditions where distractors were absent and avoided periods of declining attention skills in the learners (i.e. attention deficit periods). Assessment of each learner's academic files, overall averages and teachers' opinions were used to determine the academic performance of each learner.

Tests

To assess the different attentional skills of learners, we used tests that met all the criteria of a psychometric test:

i. They are standardized: Instructions are clear, simple and always the same. The scoring sheet allowed all examiners to correct in the same manner.

ii. They have good intra-corrector fidelity: The same observer obtains the same result at two different times for a given individual.

iii. The intra-test fidelity is respected: Cut in half, the test provides the same results, thus showing high homogeneity of the test.

iv. Sensitivity: Implies that the evaluation is precise.

v. They have good content validity: The tests measured well what they are supposed to measure.

Trail Making Test *(TMT)*

This test was designed by Reitan and Wolfson (1985) (6) to assess mental flexibility or attentional flexibility, visual exploration and visuo-motor skills. The TMT has been widely used by clinical psychologists due to its advantages, particularly its ease of use and its speed. This test is composed of two parts. Part A consists of linking an increasing series of numbers from 1 to 25 by selecting at each moment the relevant number from among the 25 possible items. In part B, the subject must lead two alternating series at the same time: a series of numbers and a series of letters (1-A-2-B-3-C...13). It is therefore a matter of planning in parallel, but in an alternating manner, two automated series without interfering with each other by permanently activating the relevant sequence and temporarily inhibiting the second one. Part B is more complex than part A, and allows the evaluation of "*shifting*".

Stroop test

The purpose of this test is to assess selective attention. It is one of the few tests that specifically assesses selective attention skills and requires little equipment. It consists of 3 sheets of A4 format paper: The first card (A) consists of a sequence of words written in black ink and naming 4 colours (green, yellow, red, blue) arranged randomly in 10 rows of 5 words. The second card (B) represents a series of coloured rectangles (green, yellow, red, blue) randomly arranged in 10 rows of 5 rectangles. The third card (C) retains the characteristics of card A (with a new random arrangement) but the printing ink is different for each word. The colour name is never printed in the named colour. For the final score, we recorded the number of items processed, the number of mistakes made by the learners for the three tests for 45 seconds according to the rating by Desbrosses S (2007) (7).

d2-R Sustained Attention Test

This test was conceived in order to evaluate sustained attention; it mainly uses concentration on visual perceptions. It is part of the so-called "dam" tests. It is an A4 sheet, where there are 14 lines of 47 signs, which are "p" or "d", accompanied by one or two lines at the top and/or at the bottom. This gives, in combination, 15 possible distractors. The subject is invited to find on the sheet all the "d" accompanied by only 2 lines, no more no less. The subject has 20 seconds per line (280s for the complete test). The data takes into account the total number of signs observed during these 280s, the number of errors by substitution as well as the number of omissions. We obtained a percentage of error as well as a productivity score for this test.

Statistical analysis

The collated data were first computed in Excel. After filtering the matrix, the data was transferred to the statistical processing software support (SPSS Version 21). The statistical analyses chosen in this study are descriptive (mean, median, standard deviation, etc.) and analytical (Pearson correlation, student's t-test, multiple linear regression, etc.). The results obtained were illustrated in statistical tables in the form of frequency, average and probability.

Results

Socio-demographic characteristics

The various socio-demographic characteristics of the subjects studied, including age, institution, background, level of education achieved by the learner and the level of

education of the learners' parents are represented in Table 1, with a comparison between the two sexes.

Table 1: Socio-demographic characteristics of the subjects (n=137)

Variable	Modality	Sex		Total	Chi-square (p-value)
		Female	**Male**		
Age	Average ± SD	14.5± 1.18	14.68± 1.45	14.60± 1.33	
	(Min; Max)	(13; 16)	(12; 16)	(12; 16)	
	(Skewness; Kurtosis)	(0.24; -0.86)	(0.097; -0.65)	(0.18; -0.63)	
Environment	Urban	27 (19.71%)	32 (23.36%)	59 (43.07%)	0.12 (0.94) (ns)
	Rural	37 (27.01%)	41 (56.17%)	78 (56.93%)	
Level of education reached by learner	1st middle school	18 (13.14%)	19 (13.87%)	37 (27.01%)	
	2nd middle school	24 (17.52%)	33 (24.09%)	57 (41.61%)	0.88 (0.64) (ns)
	3rd middle school	22 (16.06%)	21 (15.33%)	43 (31.39%)	
Level of father's education	Higher	6 (4.38%)	6 (4.38%)	12 (8.72%)	
	Secondary	17 (12.41%)	13 (9.49%)	30 (21.90%)	2.58 (0.46) (ns)
	Primary	8 (5.84%)	15 (10.95%)	23 (16.79%)	
	Illiterate	33 (24.09%)	39 (28.47%)	72 (52.55%)	
Level of mother's education	Higher	4 (2.92%)	0 (0%)	4 (2.92%)	
	Secondary	4 (2.92%)	5 (3.65%)	9 (6.57%)	3 (0.019)*
	Primary	8 (5.84%)	2 (1.46%)	10 (7.30%)	
	Illiterate	48 (35.04%)	66 (48.18%)	114 (83.21%)	
Total		64 (46.72%)	73 (53.28%)	137 (100%)	

SD: Standard deviation
Min: Minimum
Max: Maximum
*: Significant (p-value<0.05)
ns: Not significant

The average age (in years) of our sample is 14.60±1.33, with a minimum age of 12 years and a maximum age of 16 years. The average age is 14.68±1.45 for boys and 14.5±1.18 for girls. The values of the Skewness and Kurtosis coefficients (0.18; -0.63) confirmed that our distribution is Gaussian. The distribution by sex showed that 46.72% (n=64) were female and 53.28% (n=73) were male (Figure 1). The sex ratio was therefore balanced (chi-square=0.5; p<0.49).

The distribution of learners according to the level of education achieved showed that 27.01% (n=37) were in the first year, 41.61% (n=57) were in the second year and 31.39% (n=43) were in the third year of middle school. The learners in our sample come from four schools, two of which are located in urban areas (n=59) and the other two in rural areas (n=78). More than half (n=72; 52.55%) of the fathers of the learners in our sample were illiterate. 16.79% (n=23) of fathers had a level of education that did not go beyond primary school, and 21.90% (n=30) of fathers had a secondary school level of education. Only 8.72% (n=12) of fathers of the learners in our sample had a higher level of education. The majority of mothers of the learners in our sample were illiterate (n=114; 83.21%). Mothers with a level of education beyond primary school was 7.30% (n=10), while mothers who had a secondary school level of education was 6.57% (n=9). Only a small minority of the mothers of learners in our sample (n=4; 2.92%) had a higher level of education.

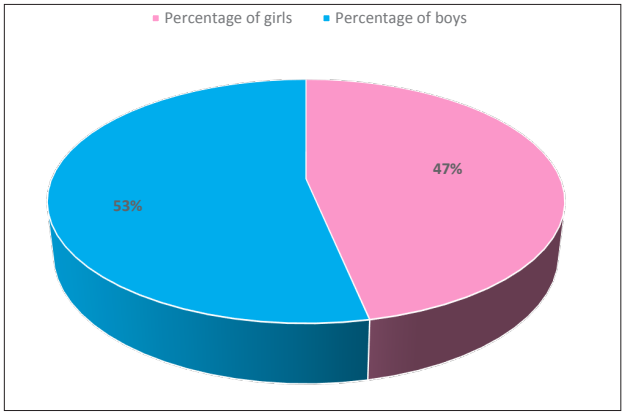

Figure 1: Percentage of girls and boys from the sample studied

Association between attentional flexibility and academic performance

In order to study the relationship between (i) school performance and the scores in tasks A and B of the TMT, and (ii) the difference TB-TA and the number of errors committed by learners, a joint analysis was carried out by means of the multiple linear regression test. The results are shown in Table 2.

The multiple regression analysis showed that academic performance was negatively correlated with the scores of the two TMT tasks A and B and the time difference between the two tasks, respectively [Task A (r=-0.205; p<0.016); Task B (r=-0.427; p<0.000); Time difference between the two tasks (r=-0.375; p<0.000)]. However, there was no correlation between academic performance and learner errors in the TMT tasks. It can be concluded that attentional flexibility was diminished in the least successful learners and that the double task affects the time taken by the learner to complete the task rather than the accuracy of TMT task performance.

Table 2: Joint analysis via the multiple linear regression test for learner scores in the Trail Making Test (TMT)

	TA	TB	TB-TA	Errors	Academic performance
TA	**1**	**0.324** ** **(p<0.000)**	**-0.030 p<0.726**	**-0.069 p<0.425**	**-0.205** * **p<0.016**
TB		1	0.936** p<0.000	0.336** p<0.000	-0.427** p<0.000
TB-TA			1	0.381** p<0.000	-0.375** p<0.000
Errors				1	-0.061 p<0.482
Academic performance					1

TA: TMT task A reaction time
TB: TMT task B reaction time
TB-TA: Time difference between the two tasks
**: Significant (p-value<0.01; bilateral)
*: Significant (p-value<0.05; bilateral)

Association between selective attention and academic performance

In order to study the relationship between academic performance and the scores of the various tasks of the Stroop test, a joint analysis was performed using the multiple linear regression test. The results are shown in Table 3.

Results of the simple linear regression analysis showed that academic performance was negatively correlated with the score of errors committed by learners in the three tasks of the Stroop test (reading task, naming task and interference task), respectively [(r=-0.266; p<0.002) for errors committed in the reading task; (r=-0.391; p<0.000) for errors made in the naming task; (r=-0.290; p<0.001) for errors made in the interference task]. On the other hand, there was a positive correlation between school performance and the scores of items totaled by the learners in the three tasks of the Stroop test, respectively [(r=0.424; p<0.000) for the score of items in the reading task; (r=0.593; p<0.000) for the score of items in the naming task; (r=0.322; p<0.000) for the score of the items in the interference task and (r=0.473; p<0.000) for the

Table 3: Joint analysis via the multiple linear regression test for learner scores in the Stroop Test

	Academic performance	Reading task	Task 1 Errors	Naming task	Task 2 Errors	Interference task	Task 3 Errors	Interference score
Academic performance	1	0.424** 0.000	-0.266** 0.002	0.593** 0.000	-0.391** 0.000	0.322** 0.000	-0.290** 0.001	0.473** 0.000
Reading task	0.424** 0.000	1	-0.534** 0.000	0.243** 0.004	-0.323** 0.000	0.087 0.311	-0.391** 0.000	0.205* 0.016
Task 1 Errors	-0.266** 0.002		1	-0.187* 0.029	0.290** 0.001	-0.109 0.204	0.259** 0.002	-0.128 0.135
Naming task	0.593** 0.000			1	-0.483** 0.000	0.628** 0.000	-0.299** 0.000	0.699** 0.000
Task 2 Errors	-0.391** 0.000				1	-0.364** 0.000	0.327** 0.000	-0.261** 0.002
Interference task	0.322** 0.000					1	-0.396** 0.000	-0.050 0.565
Task 3 Errors	-0.290** 0.001						1	-0.057 0.512
Interference score	0.473** 0.000							1

**: Significant (p-value<0.01; bilateral)
*: Significant (p-value<0.05; bilateral)

interference score]. It can be concluded that the more learners exhibit school performance, the more they detect additional items and the less errors they make in Stroop's tasks. Therefore, better performance of selective attention implies better academic performance.

Association between sustained attention and academic performance

In order to examine the relationship between the dependent variable, academic performance, the power of concentration of learners, and the number of errors made by learners during the execution of the d2-R test, a joint analysis was performed using the multiple linear regression test (Table 4).

Table 4: Joint analysis of multiple regression for learner scores in the d2-R Test

	Academic performance	Power of concentration (CC)	Percentage of errors (% F)
Academic performance	**1**	**0.171*** **p<0.046**	**-0.222**** **p<0.009**
Power of concentration (CC)	**0.171*** **0.046**	**1**	**0.106** **0.218**
Percentage of errors (%F)	**-0.222**** **0.009**	**0.106** **0.218**	**1**

**: Significant (p-value<0.01; bilateral)
*: Significant (p-value<0.05; bilateral)

The multiple regression analysis showed that academic performance was negatively correlated with the percentage of errors (%F) that learners make when performing tasks that require sustained attention with (r=-0.222; p<0.009). On the other hand, there was a positive correlation between academic performance and the concentration power of learners in the d2-R tests of sustained attention (r=0.171; p<0.046). From these results, we can conclude that the more learners develop sustained attention, which is required in several learning tasks, the better their academic performance.

From an examination of the correlations between the different variables assessed in the three tests with academic performance, and by considering the diagram of components in the space after rotation (Figure 2), the following conclusions can be drawn:

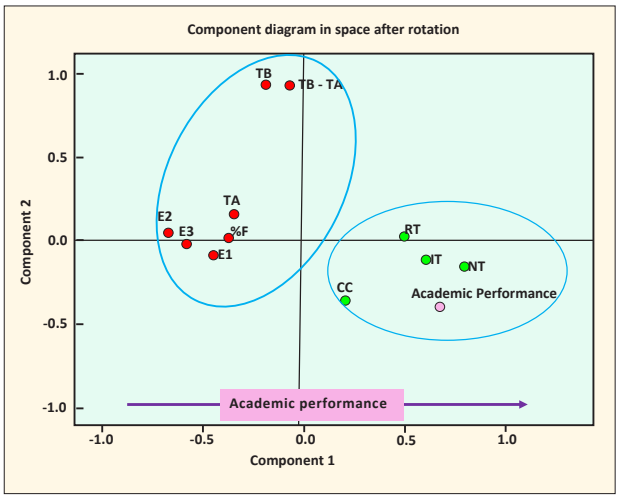

Figure 2: Projection of scores and errors in the four tests and academic performance (average) according to the two components of Principal Component Analysis (PCA)

TA: TMT task A reaction time
TB: TMT task B reaction time
TB-TA: time difference between the two tasks
CC: Concentration power
%F: Error percentage
RT: Score of the reading task
NT: Score of the naming task
IT: Score of the interference task
E1: Errors in task 1
E2: Errors in task 2
E3: Errors in task 3

The study of Pearson's correlation, according to the two components of the Principal Component Analysis (PCA) (Figure 2), between the different variables in the different tasks of the three tests and school performance shows clusters of positively- and negatively-correlated variables. However, the projection of the set of variables along the two axes 1 and 2 reveals two groups of correlated variables:

i. The first group is composed of scores from the three tasks of the Stroop test, which translates into the number of items recorded in the learners in this test, the power of concentration assessed by the d-2R test, and the score of school performance, located on the positive side of component 1.

ii. The second group gathers the error score and reaction time in the two TMT tasks, the error scores of the learners in performing the three tasks of the Stroop test, and the number of errors recorded in the d-2R test of sustained attention, located on the negative side of axis 1.

Discussion

The use of neurocognitive testing has been aimed at highlighting the impact of attention abilities on academic performance among middle school learners in our sample. Our results showed that academic performance was negatively correlated with learners' scores on TMT tasks. Therefore, a link can be established between attentional or mental flexibility and learners' academic performance. These results corroborate those of several studies who have associated reading and writing skills in learners with mental flexibility (8), and between mathematical skills and mental flexibility (9). This is explained by the fact that double or multiple tasks have the effect of distributing attentional resources during the execution of cognitive tasks (5). An association between value learning and attention allocation has been asserted by an analysis of neural data during attentional flexibility tasks (10).

Exploitation of the Stroop test results indicated that academic performance was negatively correlated with the score of errors committed by learners on the test tasks. On the other hand, there was a positive correlation between academic performance and the scores of the items totalled by learners on the test tasks. This led to the conclusion that better performance in selective attention implies better academic performance. This finding corroborates with several studies that have demonstrated the influence of selective attention on learning (4) and the importance of cognitive control in resisting interference (4, 11). This has been proven in several domains such as logical reasoning, number retention (12, 13), class inclusion (14), as well as in basic academic learning such as mathematics and spelling (15). Other studies have shown the impact of selective attention skills on children's language, reading and digital skills (16). Selective attention is intimately linked to the function of inhibition. In learning conditions, the learner is constantly influenced by many distractors that he/she has to face and inhibits them from directing their attention to the relevant target in order to perform profitable cognitive work. Other studies have shown that specific learning disorders are particularly frequent in children with attention-deficit/hyperactivity disorder (ADHD), and specific re-education (oral, written or logic-mathematical language) is often necessary (17).

Results of the d2-R test of sustained attention showed a positive correlation between academic performance and learners' power of concentration, while a negative correlation was recorded between learners' performance and the percentage of errors (%F) made when performing d2-R test tasks. It can be concluded that the more learners develop sustained attention, which is required in many tasks of the learning process, the better their academic performance. Most school tasks fall into the category of voluntary sustained attention. This finding is corroborated by the work of several studies which showed that sustained attention is the basis for training and goal planning (18) and of general cognitive competence (19). There is a growing body of evidence to support these claims, as sustained attention has been associated with cognitive performance (20). In addition, sustained attention deficits have been associated with disorders such as ADHD in children (21) and adolescents (22) and are thought to be closely related to executive functions underlying planning and goal-oriented behaviour, such as working memory (23) and inhibitory control (24). It is therefore clear that difficulties with sustained attention are associated with both levels of academic adjustment and it decreases over time (25).

The results of our study are among the few research studies in Morocco that are interested in verifying the links between attention and learning using standardised tests. This research has shown the important relationship between different types of attention and the academic performance of learners.

Pedagogical implications

In light of these results, we found it interesting to reflect on the approaches and methods to be followed in order to better capture the attention of learners. We propose:

i. to counteract the effects of distractors. Distractors from the immediate environment should be reduced as much as possible (i.e. work in a calm environment, measure the light, avoid distractors - visual and auditory distractors in the room, etc.).

ii. another way to improve lack of attentive control is to teach learners to become aware of the importance of attention by subjecting them to training.

iii. to avoid learning situations characterized by double or multiple tasks as they are costly in terms of attentional resources.

iv. to adopt mindfulness meditation programmes offered in the classroom aimed at improving learners' attentional capacities.

v. a better involvement of students in most of the pedagogical activities proposed.

vi. to vary the rhythms and learning activities, and the stimulus inputs (auditory, visual, kinaesthetic, etc.) to avoid inattention by learners.

Limitations

It would have been preferable to increase the sample size, to add additional neuropsychological tests and to use digital versions of the tests to further assess the attentional process.

Conclusion

In light of these results, a positive correlation can be noted between the attentional skills (attentional flexibility, selective attention and sustained attention) of learners and their academic performance. Learners' academic performance can already be predicted by the scores recorded or by the number of errors made by the learners when executing one of the three tests

used to assess attentional abilities. This study found a relationship between academic performance and learners' attentional abilities. In-depth diagnosis and follow-up of attentional disorders to identify learners with attention deficit disorders is of paramount importance for the implementation of an effective remediation program for these disorders.

Competing interests

The authors declare that they have no competing interest.

Consent

We have complied with the ethical conditions declared by the kenitra doctoral study center.

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