ORIGINAL ARTICLE

Study of visual perception and working memory and their impact on motor performance in moroccan adolescents attending school

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Abstract

OBJECTIVES: Athletes' mental, physical, and technical qualities are essential. Neurocognitive functions are necessary for any motor task and the achievement of motor performance. The present study aims to analyse the role of visual perception and working memory as neurocognitive functions in the motor performance of Moroccan adolescents attending school.

METHODS: A four-month study was conducted, including Moroccan adolescents enrolled in school from 4 March to 29 June 2022. A comparative and predictive method was used; the Rey-Osterrieth Complex Figure Test (ROCF-A) was used to assess visual perception and working memory, while floor gymnastics assessed motor performance as physical activity and sport.

RESULTS: The number of students who participated in the study was 262, of which (149 girls (56.9%) and 113 boys (43.1%)), and the average age was 16.99 ± 1.17 years. Range: 14-20. It was divided into three school levels: common core (TC) 29.4%, 1st-year baccalaureate (1BAC) 58.8%, and 2nd-year baccalaureate (2BAC) 11.8%. The results showed a relationship between visual perception, working memory and motor performance (r=0.218 and r=0.693, respectively); the result of the multiple linear regression confirms the relationship by significantly explaining the variation in motor performance.

CONCLUSION: Visual perception and working memory are primary and determining factors for motor performance in young adolescents attending school.

Introduction

Learning is a cognitive process consisting of having a perception of the environment through acquiring a representation. It thus modifies one's behaviour for an adequate and adapted response. To understand the phenomenon of learning, it is necessary to understand the conditions that give rise to this learning. Several studies link learning disability to the impairment of psychological processes, particularly cognitive abili-

ties. Impairments in psychological processes, which include the cognitive abilities of perception, language, memory, attention, concept formation, problem-solving and others, act on and interfere with the child's learning. Any assessment of learning involves the assessment of performance, which can then be seen as the visible translation of the learning achieved. (Arnaud *et al.* 1990) In this context, performance is an achievement whose optimal conditions lead to the production of a feat.

Physical and sports education is part of the school teaching disciplines, making physical and sports activities (PSA) a means of learning, education and transmission of know-how and skills, as well as the construction of competences. During the sessions of the learning cycle of gymnastics on the ground, and in the phase of the execution of the learner of a sequence made up of a whole of gymnastic elements of various levels of difficulties in all coherence and harmony, which will be judged and evaluated by the teacher, several pupils mark several stops at the time of the execution of this sequence, knowing that all the pupils have had the sufficient time of the learning of the gymnastic elements. The study of the source of this motor blockage leads us to look for its potential source, whether it is related to extrinsic factors or intrinsic factors that consider the psychological and mental characteristics of the students. Speaking of a blockage which is the result of forgetfulness, taking into account that the motor performance of the pupil linked to the reproduction of gymnastic elements well mastered during learning should be recalled in the most precise way possible, the evocation of perceptive and especially mnemonic aptitudes remains primordial to explain this difficulty, an observation supported by the fact that physical and sports activity remains a school teaching subject, its performance is linked to the pupils' learning, their neuropsychological capacities (Eloirdi *et al.* 2019). This is supported by the fact that physical and sports activity is still a school subject, its performance is linked to students' learning, neuropsychological capacities, and that psychological factors exert a significant influence on sports performance according to gender and age (Cazorla *et al.* 1984, Zerzouri 2002). Research, specifically on the activities of athletes while they are engaged in sports tasks, has focused on mental processes during activity (Hauw *et al.* 2003).

From the above, it is assumed that cognitive functions play an essential role in motor learning and that sports and motor performance depend on the proper functioning of these functions. Studies on the neurocognitive profile of students and its impact on motor performance are rare in Morocco. In this sense, the present study investigates motor performance during gymnastics through cognitive functions, particularly perception and working memory, in young Moroccan adolescents attending school.

Materials and methods

Location and duration of the study

The study was conducted in a Moroccan high school qualifying "Salman Elfarissi", located in the Skhirat Témara province of the Sale Rabat Kenitra region in central Morocco. The study duration is four months, from 4 March to 29 June 2022.

The subject of the study

The number of students who participated in the study was 262, of which 149 were girls (56.9%) and 113 boys (43.1%), with an average age of 16.99 ± 1.17 years.

Inclusion and exclusion criteria were established to provide a representative sample of the general population.

• **The inclusion criteria**

Students in qualifying secondary education between 14 and 20 studies in a public educational institution. Physically fit for physical and sports activities.

• **The exclusion criteria**

Uncorrected visual impairment, history of neurological disease (stroke or head injury), use of medication that may cause attention deficit and/or drowsiness, severe depression, or unstable mental illness.

Tools used

• **The Rey-Osterrieth Complex Figure Test (ROCF-A)**

A digital version of the ROCF-A test was used to evaluate visual perception and working memory. The ROCF-A test included the following instruments: a digital pen with pencil lead and an infrared camera

Tab. 1. Distribution of the sample by gender, age, and educational level

		Frequency	Percentage
SEX	Boys	113	43,1
	Girls	149	56,9
AGE	≤ 17	187	71,4
	>17	75	28,6
SCHOOL LEVEL	TC	77	29,4
	1BAC	154	58,8
	2BAC	31	11,8

Tab. 2. Descriptive statistics of visual perception and working memory

	Minimum	Maximum	Average	SD
score for copying (visual perception)	42	72	68,81	4,939
score for reproduction (working memory)	6	72	49,46	14,445
Motor performance (floor gymnastics)	4	13	9,17	1,575

Tab. 3. Motor performance averages by gender, age, and school level

		Mean ± SD	Test	Sig
SEX	Boys	9,49± 1,477	t = 2,858	*p* = 0,005
	Girls	8,93 ± 1,609		
AGE	≤ 17 years	9,11 ± 1,613	t = -1,052	*p* = 0,294
	>17 years	9,33 ± 1,473		
SCHOOL LEVEL	TC	9,29 ± 1,366	F= 0,484	*p* = 0,885
	1BAC	9,08 ± 1,657		
	2BAC	9,32 ± 1,661		

(Anoto pen system). CREDAGE10 A4 paper, whose usual appearance does not bother the writer. The pen records the dynamics of the lines as a sequence of x and y coordinates, as well as the instantaneous pressures. The ELIAN (Expert Line Information Analyzer) software allows the pen data to be visualized and analyzed. Among the available versions, the "Expert" version generates Excel sheets and analyses to assist in diagnosis. ELIAN performs an automated analysis and gives access to very fine objective data (1/10 mm, 1/100 second). After completing the reproduction phase of the drawing, the pen is put away and connected to the computer via the USB interface, and the software is executed on the computer. The traces are loaded immediately. The test is carried out in two phases: the first phase, the copying phase, evaluates visual perception. The subject sketches the figure by looking at the model. The second phase corresponds to the phase of reproduction of the figure and evaluates the working memory. The subject is asked to try to reproduce the figure even if it seems difficult without support. The test duration is unlimited and timed for both test phases. The interval between copying and reproduction must be less than three minutes (Wallon & Messmin, 2009).

Two procedures are applied to the results (Rey, 1959): Numerical scoring is the traditional method used to assess the accuracy of the achievement (the quality of the production). The figure is then divided into 18 elements (details), each scoring from 0 to 4 points:
- Correctly drawn and well placed (4 points)
- Correctly drawn and badly placed (2 points)
- Correctly drawn, well placed but not perfect (3 points)
- Distorted or incomplete and well placed (2 points)
- Distorted or incomplete and badly placed (1 point)
- Not recognizable or absent (0 points)

A total score of 72 points is based on the accuracy of the design.

An analysis of the method of reproducing the lines (type rating). According to Osterrieth (Osterrieth, 1944), there are seven types of organization: type I is the best, and type VII is the worst.

Type I: draws the central rectangle first, then the related elements. **Type II**: first, draws a detail (often the cross), then the central frame and surrounding elements. **Type III**: The execution strategy consists of imitating the general outline and positioning the elements within the outline, sometimes poorly positioned. **Type IV**: Juxtaposition of details, drawing the elements successively. **Type V**: details on a confusing background that are drawn disorganized (elements of the figure recognized but without an overall formal structure). **Type VI**: figure inspired by a familiar model (church, a fish, a man in a house, etc.). **Type VII**: draws a few scattered elements (scribble). However, it is the numerical notation that interested us.

• Sports performance

We have chosen floor gymnastics as an individual physical activity and sport. The choice of this school physical activity is mainly based on the solicitation of psychic capacities, in particular perception and memory, to achieve performance.

During ten learning sessions, the students learn the different steps of realizing the gymnastic elements belonging to the different levels. All students perform a gymnastic sequence individually and equally in public. The grading is based on three criteria, each of which is graded on 5 points: composition (choice of gymnastic families, arrangement, rhythm, amplitude, and ease in performing the routine), difficulty (number and category of gymnastic elements performed), execution (technical quality of the gymnastic routine).

Tab. 4. Correlation between motor performance, visual perception and working memory

	Visual perception(VP)	Working memory (WM)	Mortice performance (GYM)
Visual perception (VP)	1	,435**	,218**
Working memory (WM)	,435**	1	,693**
Motor performance (GYM)	,218**	,693**	1

Tab. 5. Multiple linear regression results (stepwise method)

Dependent variable	Predictive variables (explanatory)	R	R^2	F	Sig	B	t	Sig
Motor performance (GYM)	Working memory (WM)	0,693	0,480	239,761	0,000	0,076	15,484	0,000
	Visual perception (VP)	0,699	0,488	123,586	0,000	-0,033	-2,082	0,0382

Statistical analysis

The statistical analysis is based on two aspects: one descriptive and one analytical.

Descriptive statistics

The results, motor performance, visual perception and working memory, were expressed as mean ± standard deviation.

Analytical statistics

Student's t-tests and ANOVA were used to compare mean motor performance by study group, and correlation tests were used to assess the relationship between visual perception, working memory and motor performance.

Results

The distribution of the sample in Table 1 shows the distribution of the sample by gender, age, and educational level. By gender, boys comprised 43.1% of the population, and girls comprised 65.9%. For age, students under 17 years of age represented 71.4%. Regarding educational level, the sample included 29.4% of high school students, 58.8% of 1st-year baccalaureate students and 11.8% of 2nd-year baccalaureate students.

Table 2 presents the descriptive statistics of the scores for visual perception, working memory and motor performance. The mean score for copying (68.81) was higher than the mean score for reproduction (49.46); this is confirmed by the Student's t-test, which was significant (t = 20.51, $p < 0.001$). For motor performance, the mean score was 9.17 with (min = 4 and max = 13).

The analysis of motor performance (Table 3) showed that: Depending on gender, the boys' average is higher than the girls', with Student's t-test showing that this difference is significant (t = 2.85, $p = 0.005$). This result implies that boys learn better than girls. On the other hand, for age, students over 17 years old achieved a higher average than students under 17 years old. This slight difference is statistically insignificant (t = 1.052, $p = 0.294$). The same result is observed for the level of education, and there is a slight difference between the three levels (TC, 1BAC, 2BAC). The analysis of variance showed that this difference was insignificant (F = 0.4, $p = 0.88$).

Table 4, which contains the correlations between visual perception, working memory and motor performance, shows that visual perception and working memory are significantly correlated with each other and motor performance.

Multiple linear regression was used to draw a model that links the three variables (Table 5) in which visual perception and working memory can predict motor performance in floor gymnastics. This regression (stepwise method) with motor performance as the dependent variable and visual perception and working memory as explanatory variables excluded visual perception and retained only working memory in the model with a standardised coefficient of 0.69.

The model is more accurate for motor performance (t = 15.484, $p = 0.00$) but not for visual perception (t = -2.082, $p = 0.38$).

Therefore, the linear model is as follows:

MP(GYM) = 0.76 WM + 5.437

Discussion

This analysis aimed to study the role of visual perception and working memory in motor performance in physical education and sports, specifically in floor gymnastics in Moroccan high school students. For this purpose, 262 students participated in the study, classified according to sex, age and school level.

A comparison of visual perception represented by the copying phase and working memory represented by the reproducing phase (the time between the two phases is 3 min) shows that the copying score is higher than the reproducing phase, a result similar to the study conducted by (Alice 2012). This difference is because the copying phase requires more additional

skills, including retrieving information in the copying phase. (Shorr *et al.* 1992) The difference is that the copying phase requires more additional skills, including retrieval of information in the copying phase than the copying phase, even though the scoring system is the same for both phases.

In terms of motor performance, the results of this study revealed that boys performed better than girls. This superiority may be due to morphological differences. Moreover, boys perform better than girls in physical ability tests, excluding flexibility tests (Famose *et al.* 1988).

The neurocognitive study of motor performance in floor gymnastics has shown that perception and working memory explain, in a significant way, its variation; indeed, the visual system can use the kinematic information contained in a movement to identify this movement and also to anticipate the identity of the following movements (Bidet-Ildei 2006). In addition, several studies have shown a relationship and link between motor and perceptual difficulties. Researchers have shown that patients with apraxia have difficulty distinguishing between gestures they have difficulty producing. (Heilman *et al.* 1982). Similar results were found in the DC patient with dysgraphia following a parietal lesion (Chary *et al.* 2004).

A strong positive correlation between working memory and motor performance in floor gymnastics has been observed. Motor performance depends on the reproduction of the gymnastic elements studied during the learning sessions and the execution of a coherent, aesthetic, and precise gymnastic sequence, which requires, in the first place, an encoding, retention and retrieval of the information necessary for motor production. Results observed in dancers, whose ability to encode, maintain and retrieve useful information during the reproduction of long sequences of movements affects their performance (Allard & Starkes 1991). There is an encoding of the information to be recalled by the performer, an elaboration of internal reference, a reproduction of the requested figure or sequence, and an evaluation of the execution. (Cadopi 2005). Based on a model of human working memory (Baddeley 1992), researchers (Smyth & Pendleton 1994, Jean *et al.* 2001, Jean 2001) analysed the nature of the encoding of information in the memorisation of body shapes. The results show that encoding involves the spatial, kinaesthetic, and verbal registers of working memory.

Motor performance in gymnastics also depends on precise planning of all the gymnastic elements and their orders of execution in sequences. Working memory is involved in planning ideas through the visuospatial component, the translation of which is carried out by the central administrator and the phonological loop (Gavens & Camos 2006). The central administrator manages the execution, which is used to store and retrieve information that will be used to organize a series of subsequent actions (Brown *et al.* 1988). Other studies have shown that the grouping of information to be memorized into meaningful and well-organized sets guarantees a storage of more information and a more efficient retrieval: the usual links and connections between elements affect the probability of the appearance of one element following another, and consequently a reduction in the informational load and thus an improvement in storage is observed and translated by retrieval of each element (Smyth & Pendleton 1994, Starkes *et al.* 1987).

Conclusion

This study found that visual perception and working memory are primary and determining factors for sports performance. The results prove the interest in a cognitive study of motor performance in floor gymnastics through perceptual and memory processes.

It emerges that neuropsychological ability, especially working memory, significantly explains students' motor performance in floor gymnastics. This result adds to other studies (Cazorla *et al.* 1984, Zerzouri 2002, Eloirdi *et al.* 2014) highlighting the critical role of psychological factors in sports performance.

On the other hand, a study on the relationship between visual perception, working memory functioning, self-esteem, and depressive state, in terms of their influence on motor performance, could help draw an excellent neurocognitive profile for Moroccan adolescent students. Also, by confirming the importance of visual perception and working memory in motor performance, more oriented research through programs integrating digital and clinical technologies can provide important information in neuroscience in the field of physical education and sports and the health of Moroccan children and adolescents, so that more appropriate and more adapted learning situations that affect and develop cognitive functions in parallel with motor learning remain necessary to promote the development of these skills. Moreover, that training of physical education and sports teachers in the field of educational neuroscience is necessary.

Conflict of interest

The authors declare that there is no conflict of interest.

REFERENCES

1 Alice T-C (2012). Etalonnage du test de la Figure Complexe de Rey auprès de la population 20–39 ans. Cognitive Sci. Dumas, 730784.
2 Allard F & Starkes JL (1991). Motor-skill experts in sports, dance, and other domains.
3 Arnaud P, Dhellemmes R, Laurin L (1990). L'enseignement des activités athlétiques en milieu scolaire: Des pistes pour l'innovation.
4 Baddeley AD (1992). La mémoire humaine : Théorie et pratique. Presses universitaires de Grenoble.

5 Bidet-Ildei C (2006). Motricité et perception visuelle des mouvements humains : Expériences chez l'adulte, l'enfant et le patient parkinsonien.
6 Brown JS, McDonald JL, Brown TL, Carr TH (1988). Adapting to processing demands in discourse production : The case of handwriting. *J Exp Psychol: Human Perception and Performance.* **14**(1): 45.
7 Cadopi M (2005). La motricité du danseur: Approche cognitive: Bulletin de psychologie. *Numéro.* **475**(1): 29–37. https://doi.org/10.3917/bupsy.475.0029
8 Cazorla G, Montpetit R, Prokop P, Cervetti J (1984). De l'évaluation des nageurs de haut niveau… à la détection des jeunes talents. *Travaux et recherches.* **7**: 185–208.
9 Chary C, Méary D, Orliaguet J-P, David D, Moreaud O, Kandel S (2004). Influence of motor disorders on the visual perception of human movements in a case of peripheral dysgraphia. *Neurocase.* **10**(3): 223–232.
10 Eloirdi A, Ahami A, Mammad K (2019). Neurocognitive study of school performance among Moroccan high school students: The role of working memory. *Dementia Neuropsychol.* **13**: 232–237. https://doi.org/10.1590/1980-57642018dn13-020013
11 Eloirdi A, Arfaoui A, Ahami, AOT (2014). Evaluation de l'impact de l'estime de soi et de l'état dépressif sur la performance sportive chez les jeunes adolescents scolarisés. *Antropo.* **32**: 25–34.
12 Famose J-P, Durand M, Durand M (1988). Aptitudes et performance motrice. Éditions" Revue EPS".
13 Gavens N & Camos V (2006). La mémoire de travail: Une place centrale dans les apprentissages scolaires fondamentaux. *Apprentissages et enseignement: Sciences cognitives et éducation.* **91**: 106.
14 Hauw D, Berthelot C, Durand M (2003). Enhancing performance in elite athletes through situated-cognition analysis : Trampolinists' course of action during competition activity. *Int J Sport Psychol.* **34**(4): 299–321.
15 Heilman KM, Rothi LJ, & Valenstein E (1982). Two forms of ideomotor apraxia. *Neurol.* **32**(4): 342–342.
16 Jean, J. (2001). Mémoire de travail et rappel de séquences de mouvements chez les danseurs experts et novices.
17 Jean J, Cadopi M, Ille A (2001). How are dance sequences encoded and recalled by expert dancers? *Curr Psychol Cognition.* **20**(5): 325–338.
18 Osterrieth PA (1944). Le test de copie d'une figure complexe; contribution à l'étude de la perception et de la mémoire. [Test of copying a complex figure; contribution to the study of perception and memory.]. *Arch de Psychol.* **30**: 206–356.
19 Rey A (1959). Test de copie d'une figure complexe. Centre de psychologie appliquée.
20 Shorr JS, Delis DC, Massman PJ (1992). Memory for the Rey-Osterrieth Figure: Perceptual clustering, encoding, and storage. *Neuropsychol.* **6**: 43–50. https://doi.org/10.1037/0894-4105.6.1.43
21 Smyth MM & Pendleton LR (1994). Memory for movement in professional ballet dancers. *Int J Sport Psychol.* **25**(3): 282–294.
22 Starkes JL, Deakin JM, Lindley S, Crisp F (1987). Motor versus verbal recall of ballet sequences by young expert dancers. *J Sport Psychol.* **9**(3). PAGE NUMBERS???
23 Wallon P & Messmin C (2009). Figure complexe de Rey A et B: guide d'utilisation et d'interprétation. Edition ECPA.
24 Zerzouri S (2002). Certains déterminants psychosociologiques de la performance sportive-le cas de l'athlétisme.