RESEARCH ARTICLE

ACTA Vol. 20, No. 1, 2022, 35-51
NEUROPSYCHOLOGICA

Received: 17.09.2021
Accepted: 18.03.2022

A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

Executive Function and Memory for the Rey-Osterreith Complex Figure Task: Relationship between Gender, Heart rate and Neuropsychological performance in Moroccan student sample

Elmossati Mohamed Salim[1,2][A,B,C,D,E,F], Ahami Ahmed Omar Touhami[1][A,B,C,D,E], Hassan Oudda[2][A,B,C,D,E], Taher Moussa Ahmadou[1][A,B,C,D,E]

[1] Cognitivo-Behavioral Neuroscience and Applied Nutrition Laboratory, Clinical Neuropsychology Team,Department of Biology, Faculty of Sciences, Ibn Tofail University, Kenitra, Morocco.
[2] Laboratory of Advanced Materials and Process Engineering. Department of Chemistry, Faculty of Science, Ibn Tofail University, Kenitra.

SUMMARY

Background: The present study has been conducted to investigate the visuospatial constructive cognition and memory among healthy students, as measured by the Rey Complex Figure Test (RCFT). We have compared the data used to draw the figures with the hypothesis that gender and physiological measurements have an impact on neuropsychological skills.

Material/ Methods: One hundred twenty-five students (43 male, 82 female; age 18–32 years) participated in this study with a computerized numerical recording of the digital plot of the RCFT and a set of socio-demographic variables.

Results: Results revealed that visual perception and working memory were impacted by social and health determinants. Additionally, this study presents evidence supporting the implication of resting heart rate (RHR) and organizational strategy in working memory performance. Gender effect seems to be significant in physical and physiological differences.

Conclusions: Regression analyses revealed a relevant contribution of study institution and sleep time on RCFT Copy score; RCFT Memory predicted by drawing from memory strategy, RHR, periodic medication use and marital status.

Key words: visual perception, working memory, heart rate, gender, Rey Com

INTRODUCTION

Today, neuroscience can yield crucial information on how space and body are represented in the brain. Both visual attention and working memory are crucial to the control of common everyday behavior (Theeuwes at al., 2011). Behavior was assumed to be controlled by a limited capacity attentional system, the central executive (Baddeley, 2001). Executive function (EF) is necessary for regulation of goal-directed behavior, and encompasses cognitive processes including working memory, sustained attention, inhibition, task switching, and performance monitoring (Anderson et al., 2001). Complete tasks and cope with stressful situations in any environment need cognitive skills, physical and physiological energy. University is one of the most energy-consuming environments requires more and more capacities to deal with daily challenges.

Appropriate performance and personal adjustment in daily life require both attention and memory; which, in turn, are indispensable preconditions for suitable functioning of other cognitive domains (Lezak, 1995). One aspect of information-processing that is tightly connected to attentional control, as well as explicit memory, is working memory (Evi et al, 2012). Working memory refers to the capacity to simultaneously store and process information (Jonides et al. 2007).Working memory consists of three components: a central executive system and two buffers, namely “phonological loop” and “visuospatial sketch pad” (Baddeley, 1992). Baddeley proposed a revision of working memory model with four components by increasing the pleasure detector and episodic buffer. The model is used to describe the influence of emotional factors on the working memory (Baddeley, 2012).Working memory has been applied to poor performance in such academic areas as reading comprehension (e.g., Carretti, Borella, Cornoldi, & De Beni, 2009), math (Berg, 2008), and writing (Richards et al., 2009), as well as in general educational attainment (Gathercole et al., 2008).

Neuropsychological analysis allows determining weak and strong neuropsychological factors during development, not only in the presence of learning disorders, but also in normo-typical development conditions in regular education, where students may also have poor academic performance, understood as the difficulty to approach the level of knowledge, skills and attitudes demonstrated by students in an area or subject compared with the norm of age and academic level (Edel, 2003). In many cases, teachers and researchers approach the level of academic performance based on the student’s school grades. However, it would be convenient to consider not only this, but also the intellectual development and family integration, since a high correlation between these variables and academic performance has been identified, both in upper secondary and higher level students (Muñoz, 1993). Deficits in sustained attention can hamper academic and occupational performance (Biederman et al., 2007).

Gender differences in cognition have been a source of curiosity and conflict for decades (Riley, 2016).For example Gender differences in sustained attentional control are incompletely characterized. Some studies show no effect of gender on sustained attention (Chan, 2001), while others suggest that men may have greater vigilance (Blatter et al., 2006), and women may have enhanced inhibitory control (Yuan, 2008). Improved living conditions and less gender-restricted educational opportunities are associated with increased gender differences favoring women in some cognitive functions and decreases or elimination of gender differences in other cognitive abilities (Weber,2014).Past research has also presented evidence of sex differences in both executive function and self-regulation (Franklin et al., 2018). In an electrophysiological study, Moran, Taylor, and Moser (2012) found enhanced error-related negativity (ERN) response (brain activity after making an error) only in women with high worry, suggesting that worry may strongly influence behavioral outcomes in women. Moreover, a recent study found statistically significant interactions between sex and average controllability at somatomotor regions (Cornblath, 2018).

Performance on neuropsychological tests requires coordination of abilities from multiple cognitive domains, and the composite nature of Executive Functioning tests is all the more salient given their sensitivity to more basic cognitive abilities (Enright et al., 2015). The Rey-Osterreith Complex Figure Task (RCFT), which is one of the oldest and most widely used neuropsychological measures of visuospatial abilities and perceptual organization (Tombaugh & Hubley, 1991), has become a widely used test when assessing visuospatial constructional abilities for clinicians and researchers alike. The ROCFT is a test that allows the evaluation of different neurocognitive processes such as visual perception, visuospatial organization, working memory, cognitive inhibition and attention (Vannetzel, 2010).It appears to be a valuable component of any neuropsychological evaluation (Somerville et al., 2000). The relationship between arterial blood pressure and cognitive function has been extensively examined (waldstein et al, 1991). An association between high blood pressure and cognitive impairment has been demonstrated in healthy old people (Starr, 1993). Recent study by Siennicki-Lantz et al.,(1998)found that reductions in systolic blood pressure (SBP) correlate with reduced blood flow in white matter areas. We sought to measure the cognitive function of a sample of healthy young adults and examine its relationship with blood pressure and heart rate.

Education in Morocco has become a rapidly changing sector forced by several constraints such as overcrowded academic institutions, policies poorly adapted to the Moroccan context, rareness of field studies, and international requirements (Elmossati et al., 2016); to cope with this changing environment, students need cognitive abilities selected in base of valid neuropsychological studies. The purpose of this study is to measure the gender effect among neuropsychological performance and determine the relationship between visual perception, working memory, heart rate, and blood pressure in case study of Moroccan student.

MATERIALS AND METHODS

Participants

This is an exploratory descriptive study conducted with a sample of 125 students including 43 male (mean age = 22.25 ± 3.87 years) and 82 female (mean age = 20.58 ± 2.32 years). The study was conducted in March, April 2019 at national school of applied sciences in Alhoceima (ENSAH), faculty of science and technology in Alhoceima (FSTH) and the Faculty of Science of Ibn Tofail University in Kenitra (SFITU), the mean number of years of education was 14.38 (SD = 1.44, range = 13-20), the participants were students attending public scientific educational institutions, from different Moroccan geographic areas. Exclusion criteria were: uncorrected visual disorders, neurological antecedents (cerebrovascular accident or head trauma), and use of pharmacological treatment potentially causing attention disorders and/or drowsiness.

Material

The Rey-Osterrieth Complex Figure Test (RCFT-A)

For the evaluation of the neuropsychological skills of the patients included in the study, we used the Rey's Complex Figure test (RCFT) type A. The Rey-Osterrieth Complex Figure Test (RCFT), which was developed by Rey in 1941 and standardized by Osterrieth in 1944, is a widely used neuropsychological test for the evaluation of visuospatial constructional ability and visual memory. Recently, the ROCF has been a useful tool for measuring executive function that is mediated by the prefrontal lobe (Shin and al,.2006).Performance accuracy was calculated by applying the standard scoring criteria, in which the geometrical figure is divided into 18 units and scored on a 2-point scale for both accuracy and placement (Meyers and Meyers, 1995).

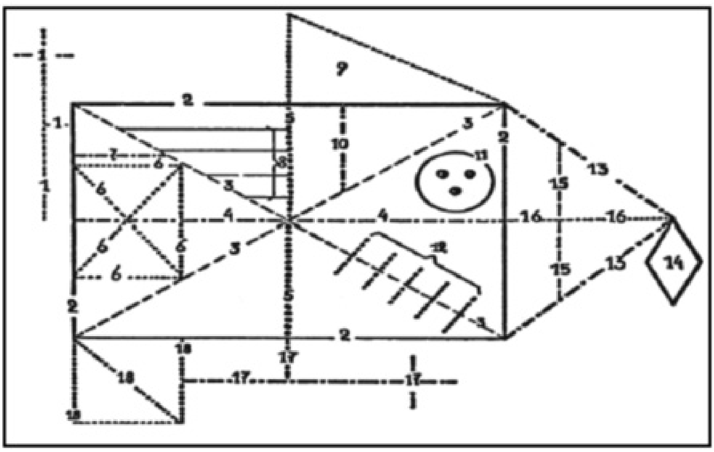

Fig. 1. Rey's Complex Figure in 18 Elements. Mesmin and Walloon (2009)

The ROCF stimulus is a line drawing, which is made up of 34 lines of varying length, plus three dots inside a circle. In practice, the RCF is typically used as part of the RCFT to evaluate an individual's ability to accurately copy a two-dimensional figure, and subsequently as a measure of immediate and delayed visuospatial memory (Walker, 2006). The drawings were collected using a digital pen (Anoto pen system) which records the dynamics of the lines drawn on the paper along with other parameters such as line speed and pressure. Software is available enabling the drawing process to be visualized on the computer screen in real time. The software is known as Elian, or "Expert Line Information Analyzer", and was developed by Wallon and his team between 1995 and 2005. The lines drawn are displayed on the screen in real-time according to various modes: dynamic, at several speeds, step by step (stroke by stroke, dot by dot), back and forth movements (hesitations). Several color modes enable the number of strokes, their order and direction, instant speeds and the pressure exerted to be visualized. In addition, this technique indicates several numerical parameters including time, the length of the line, speed and dimensions (Bossuroy, 2014). The RCFT test is divided into two phases: for the copying phase, assessing visual perception, the model is presented horizontally to the subject and must be clearly visible, the subject is then asked to copy this drawing. During the delay period (about three minutes), participants completed a health determinants oriented survey. The second phase of the test is reproducing from memory, assessing working memory: the model is subsequently removed and the subject asked to reproduce the figure, this was followed by a measurement of resting heart rate (RHR), heart rhythm (HR), blood pressure (BP), weight and stature. Duration is free of limits for both copying and reproduction.

Rating methods

1. Digital rating

The Digital rating adapted from Osterrieth's (1944) work by Taylor (1959) is the most common traditional method for assessing the accuracy of realization. The figure is then divided into 18 elements (details), each being noted from 0 to 4:

- Correctly drawn and well placed (4),
- Correctly drawn and misplaced (2),
- Correctly drawn, well placed but imperfect (3),
- Deformed or incomplete and well placed (2),
- Deformed or incomplete and misplaced (1),
- Unrecognizable or absent (0).

According to the accuracy of the copy, with a total score of 72 points.

2. Rating by types

To know the type of organization used, the ELIAN software allows you to record the succession of features. According to (Osterrieth, 1945) there are seven types of organization:

- Construction of the structure,
- Details encompassed in the structure,
- General outline,
- Juxtaposition of details,
- Details on a confused background,
- Reduction to a familiar scheme,
- Scribbling.

Information Sheet

All students participating in this study completed a fact sheet that provided information on socio-demographic variables and a battery of health determinants as described below:

- Study institution (national school of applied sciences in Alhoceima (ENSAH), faculty of science and technology in Alhoceima (FSTH) or the Science Faculty in Ibn Tofail University in Kenitra (SFITU))
- Geographical Residence (classified into three categories according to the geographic distance from study institute)
- Financial support (no support, family support, social contribution (scholarship), or mixed support)
- Drug use (polar question)
- Alcohol consumption (polar question)
- Periodic use of medications (polar question)
- Student accommodation type (with the family, private rental, roommate or university residence)
- Average sleep duration (less than 5 hours, between 6 and 8 hours, or more than 8 hours)
- Sleep pattern (indicated by the usually sleeping hour)
- Regular practice of sport (polar question)
- Resting heart rate (RHR), blood pressure (BP), weight and stature (continuous variables)
- Presence of Abnormal Heart Rhythms – Arrhythmias – (polar question)

Statistical Analysis

The socio-demographic variables were compared using Pearson's chi-squared test for gender, Brown-Forsythe test (F^*-test) for age and education. Pearson's correlation was used to examine the associations among RCFT performance (Quotation, Duration, Average strokes size, Drawing width, and Drawing height), physical and physiological measurements. Kruskal Wallis H Test and Mann Whitney U Test were conducted to see any difference in our metric variables according to gender, marital status and our health determinants battery. In order to predict the executive function scores by RCFT for copy and memory conditions, step-wise multivariate regression analyses were performed

RESULTS

Descriptive Statistics and Group Differences

Drawing Strategy

Previous researches indicating the importance of examining qualitative features of the RCFT and suggest that systems using only one quantitative visuoconstruction summary score may miss valuable information, such as the organizational strategy employed by the patient (Somerville et al, 2000).

We note the absence of type VI and VII in three groups during the realization of the copy phase, and only one case in memory phase. Otherwise, the dominant strategies in type for both Female students and Male student are type IV during drawing copy, and type II in Rey memory test part.

Digital Evaluation

Gender Effect:

Association was found between gender and Study institution ($X^2(2)>=10.574$, $p = 0.005$), with Drug use ($X^2(2)>=11.418$, $p = 0.001$), and Alcohol consumption ($X^2(2)>=11.450$, $p = 0.001$); moderate significant relationship with Financial support ($X^2(2)>=9.225$, $p = 0.026$), and with Sleep pattern ($X^2(2)>=27.739$, $p = 0.015$); a strong significant relationship with Student accommodation type ($X^2(2)>=14.345$, $p = 0.002$), and with Regular practice of sport ($X^2(2)>=9.819$, $p = 0.002$). The differences in age (F*=7.554, $p = 0.008$) were important and statis-

Table 1. Drawing strategy for both copy and memory test part by ratio

	Female		Male	
Drawing type	RCFT Copy	RCFT Memory	RCFT Copy	RCFT Memory
Type I	24.4%	31.7%	20.9%	20.9%
Type II	30.5%	34.1%	32.6%	46.5%
Type III	4.9 %	6.2%	9.3%	14%
Type IV	40.2%	24.4%	37.2%	14%
Type V		2.4%		4.6%
Type VI		1.2%		
Type VII				

Table 2. RCFT and health indicators means by Gender

	Female			**Male**			
	Min	**Max**	**Mean (SD)**	**Min**	**Max**	**Mean (SD)**	**Sig**
RCFT copy	53	72	68.28(3.71)	55	72	67.35(3.78)	0.117
RCFT memory	13	69	41.49(11.10)	18	62	46.07(10.62)	0.007
BMI	16.14	39.09	22.26(3.84)	17.15	40	23.87(5.33)	0.084
SBP	86	146	111.91(11.63)	102	140	121.88(9.01)	0.000
DBP	55	93	70.95(8.11)	60	92	75.21(7.98)	0.006
RHR	55	108	77.73(9.90)	50	94	70.98(10.18)	0.001

MBI, Body Mass Index; SBP, systolic blood pressure; DBP, diastolic blood pressure; RHR, Resting heart rate tically significant and non significant on education (F*=1.623, *p* = 0.207). And by Welch's test the differences in weight ($F_{1, 68.77}$ = 25.128, p = 0.000), stature ($F_{1, 62.02}$ = 59.377, p = 0.000), SBP ($F_{1, 105.60}$ = 28.068, p = 0.000), DBP ($F_{1, 86.63}$ = 7.941, p = 0.006), and RHR ($F_{1, 83.37}$ = 12.642, p = 0.000), were strongly significant.

As shown above, there was noticeable variability on socio-demographic and health indicators for both groups. The means and standard deviations for each physiological measure included in the battery and the Rey-Osterrieth Complex Figure scores by gender are displayed in Table 2.

As illustrated in Table 2, there was noticeable variability on the standard RCFT Memory, blood pressure and resting heart rate according to gender differences, contrariwise no significant means differences was shown in RCFT Copy and Body mass index. The distribution of the means of the RCFT Memory scores shows that they are higher among Males (46.07± 10.62), compared to Females (41.49 ± 11.10).However, the differences between the means of RCFT Copy scores and BMI by gender are not significant. Also means distribution are higher in SBP among Males (121.88 ± 9.01), compared to females (111.91 ± 11.63), and in DBP male's means (75.21 ± 7.98) higher than female's means (70.95 ± 8.11). The distribution of the means of the RHR shows that they are higher among Females (77.73 ± 9.90), compared to Males (70.98 ± 10.18).

Differences in Metric Variables

Kruskal Wallis H test and Mann Whitney U Test was conducted to see any difference in our metric variables according to categorical socio-demographic variables and our health determinants battery

- RCFT Copy

A Kruskal-Wallis H test showed that there was a statistically significant difference in RFCT copy between the different Student accommodation type, χ2(2) = 9.112, p = .028, with a mean rank of 45.44 for “with the family” , 62.34 for “private rental”, 74.50 for roommate, and 67.50 for university residence; and between three institutional groups, χ2(2) = 9.603, p = .008, with a mean rank of 68.09 for ENSAH , 63.17 for FSTH and 67.56 for SFITU.

- RCFT Memory

Mann Whitney U Test showed that there was a statistically significant difference in RFCT memory according to gender, (U = 1248, p = .007), with the male group's memory performance was statistically higher than the female group. And there is a statistical significant differences by the periodic use of medications (U = 567.5, p = .05), it can be concluded that the performance in the non use of medications group was statistically significantly higher than the other group.

- Weight and stature

Mann Whitney U Test showed that there was a statistically significant difference in both weight and stature according to gender, (U = 732, 5 p = .000) and (U = 417, 5 p = .000) respectively; according to practice of sport, (U = 989 p = .018) and (U = 919 p = .006), respectively; also with sleep pattern (U = 1328.5 p = .004) and (U = 1337.5 p = .004) respectively.

A statistically significant difference only in stature was shown according to drug use (U = 547, 5 p = .008), Alcohol consumption (U = 533, 5 p = .027), Study institution χ2(2) = 9.348, p = .009, and Student accommodation χ2(2) = 8.917, p = .030.

- Education years

A Kruskal-Wallis H test showed that there was a statistically significant difference in education years between Geographical Residence groups χ2(2) = 10.241, p = .006, and study institution groups χ2(2) = 15.001, p = .001.Mann Whitney U Test showed also a slight statistically significant difference in education years between marital status groups (U = 94, p = .031).

- Systolic and Diastolic blood pressure

Mann Whitney U Test showed that there was a statistically significant difference in systolic and diastolic blood pressure according to gender, (U = 848.5, p = .000), (U = 1246.5, p = .001) respectively. Also, a significant difference in only systolic blood pressure was shown according to drug use (U = 529, 5 p = .005), and Alcohol consumption (U = 551, 5 p = .038). And it can be concluded that diastolic blood pressure in the Arrhythmias group was statistically significantly higher than the normal heart rhythm group (U = 294.5, p = .03).

- Resting heart rate

According to gender (U = 1125.5, p = .001) and drug use (U = 503.5, p = .003), Mann Whitney U test showed that there was a significant difference in Resting heat rate.

Correlation Analysis

Numerical Drawing Data, Physical and Physiological Measurements: According to dynamics data collected by using digital pen we can study the implication of some hidden factors in the standard RFCT like duration, average strokes, drawing height and drawing width in both copy and memory phase. Pearson's correlation was conducted to visualize relationship between RCFT data, physical (weight, stature and body mass index) and physiological (blood pressure and resting heart rate) measurements. There was a significant positive correlational association between RCFT Copy score (Quotation) and the RCFT Memory score (QuotationM) (r = 0.225, p = 0.012).RCFT Copy score have negative correlation with average stroke size in memory phase (r = −0.211, p = 0.018) and positive with duration of drawing from memory (r = 0.193, p = 0.031).RCFT Memory correlate significantly with copy duration (r = 0.180, p = 0.045). Body mass index correlate negatively with average stroke size in copy part (r = -0.180, p = 0.045). A significant negative correlational association between Systolic blood pressure and drawing width in copy part (r = -0.194, p = 0.030), also SBP had positive correlation with weight (r = 0.411, p = 0.000), stature (r = 0.390, p = 0.000), and BMI (r = 0.290, p = 0.001). Diastolic blood pressure correlated positively with average stroke size in copy part (r = 0.182, p = 0.043), weight (r = 0.313, p = 0.000), stature (r = 0.258, p = 0.004), and BMI (r = 0.200, p = 0.025) and SBP (r = 0.624, p = 0.000). Resting heart rate correlate negatively with RCFT Memory score (r = 0.247, p = 0.005).

Table 3. Correlation analysis between numerical drawing data, physical and Physiological Measurements

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 Duration (sec)	Pearson's corr	1															
	Sig.																
2 Avg stroke size (mm)	Pearson's corr	**,210***	1														
	Sig.	,019															
3 Drawing width (mm)	Pearson's corr	,081	**,246****	1													
	Sig.	,368	,006														
4 Drawing height (mm)	Pearson's corr	**,577****	**,449****	**,342****	1												
	Sig.	,000	,000	,000													
5 Quotation	Pearson's corr	,092	-,175	-,155	-,162	1											
	Sig.	,309	,051	,085	,071												
6 DurationM (sec)	Pearson's corr	**,413****	-,093	,039	,125	**,193***	1										
	Sig.	,000	,304	,669	,163	,031											
7 Avg stroke sizeM (mm)	Pearson's corr	,122	**,670****	**,327****	**,410****	**-,211***	-,150	1									
	Sig.	,176	,000	,000	,000	,018	,095										
8 Drawing widthM (mm)	Pearson's corr	**,183***	**,422****	**,525****	**,497****	-,171	,106	**,590****	1								
	Sig.	,041	,000	,000	,000	,057	,241	,000									
9 Drawing heightM (mm)	Pearson's corr	**,228***	**,356****	**,330****	**,520****	-,161	**,213***	**,469****	**,582****	1							
	Sig.	,010	,000	,000	,000	,073	,017	,000	,000								
10 QuotationM	Pearson's corr	**,180***	,008	-,040	,061	**,225***	**,301****	-,071	,057	,160	1						
	Sig.	,045	,931	,656	,501	,012	,001	,434	,525	,074							
11 weight	Pearson's corr	,012	-,092	-,073	-,047	-,010	,058	-,091	-,093	,033	,005	1					
	Sig.	,891	,309	,418	,606	,914	,517	,311	,303	,711	,960						
12 stature	Pearson's corr	,097	,135	-,042	,014	-,062	**,187***	-,008	,006	,038	,034	**,462****	1				
	Sig.	,280	,132	,644	,873	,491	,037	,928	,949	,673	,706	,000					
13 BMI	Pearson's corr	-,047	**-,180***	-,061	-,066	,017	-,038	-,098	-,106	,025	-,009	**,869****	-,027	1			
	Sig.	,605	,045	,500	,462	,851	,677	,278	,241	,778	,917	,000	,769				
14 SBP	Pearson's corr	,056	,145	**-,194***	,055	,044	-,043	,062	,015	,058	,040	**,411****	**,320****	**,290****	1		
	Sig.	,539	,106	,030	,539	,628	,634	,495	,864	,523	,660	,000	,000	,001			
15 DBP	Pearson's corr	,031	**,182***	-,094	-,025	,056	,083	-,036	-,056	,090	-,012	**,313****	**,258****	**,200***	**,624****	1	
	Sig.	,733	,043	,298	,783	,537	,359	,692	,535	,319	,899	,000	,004	,025	,000		
16 RHR	Pearson's corr	-,049	,078	-,039	-,028	,094	-,091	,113	,018	-,077	**-,247****	-,128	-,121	-,087	-,068	-,004	1
	Sig.	,589	,390	,665	,759	,298	,314	,208	,845	,396	,005	,155	,180	,335	,453	,965	

** La corrélation est significative au niveau 0.01 (bilatéral). * La corrélation est significative au niveau 0.05 (bilatéral).

DurationM (sec): drawing duration in copy part; Avg stroke size (mm): average stroke size in copy part; Drawing width (mm): drawing width in copy
part; Drawing height (mm): drawing width in copy part ; Quotation : RCFT Copy
DurationM (sec): drawing duration in memory part;, Avg stroke sizeM (mm): average stroke size in memory part; Drawing widthM (mm): drawing
width in memory part; Drawing heightM (mm): drawing width in memory part ; QuotationM : RCFT memory

Predictive modeling

Visual Perception and Working Memory Models: For the linear regression analysis predicting RCFT Copy, we included all socio-demographic, copy strategy adopted in drawing, and all our battery of health determinants variables as independent variables, by using stepwise method results are shown in Table 4.

With all variables entered, the regression produced a significant model predicting RCFT Copy, F (2, 123) = 7.167, p = .001, with an R of 0.325 (adjusted R2 = .091). However, within the model, only study institution and average sleep were significant predictors of Rey figure test in copy phase, copy strategy was not a significant predictor of RCFT Copy score. Higher RCFT Copy score were associated with ENSAH's group and lower sleep duration. Furthermore, this regression model appears to have acceptable statistical properties. The Variance Inflation Factors (VIFs) were all low (range 1.000–1.001) indicating multicollinearity is not a problem.

For the linear regression predicting RCFT Memory, the same procedure was followed with the same independent variables, with addition of drawing strategy variable in memory phase.

This again produced a significant model predicting memory score, F(4,119) = 10.446, p = .000, with an R of 0.510 (adjusted R2 = 0.235). However, within this model Recall strategy appeared as a significant predictor. Resting heart rate scores remained significantly associated with the dependent variable, indicating lower working memory performance was associated with higher RHR score, also use of medications and marital status were significant predictors in this model. Regarding the psychometric properties of the model, the VIFs were acceptable (range 1.027–1.166). The integration of RCFT Copy score as an independent variable produced a significant model, F(5,118) = 10.208, p = .000, with a slight amelioration in power of predicting, with an R of 0.549 (adjusted R2 = 0.272), indicating lower working memory performance was associated with lower RCFT Copy score. The results are shown in Table 5.

Table 4. Multiple linear regression analysis predicting RCFT Copy

	B	SE B	β	t	p
Study institution	-1,246	,452	-,271	-3,153	,002
Average sleep duration	-1,183	,536	-,190	-2,207	,029

B = unstandardized beta, SE B = standard error for B, β = standardized beta

Table 5. Multiple linear regression analysis predicting RCFT Memory

	B	SE B	β	t	p
Recall strategy	-2,781	,707	-,307	-3,933	,000
RHR	-,301	,083	-,279	-3,607	,001
RCFT Copy	,616	231	208	2,666	,009
Periodic use of medications	-8,641	2,820	-,253	-3,065	,003
marital status	13,146	5,229	,209	2,514	,013

B = unstandardized beta, SE B = standard error for B, β = standardized beta

DISCUSSION

This study presents evidence supporting the presence of gender differences in working memory among students, and that male's performance was higher than the female's. Gender was significantly associated with age, study institution, student accommodation, financial support, drug use, and alcohol consumption, also with sleep pattern, regular practice of sport and with our physiological variables (SBP, DBP, and RHR).Healthy men were significantly better than normal female subjects on nonverbal memory tasks(Segalàs, 2010).However, visual perception shows no significant differences according to gender. Sex has no effect on visual perception and working memory (Eloirdi *et al.,2018)*. Those differences may be due to health determinants influence and brain structure. With the advent of neuroimaging, multiple studies have found sex differences in the brain (Allen et al., 2003), found relatively larger genu of the callosum in men, suggesting more bihemispheric communication of the motor tasks likely to be mediated through this region of the callosum (Dubb et al.,2003).Importantly, the functional connectivity of the right superior temporal gyrus with the ventral attention network of cognitively healthy subjects mediates the impact of elevated blood pressure on information-processing speed, with a preserved corpus callosum predicting more favorable blood pressure levels (Wong et al.,2017).Drawing characteristics on RCF test (duration, average strokes size, drawing width and height) seem to be in relationship with visual perception, working memory and physiological variables, these results corroborate the importance of this data when assessing visuospatial constructional abilities and can lead to better understanding of information-processing in the brain and may preserve valuable information from this widely used test.

Visual perception mean score (67.96 ± 3.75) was higher than working memory mean score (42.94 ± 11.13).Although the rating system was the same for both phases, the reproduction phase requires additional skills (Eloirdi *et al., 2019)*. It is often assumed that impaired brain processes that lead to poor performance on neuropsychological tests will also lead to poor performance in situations outside the testing environment (Chaytor et al., 2006).the integration of such tools in educational or industrial environment will be able to change negative behaviors in the workplace and improve productivity.

Our findings suggest that differences in RCFT Copy scores can be explained by student accommodation with a roommate as the highest rank mean; the study also shows a significant difference in visual perception according to study institution. Differences in working memory are significantly explained by gender, Mann Whitney U Test shows that male's performance in working memory was higher than the female's; another relationship between working memory and periodic use of medications showed a better performance in non use group. Variance in weight shows a significant relationship with gender, sport practice and sleep pattern; according to those categorical variables, and in accordance with Alcohol consumption, study institution and student accommodation can explain the differences in stature. Statistics show that there was a statistically significant difference in education years according to geographical distance from the institution, study institution, and marital status.

Our results demonstrate that there was a statistically significant difference in blood pressure (SBP and DBP) between males and females, and according to drug and alcohol consumption only in SBP; this test showed also that diastolic blood pressure in the Arrhythmias group was higher than the normal heart rhythm group. Finally, Mann Whitney U Test showed that there was a statistically significant difference in RHR measurements between the different gender and drug use groups. Overall, by this study results, those determinants of health can lead to the improvement of neuropsychological abilities and maybe Impact our physical and physiological variables.

Regression analyses revealed a relevant contribution of study institution and average sleep duration on RCFT Copy score in the total sample. In Morocco, access to one of these education environments is conditioned by the student's results in Baccalaureate - high school diploma- (good general result for ENSAH and good results on scientific courses for FSTH and unconditional free access for the university SFITU), the impact of this conditional selective process and sleep time predict about 27 % of the variance in the total visual perception performance. Our study confirms and expands on previous findings on the association between objective measures of sleep and neuropsychological impairment (Fernandez-Mendoza et al., 2010). Total sleep deprivation, partial sleep deprivation and sleep fragmentation all have a significant impact on sleepiness and psychomotor performance (Michael, 2003).But the predicted variance was extremely low due to small size of this sample. Our model of RCFT Copy measures predicted 9.1% of the variance in the total visual performance.

By using regression, working memory model was predicted by recall strategy, RHR, medication use and marital status. Strategy type I and II maybe associated with the best results in delayed recall trial. Shorr et al. (1992) proposed that including a wide range of organizational elements and identifying multiple junctures for each element might provide a finer analysis of an individual’s organizational strategy. Moderate correlation between drawing data in this study among copy and recall trial can be in relationship with some kind of adaptation in strategy; this purpose corroborated by the insignificance of strategy adopted during copy phase in both RCFT Copy and RCFT Memory models. This finding needs more neuropsychological and Neuroplasticity advanced research to be improved and can largely impact our working memory performance. With others, previous test battery studies found that recall strategy shift with practice for heart rate (Dalezman, 1976).Heart rate leads negatively to the enhancement of the model, increasing heart rate associated with decreasing RCFT Memory score. Significant relationship between EF task performance and resting heart rate variability (HRV) only for state-oriented individuals but not for action-oriented individuals (Groß, 2020).Contrary to our prediction, Hovland et al. (2012) find that Greater high frequency HRV was associated with higher standardized scores on the neuropsychological tests, and vice versa. Also, Thayer et al., (2009) found evidence for an association between higher levels of resting HRV and superior performance on tasks that tap executive functions.“Periodic medication use” is another interesting variable in our working memory model that decreases the performance, but this still is a general finding due to non-determination of medication nature in our survey. From neuropsychological literature the majority of studies focused on adherence in relation with EF, and up to our knowledge, we didn’t find periodic medication use as dependent variable in any interesting neuropsychological study. Marital status intervenes in performing our predictive model with a higher score showed among married person’s cases as well.

This model slightly improved by the integration of RCFT Copy score, significant association between increasing performance in visual perception and increasing working memory score has been showed. The same find has been cited by previous studies (Bennett-Levy, 1984; Bonne at al., 1993; Fastame, 2020). The role of visual attention in working memory: not only is attention the vehicle to keep and store information into working memory, it is also the vehicle by which information is retrieved from visual working memory (Theeuwes at al., 2011). Better Figure Copy scores predicted more skill transfer at one-month follow-up (VanGilder et al., 2021). We can conclude that to increase working memory performance in institutional environment we need a better implementation of diagnostic tools in order to cope with executive function deficits and improve organizational strategies by development of oriented cognitive abilities with a continuous physical and physiological monitoring of the persons belonging to this institution.

We hope that interesting properties predicted by this study will promote efforts toward improving the neuropsychological performance by using numerical psychometric instruments from multidimensional perspective in order to raise performance and skills in any institutional environment.

Limitations

Limitations of the present study arise from the composition of the sample. While participation in this study was open to any student that assumes interest to participate, we formed a random sample with unbalanced size according to age, gender or their study institution. Also, in terms of the generalization of present findings to the general population is that the sample consists of highly educated healthy young adults volunteers.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

REFERENCES

Allen JS., Damasio H., Grabowski TJ., Bruss J., Zhang W. (2003) Sexual dimorphism and asymmetries in the gray-white composition of the human cerebrum. Neuroimage 18(4):880–894. https://doi.org/10.1016/S1053-8119(03)00034-X

Anderson,VA., Anderson,P., Northam, E., Jacobs, R., and Catroppa, C. (2001). Developmental neuropsychology 20, 385. https://doi.org/10.1207/S15326942DN2001_5

Baddeley, A. (1992). Working Memory. Science, 255, 556-559. DOI: 10.1126/science.1736359

Baddeley, A. D., Chincotta, D. M., & Adlam, A. (2001). Working memory and the control of action: Evidence from task switching. Journal of Experimental Psychology: General, 130, 641–657. https://doi.org/10.1037/0096-3445.130.4.641

Baddeley, A. (2012). Working Memory: Theories, Models and Controversies. Annual Review of Psychology, 63, 1-29. https://doi.org/10.1146/annurev-psych-120710-100422

Bennett-Levy, J. (1984). Determinants of performance on the Rey-Ostemeth Complex Figure Test: An analysis, and a new technique for single-case assessment. British Journal of Clinical Psychology, 23, 109-1 19. https://doi.org/10.1111/j.2044-8260.1984.tb00634.x

Berg, D. H. (2008). Working memory and arithmetic calculation in children: The contributory roles of processing speed, short-term memory, and reading. Journal of Experimental Child Psychology, 99(4), 288–308. https://doi.org/10.1016/j.jecp.2007.12.002

Biederman J., Petty C. R., Fried R., Doyle A. E., Spencer T., Seidman L. J. , Gross L., Poetzl K., and Faraone S. V. (2007). Acta Psychiatrica Scandinavica 116, 129. https://doi.org/10.1111/j.1600-0447.2007.01008.x

Blatter K, Graw P, Munch M, Knoblauch V, Wirz-Justice A, Cajochen C. (2006). Gender and age differences in psychomotor vigilance performance under differential sleep pressure conditions. Behav Brain Res. 168: 312–7. https://doi.org/10.1016/j.bbr.2005.11.018

Boone, Kyle Brauer; Lesser, Ira M.; Hill-gutierrez, E.; Berman, Nancy G.; D'elia, Louis F. (1993). Rey-osterrieth complex figure performance in healthy, older adults: Relationship to age, education, sex, and IQ. Clinical Neuropsychologist, 7(1), 22–28. https://doi.org/10.1080/13854049308401884

Bossuroy, M., Wallon, P., Mesmin, C., and Moro. M. R. (2014). The Impact of Cultural Background on Structural Figure Perception: Cultural Biases in the Reproduction of the Rey-Osterrieth Complex Figure. journal of cognition and culture 14 (2014) 273-285. https://doi.org/10.1163/15685373-12342125

Chan RCK. (2001).A further study on the sustained attention response to task (SART): the effect of age, gender and education. Brain Inj. Taylor & Francis. https://doi.org/10.1080/02699050110034325

Chaytor, N., & Schmitter-Edgecombe, M. (2003). The ecological validity of neuropsychological tests: A review of the literature on everyday cognitive skills. Neuropsychology Review, 13, 181–197. https://doi.org/10.1023/B:NERV.0000009483.91468.fb

Carretti, B., Borella, E., Cornoldi, C., & De Beni, R. (2009). Role of working memory in explaining the performance of individuals with specific comprehension difficulties: A meta-analysis. Learning and Individual Differences, 19, 246–251. https://doi.org/10.1016/j.lindif.2008.10.002

Cinto Segalàs; Pino Alonso; Javier Labad; Eva Real; Alberto Pertusa; Nuria Jaurrieta; Susana Jiménez-Murcia; José Manuel Menchón; Julio Vallejo (2010). A case-control study of sex differences in strategic processing and episodic memory in obsessive-compulsive disorder. , 51(3), 0–311. https://doi.org/10.1016/j.comppsych.2009.05.008

Cornblath, E.J., Tang, E., Baum, G.L., Moore, T.M., Adebimpe, A., Roalf, D.R., Gur, R.C., Gur, R.E., Pasqualetti, F., Satterthwaite, T.D., Bassett, D.S.(2018). Sex differences in network controllability as a predictor of executive function in youth, NeuroImage. https://doi.org/10.1016/j.neuroimage.2018.11.048

Dalezman, Joseph J. (1976). Effects of output order on immediate, delayed, and final recall performance. Journal of Experimental Psychology: Human Learning & Memory, 2(5), 597–608. https://doi.org/10.1037/0278-7393.2.5.597

Dubb A., Gur R., Avants B., Gee J. (2003). Characterization of sexual dimorphism in the human corpus callosum. , 20(1), 512–519. https://doi.org/10.1016/S1053-8119(03)00313-6

Edel, N. R. (2003). Academic Performance: Concept, Research and Development. Ibero-American Magazine on Quality, Efficiency and Change in Education, 1. http://www.ice.deusto.es/RINACE/reice/vol1n2/Edel.htm.

Elmossati, M.,S., Oudda, H., Ahami, A., El midaoui,A.(2016).Job Satisfaction and Psychological empowerment among teachers in Moroccan University.International Journal of Education and Research Vol. 4 No. 3. 297-308. https://www.ijern.com/journal/2016/March-2016/23.pdf

Eloirdi, A., Mammad,K., Arfaoui, A., Chtibi, H., Diallo,M.C., Wallon, P. and Ahami, A. (2018) Study of Visual Perception and Working Memory in Moroccan Adolescents Attending School. Open Journal of Medical Psychology, 7, 82-90. DOI: 10.4236/ojmp.2018.74007

Eloirdi, Aziz; Ahami, Ahmed; Mammad, Khaoula (2019). Neurocognitive study of school performance among Moroccan high school students: The role of working memory. Dementia & Neuropsychologia, 13(2), 232–237. https://doi.org/10.1590/1980-57642018dn13-020013

Evi De Lissnyder, Ernst H. W. Koster, Rudi De Raedt (2012). Emotional Interference in Working Memory is Related to Rumination. , 36(4), 348–357. https://doi.org/10.1007/s10608-011-9352-4

Fastame, M. C. (2020). Visual and spatial working memory skills implicated in copying and drawing from memory of the Rey-Osterrieth Complex Figure: What relationship in school-aged children?. Cognitive Development, (), 100826. https://doi.org/10.1016/j.cogdev.2019.100826

Fernandez-Mendoza,J., Calhoun, S. , Bixler,E.O., Slobodanka Pejovic, Karataraki, M., Liao,D., Vela-Bueno,A., Ramos-Platon,M.J., SauderK.,A., Vgontzas ,A.N.,(2010). Insomnia with Objective Short Sleep Duration is Associated with Deficits in Neuropsychological Performance: A General Population Study, Sleep, Volume 33, Issue 4, Pages 459–465. https://doi.org/10.1093/sleep/33.4.459

Gathercole, S. E., Durling, E., Evans, M., Jeffcock, S., & Stone, S. (2008). Working memory abilities and children’s performance in laboratory analogues of classroom activities. Applied Cognitive Psychology, 22(8), 1019–1037. https://doi.org/10.1002/acp.1407

Groß, D., (2020). Action versus state orientation moderates the relation between executive function task performance and resting heart rate variability. Journal of Research in Personality, 86(), 103936. https://doi.org/10.1016/j.jrp.2020.103936

Hovland A., Pallesen S., Hammar Å., Hansen A.L., Thayer JF., Tarvainen M.P., Nordhus IH. (2012). The relationships among heart rate variability, executive functions, and clinical variables in patients with panic disorder. , 86(3). https://doi.org/10.1016/j.ijpsycho.2012.10.004

Joe Enright, Megan E. O’Connell, Samantha MacKinnon & Debra G. Morgan (2015): Predictors of Completion of Executive-Functioning Tasks in a Memory Clinic Dementia Sample, Applied Neuropsychology: Adult, 1-6 . https://doi.org/10.1080/23279095.2014.992070

Jonides, J., Lewis, R. L., Nee, D. E., Lusting, C. A., Berman, M. G., & Moore, K. S. (2007). The mind and brain of short-term memory. Annual Review of Psychology, 59, 193–224. https://doi.org/10.1146/annurev.psych.59.103006.093615

Lezak, M. D. (1995). Neuropsychological assessment (3rd ed.). New York: Oxford University Press

Meyers, J. E., and Meyers, K. R. (1995). Rey Complex Figures Test and Recognition Trial: Professional manual. Odessa: Psychological Assessment Resources.

Michael H. Bonnet; Donna L. Arand (2003). Clinical effects of sleep fragmentation versus sleep deprivation. , 7(4), 0–310. https://doi.org/10.1053/smrv.2001.0245

Muñoz, M. L. (1993). Comparative Study of Some Factors That Affect Academic Performance in a Population of Upper and Upper Secondary Students. PhD, México: Ibero American University.

Osterrieth PA (1944) Le test de copie d‘une figure complexe: Contribution a l‘étude de la perception et de la mémoire. Archiv für Psychologie. 30: 30286–30356.

Osterrieth, P.A. (1945) Le test de copie d’une figure complexe. Contribution a l’étude de la perception et de la mémoire. Archives de Psychologie, 30, 306-356.

Pisella L. Visual perception is dependent on visuospatial working memory and thus on the posterior parietal cortex. Ann Phys Rehabil Med (2016). https://doi.org/10.1016/j.rehab.2016.01.002

Richards, R., Berninger, V., Winn, W., Swanson, H. L., Stock, P., Liang, O., et al. (2009). Differences in fMRI activation between children with and without spelling disability on 2-back/0-back working memory contrast. Journal of Writing, 1, 93–123.

Riley E, Okabe H, Germine L, Wilmer J, Esterman M, DeGutis J (2016) Gender Differences in Sustained Attentional Control Relate to Gender Inequality across Countries. PLoS ONE 11(11). https://doi.org/10.1371/journal.pone.0170876

Shin, M. S., Park, S. Y., Park, S. R., Seol, S. H., & Kwon, J. S. (2006). Clinical and empirical applications of the Rey–Osterrieth complex figure test. Nature Protocols, 1, 892–899. https://doi.org/10.1038/nprot.2006.115

Shorr, J.S., Delis, D.C., & Massman, P. (1992). Memory for the Rey-Osterrieth Figure: Perceptual clustering, and storage. Neuropsychology, 6 (1), 43-50. https://doi.org/10.1037/0894-4105.6.1.43

Siennicki-Lantz, A., Lilja, B., Rosen, I., & Elmstahl, S. (1998). Cerebral blood flow in white matter is correlated with systolic blood pressure and EEG in senile dementia of the Alzheimer type. Dementia and Geriatric Cognitive Disorders, 9, 29–38. https://doi.org/10.1159/000017019

Somerville, J., Tremont, G., Stern, R.A.(2000). The Boston Qualitative Scoring System as a Measure og Executive Functionning in Rey-Osterrieth Complex Figure Performance, Journal of Clinical and Experimental Neuropsychology, 22:5, 613-621. https://doi.org/10.1076/1380-3395(200010)22:5;1-9;FT613

Starr, John M.; Whalley, Lawrence J.; Inch, Susan; Shering, P. Ann (1993). Blood Pressure and Cognitive Function in Healthy Old People. Journal of the American Geriatrics Society, 41(7), 753–756. https://doi.org/10.1111/j.1532-5415.1993.tb07466.x

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. Annals of Behavioral Medicine, 37, 141–153.
https://doi.org/10.1007/s12160-009-9101-z

Theeuwes J., Kramer AF., Irwin DE. (2011). Attention on our mind: The role of spatial attention in visual working memory.Acta Psychologica, 137(2), 248–251.https://doi.org/10.1016/j.actpsy. 2010.06.011

Tim P. Moran; Danielle Taylor; Jason S. Moser (2012). Sex moderates the relationship between worry and performance monitoring brain activity in undergraduates., 85(2). https://doi.org/10.1016/j.ijpsycho.2012.05.005

Tombaugh, T. N., & Hubley, A. M. (1991). Four studies comparing the Rey-Osterrieth and Taylor Complex Figures. Journal of Clinical and Experimental Neuropsychology, 13(4), 587–599. https://doi.org/10.1080/01688639108401073

VanGilder,JL., Lohse,KR., Duff,K., Wang,P., Schaefer, SY. (2021) Evidence for associations between Rey-Osterrieth Complex Figure test and motor skill learning in older adults.Acta Psychologica. Vol:214.103261https://doi.org/10.1016/j.actpsy.2021.103261

Vannetzel, L. (2010) Testons les tests: la Figure Complexe de Rey: Au gout du jour. Approche neuropsychologique des apprentissages chez l'enfant, 109, 323-325

Waldstein SR, Manuck SB, Ryan CM, Muldoon MF. Neuropsychological correlates of hypertension: Review and methodologic considerations. Psychol Bull 199 1; 110:45 1-468. https://doi.org/10.1037/0033-2909.110.3.451

Walker, K., (2006). Dimensions of executive functioning differentially influence visuoconstruction and visuospatial memory on the reyosterrieth complex figure test.St. John's University New York

Weber D, Skirbekk V, Freund I, Herlitz A. (2014).The changing face of cognitive gender differences in Europe. Proc Natl Acad Sci U S A. 111: 11673–8. https://doi.org/10.1073/pnas.1319538111

Wong NML, Ma EP-W and Lee TMC (2017) The Integrity of the Corpus Callosum Mitigates the Impact of Blood Pressure on the Ventral Attention Network and Information Processing Speed in Healthy Adults. Front. Aging Neurosci. 9:108. https://doi.org/10.3389/fnagi.2017.00108

Yuan J, He Y, Qinglin Z, Chen A, Li H. (2008) Gender differences in behavioral inhibitory control: ERP evidence from a two-choice oddball task. Psychophysiology. 45: 986–93. https://doi.org/10.1111/j.1469-8986.2008.00693.x

Corresponding author:
Elmossati Mohamed Salim,
Cognitivo-Behavioral Neuroscience and Applied Nutrition Laboratory,
Clinical Neuropsychology Team, Department of Biology, Faculty of Sciences,
Ibn Tofail University, Kenitra, Morocco. University campus, BP 133
e-mail: edistoo369@gmail.com