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DOES WORK STRESS AFFECT NEUROCOGNITIVE FUNCTIONS? CASE OF MOROCCAN WORKERS

Samira ARJI[1[A,B,C,D,E]], Mounia ELHADDADI[1[C]], Ahmed O.T. AHAMI[1[A]], Rabea ZIRI[2[A]]

[1] Department of Biology, Laboratory of Biology and health, Faculty of Sciences, University Ibn Tofail, Kenitra, Morocco
[2] Department of Biology, Laboratory of Plant and Animal productions and Agro-industry, Faculty of Sciences, University Ibn Tofail, Kenitra, Morocco

SUMMARY

Background: Depending on its stage, stress influences cognitive functions. Indeed, several authors have ensured the degradation of cognitive functions by stress. Others did not find any association between the two. A third group of authors claimed that stress improves the performance of certain cognitive functions. Faced with this inconsistency of results, we conducted this study with the aim of finding out whether job stress alters or stimulates cognitive functions.

Material/ Methods: Our study focused on 102 workers who were asked to freely and anonymously complete a questionnaire deemed relevant at the international scale. The age of the participants is between 22 and 60 years old with an average of 37 years and a standard deviation of 11 years.The population is made up of 77% of men and 23% of women. For the school level of the subjects: 50% of the subjects have a level bac to bac+2, 30% have a level higher than bac+2 and 20% have a level lower than bac. The professional status of workers is divided into three types: 48% are supervisors and technicians, 32% are executing workers and 20% are senior managers. The participants underwent two neurocognitive tests using the ELIAN software.

Results: Analysis of the results shows that there is no significant link between work stress and the cognitive functions studied. However, the analysis of the results of each socio-professional category separately shows that stress significantly reduces the visual working memory score of young people (< 40 years old), as well as the ability to concentrate of subjects with a school level higher than bac+2. While it improves visual perception in men and old people over the age of 40.

Conclusions: There are significant links between some cognitive performances and the socio-professional characteristics of the stressed subjects. Therefore, work stress can affect neurocognitive health, which is more serious. In order to understand the relationship between work or chronic stress and cognition as well as their moderating factors, it is advisable to increase the size of the sample and to diversify the cognitive functions studied as well as their tasks.

Key words: work stress; working memory; perception; precision; ability to concentrate

INTRODUCTION

Cognitive functions are elaborate functions of logic, strategy, planning, problem solving and hypothetico-deductive reasoning (Bérubé, 1991). These functions include basic selective attention (Marko and Riečanský, 2018; Shields & al., 2016), executive functions and general intelligence factors especially reasoning and induction and working memory (Engle & al., 1999).

Chronic stress is generally associated with poorer cognitive performance. It has been shown to have cumulative negative effects on the brain (Lupien& al., 2018), and cognition (Marshall et al., 2016). High-perceived stress is associated with impaired cognitive functioning and may be a risk factor for cognitive decline (Feeney & al., 2018; Katz & al., 2016; Korten& al., 2017; Munoz & al., 2015; Turner & al., 2017). The relationships between subjective measures of chronic stress and cognitive performance were consistently stronger in the domains of executive function and working memory (Oumohand and al., 2020). Indeed, some authors have shown that acute stress impairs working memory and cognitive flexibility, while it has nuanced effects on inhibition (Shields & al., 2016; Marko and Riečanský, 2018). It also degrades long-term memory as well as self-reported memory (Shields & al., 2017). This alteration depends mainly on emotional stressors (Musić and Rossell, 2016). However, a second category of studies claims that stress improves memory performance (Cahill & al., 2003; Smeets& al., 2008; Lukasik & al., 2019). Similarly, other authors have found that stress is associated with better learning and better memory (Pulopulos& al., 2014). While a third category of studies reported no association between capillary cortisol as a biological marker of stress and cognitive performance (Jansen & al., 2017; McLennan & al., 2016; Oumohand and al., 2020). A fourth category of authors has demonstrated that there is an inverted U theory between stressors and the performance of executive functioning (Arnsten, 2009; Shinohara & al., 2018).

Faced with this inconsistency of the results, we conducted this study with the aim of finding out whether work stress alters or stimulates cognitive functions. For this, we carried out a survey among the workers of a private industrial company in Kenitra. Age, gender, education level, and professional status were singled out as possible confounders, as studies have reported systematic differences in cognition and stress due to these variables (Feeney, 2020; Stalder& al., 2017).

MATERIAL AND METHODS

This study was carried out in a Moroccan company in Kenitra working in the industrial sector in metallurgy. The population consists of 102 volunteer workers. The age of the participants is between 22 and 60 years old with an average of 37 years and a standard deviation of 11 years.The population is made up of 77% of men and 23% of women. For the school level of the subjects: 50% of the subjects have a level bac to bac+2, 30% have a level higher than bac+2 and 20% have a level lower than bac. The professional status of workers is divided into three types: 48% are supervisors and technicians, 32% are executing workers and 20% are senior managers.

To perform this study, we used the following methods and tools:

1. The Rey's complex figure (RCF) A test (Rey, 1959): The complex figure of Rey A is composed of 18 elements, it is organized in three parts: an overall shape (the large rectangle), external elements (squares, crosses, triangles), and internal elements. It allows the evaluation of different cognitive processes such as visual perception, visio-spatial organization, working memory, inhibition and attention (Vannetzel, 2010). We used the digital version of the RCF A test of the ELIAN software (Expert Line Information Analyzer). The test is carried out in two phases:

- A copy phase where the model is presented to the subject by asking him to copy it without specifying that there will be a second phase.
- A reproduction phase where, after a three-minute delay proposed by André Rey, the subject is asked to make the same drawing without seeing it (Mesmine& Wallon, 2011).

The duration of the test is free and timed both for the copy and for the reproduction. Two types of rating were used: numerical rating and type rating (Rey &Osterrieth, 1945). The numerical rating makes it possible to establish a score, in fact, the RCF-A is divided into 18 elements. They are rated one by one as follows: correctly drawn and well placed (4 points), correctly drawn and incorrectly placed (2 points), correctly drawn, well placed but imperfect (3 points), distorted or incomplete but recognizable and correctly placed (2 points), distorted or incomplete but recognizable and badly placed (1 points) and finally unrecognizable or absent (0 points). The type quotation makes it possible to understand the strategy or the planning used by the subject to copy and then reproduce the figure. This is called the type of organization. To know it, the ELIAN software makes it possible to record the succession of lines. There are seven types of organization: construction of the armature, details included in the armature, general outline, juxtaposition of details, details on a confused background, reduction to a familiar scheme and scribbling.

2. Brickenkamps' d2 test (Brickenkamp, 2002): The purpose of this test is to control visual attention and the ability to concentrate. It is a matter of discerning quickly and with certainty analogous details.This test is made up of a double-sided sheet where you can note various information concerning the subject as well as an example to be completed prior to the test to ensure that the instructions are properly understood. This example presents to the candidate the three possible variants for the target character (d accompanied by two strokes, either above, or below, or one stroke above and the other below). It also presents the character sets not to mark, in other words the “distractors” (the letter d accompanied by one, three or four lines and the letter p regardless of the number of lines). The candidate must identify and cross out the target characters among the distractors; he is warned in the event of omission of a target character or marking of a distractor character. The back of this sheet constitutes the test itself and comprises fourteen lines or series that contain forty-seven signs arranged randomly. In the instructions, it is requested to process the test quickly and if possible, without making errors. The treatment time per series is limited to 20 seconds.The rating relates to the total number of signs examined, which mea-

sures the subject's productivity or processing speed. The number of errors as well as their distribution which measures the will and the perseverance and finally the global performance or the capacity of concentration and the precision of the subject represented by the total number of signs processed from which the total number of faults was deducted (Merten& al., 2012). The interest of the test is ensured by the shortness of its administration time as well as the speed and accuracy of the analysis of the results.

3. Job Content Questionnaire (JCQ) (Karazek& al., 1998): From Karasek's model (Karazek, 1979) in its French version completed by six items that explore recognition at work from the questionnaire of Seirgrist (Seirgrist, 1991). The JCQ is presented in the form of a self-questionnaire, which includes 26 items evaluating three dimensions: psychological demand (PD), decision latitude (DL) and social support (SS). Symptom frequency was measured on a four-point scale where zero corresponds to “strongly disagree” and four corresponds to “strongly agree”. A combination of low decision latitude and high psychological demand results in a tense work situation or “job-strain”. A job-strain situation in addition to low social support places the subject in the context of stressed work or “iso-strain”. The subject is stressed in his work if he is in the job-strain or iso-strain situation. The internal consistency of the questionnaire for this population is satisfactory, $\alpha = 0.75$.

Statistical analysis was performed with SPSS 25 software. Pearson correlations in addition to linear regressions were performed to study associations and links between quantitative variables, respectively. The T-test for the independent samples was carried out to verify the link between the Job-strain or Iso-strain variables (two-modality variables) and the cognitive function variables (quantitative), preceded by the normality tests to ensure that the distribution of quantitative variables follows the normal law. The Khi2 test was used to verify the link between the categorical variables. A threshold of 5% was maintained to confirm the significance of the two tests. In order to study the effect of control variables (age, gender, educational level and professional status), the population was divided into categories, for each of which hypotheses were tested to verify the significance.

RESULTS

Correlation between the components of work stress and cognitive functions

Investigating associations between job stress components and cognitive function scores, only a single significant weak positive correlation was obtained between recognition at work and RCF execution time (r=0.259) at 1% (see: Table 1). Other apparent correlations are inter-correlations between cognitive task scores; for example, there are significant positive correlations between ability to concentrate and processing speed, as well as with RCF perception and its working memory. In addition to a significant positive inter-correlation between two components of stress: social support and decision latitude.

Table 1. Correlations between work stress components and cognitive function scores

Variables	Mean	Std. dev.	1	2	3	4	5	6	7	8	9	10
Decision latitude	69.22	8.46										
Psychological demand	22.70	4.09	-0.001									
Social support	24.59	3.79	.487**	-0.114								
Recognition at work	16.75	3.20	-0.035	0.111	0.014							
RCF perception score	60.92	6.72	-0.054	-0.053	-0.147	0.021						
RCF working memory score	38.72	10.94	-0.120	-0.040	-0.110	0.027	.530**					
RCF execution time	160.97	67.09	0.006	0.039	0.010	.259**	0.014	-0.164				
Memory RCF Execution Time	145.25	72.60	-0.021	0.059	-0.002	0.129	0.098	-0.135	.516**			
Processing speed	141.44	38.41	0.124	0.096	-0.007	-0.070	0.122	.223*	-.253*	-.210*		
Ability to concentrate	89.78	60.32	0.030	0.131	-0.068	-0.010	.267**	.318**	-0.177	-0.134	.775**	
Precision	0.44	0.47	0.159	-0.117	0.073	0.000	0.129	.220*	0.118	0.047	0.101	0.088

N=102; ** P < 0.01; * P < 0.05

Results of the visio-spatial organization types of RCF

For the visio-spatial organization types of RCF used in reproduction and in copying, we note that type1 (construction of the large rectangle as a framework) is the most used by this population in copying as in reproduction: (60% in copying

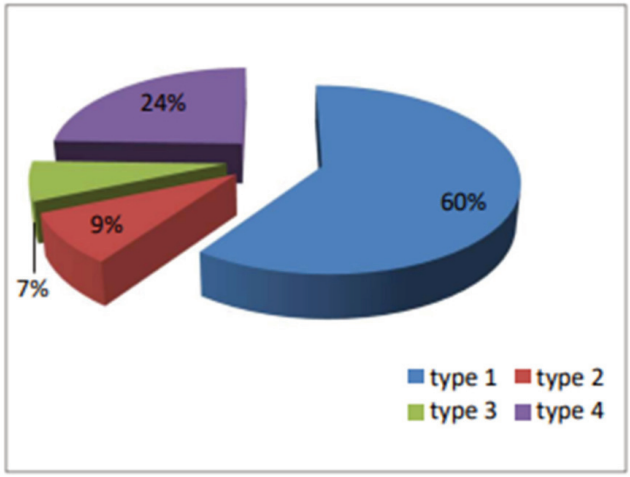

Fig. 1. The type quotation of the copy RCF

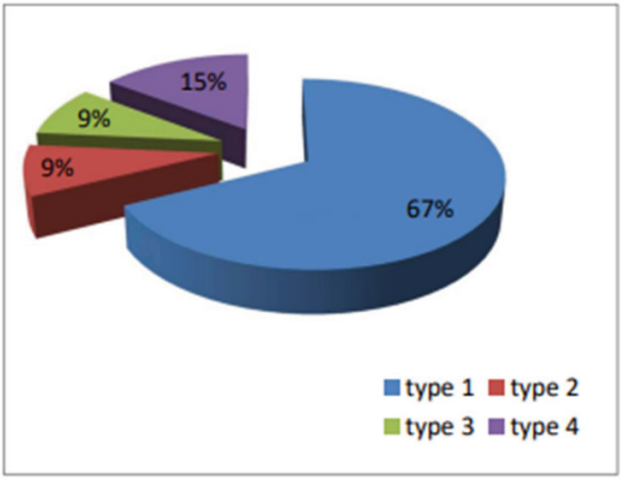

Fig. 2. The type quotation of the reproduction of RCF

and 67.65% in reproduction). We also note a slight increase in the use of this type in reproduction compared to the copying phase.

Our results also show that type 4 (detail juxtaposition) is the most used after type1 by the different groups, with a decrease in the appearance of this type during reproduction (24.51% in copying and 14.71% in reproduction).

Prediction of cognitive function scores by work stress components

Linear regression analyzes show only two significant associations between work stress components and cognitive function scores (see: Table 2). Indeed, social support predicts negatively and significantly the precision score (B=-0.003; P=0.033). In addition, recognition at work positively and significantly predicted the execution time score of RCF (B=5.431; p=0.01).

Table 2. Linear regression between cognitive function scores and work stress components

	Decision latitude		Psychological demand		Social support		Recognition at work	
	B	sig.	B	sig.	B	sig.	B	Sig.
RCF perception score	0.024	0.79	-0.125	0.456	-0.303	0.143	0.07	0.743
RCF working memory scores	-0.106	0.48	-0.141	0.607	-0.222	0.508	0.108	0.756
RCF execution time	0.114	0.899	0.17	0.918	0.011	0.996	5,431	0.01
Memory RCF Execution Time	-0.195	0.845	0.835	0.646	0.234	0.916	2.79	0.229
Processing speed	0.709	0.177	0.902	0.346	-0.719	0.54	-0.899	0.459
Ability to concentrate	0.521	0.527	1,812	0.231	-1.415	0.445	-0.381	0.842
Precision	0.01	0.137	-0.014	0.232	-0.003	0.033	0.003	0.845

Results of normality tests of cognitive function scores

Before carrying out the hypothesis tests, an analysis of the normality of the quantitative variables was carried out according to the "PP-Plot" test. The set of variables showed a distribution similar to the normal law distribution. Figure 3 illustrates these observations well, with some caveats for precision scores.

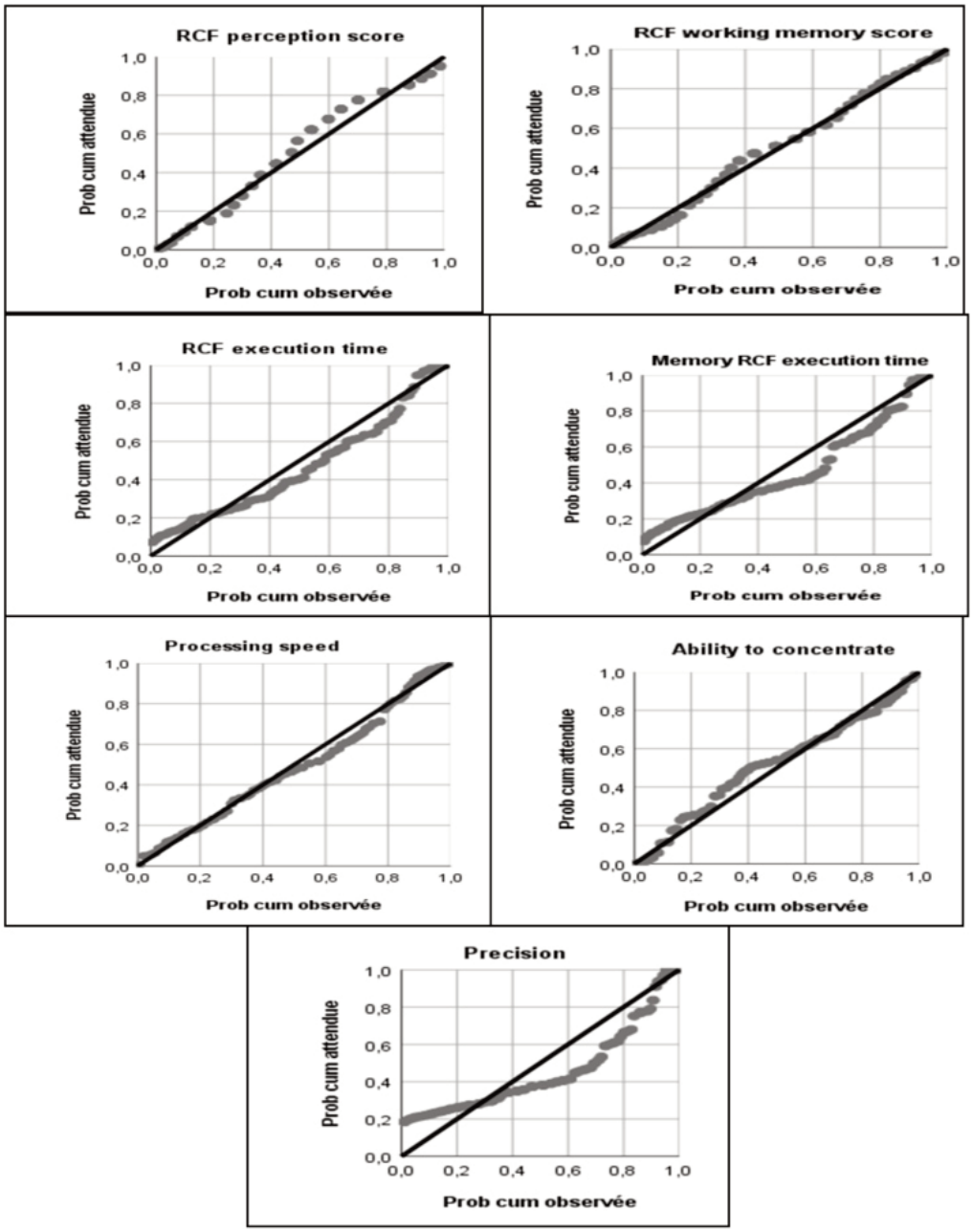

Fig. 3. “PP-Plot” diagrams of quantitative variables

Work stress and cognitive functions

Our results show that there is no significant association between cognitive function scores and work stress (see: Table 3). Similarly, Organization types of RCF and memory RCF are not related to work stress.

Table 3. Work stress and cognitive functions

	Work stress				P-value
	Normal people		Stressed people		
	Mean	Std. dev.	Mean	Std. dev.	
RCF perception score	60	6	62	7	0.161
RCF working memory score	39	11	38	10	0.543
RCF execution time	165	70	153	62	0.411
Memory RCF Execution Time	147	76	142	67	0.772
Processing speed	138	40	148	35	0.250
Ability to concentrate	90	64	90	52	0.961
Precision	0.44	0.50	0.43	0.40	0.908
Organization types of RCF	–	–	–	–	0.383
Organization types of RCF Memory	–	–	–	–	0.999

Socio-professional variables, work stress and cognitive functions

Considering the control variables, the results show that there are some significant links between some cognitive scores and work stress (see: Table 4). Indeed, the visual working memory decreases significantly with work stress in the age group under 40 (p=0.049); the visual perception score increases significantly with work stress in the age group over 40 (p=0.003), and in men (p=0.041); the ability to concentrate decreases significantly with work stress in subjects with a school level higher than bac+2.

Table 4. Socio-professional variables, work stress and cognitive functions

		RCF perception score	RCF working memory score	RCF execution time	Memory RCF Execution Time	Processing speed	Ability to concentrate	Precision
		Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)	Mean (Std. dev.)
age < 40 years old	Normal person	61 (6)	42 (11)	158 (64)	136 (60)	147 (43)	98 (67)	0.45 (0.48)
Age > 40 years old	Stressed person	61 (7)	37 (9)	141 (52)	137 (56)	156 (31)	96 (49)	0.44 (0.41)
	P	0.847	0.049	0.263	0.979	0.342	0.896	0.921
	Normal person	60 (7)	35 (11)	175 (77)	162 (93)	127 (32)	78 (60)	0.43 (0.54)
	Stressed person	67 (4)	40 (14)	191 (76)	160 (95)	122 (36)	73 (59)	0.41 (0.40)
	P	0.003	0.303	0.595	0.953	0.747	0.847	0.898
Women	Normal person	61 (6)	39 (9)	172 (78)	128 (47)	145 (51)	91 (80)	0.34 (0.28)
	Stressed person	58 (8)	33 (7)	137 (39)	123 (51)	141 (13)	64 (54)	0.28 (0.32)
	P	0.291	0.135	0.306	0.815	0.739	0.465	0.671
Men	Normal person	60 (7)	39 (12)	162 67)	153 (83)	136 (35)	89 (59)	0.48 (0.56)
	Stressed person	63 (7)	39 (11)	157 (66)	147 (70)	149 (38)	96 (50)	0.48 (0.42)
	P	0.041	0.898	0.729	0.721	0.127	0.613	0.903
School Level <bac	Normal person	58 (6)	38 (14)	200 (86)	191 (113)	117 (23)	74 (48)	0.53 (0.7)
	Stressed person	57 (6)	27 (9)	153 (52)	136 (74)	142 (66)	99 (75)	0.52 (0.2)
	P	0.689	0.168	0.313	0.37	0.514	0.408	0.981

School level Bac to bac+2 level	Normal person	61 (7)	40 (10)	152 (53)	134 (62)	133 (34)	75 (66)	0.44 (0.4)
	Stressed person	64 (5)	40 (8)	165 (68)	146 (61)	151 (34)	89 (53)	0.47 (0.5)
	P	0.076	0.914	0.465	0.522	0.092	0.456	0.868
School level > bac +2	Normal person	61 (6)	39 (11)	157 (77)	132 (41)	167 (47)	132 (57)	0.37 (0.4)
	Stressed person	62 (9)	39 (12)	138 (57)	140 (77)	146 (28)	89 (47)	0.37 (0.3)
	P	0.852	0.999	0.448	0.722	0.125	0.032	0.959
Executing workers	Normal person	60 (7)	38 (14)	163 (60)	166 (103)	134 (31)	78 (54)	0.41 (0.4)
	Stressed person	63 (7)	32 (8)	174 (55)	176 (67)	145 (43)	94 (54)	0.55 (0.4)
	P	0.26	0.121	0.657	0.787	0.42	0.451	0.381
Supervisors, technicians	Normal person	61 (6)	40 (10)	174 (81)	138 (60)	128 (39)	76 (68)	0.46 (0.6)
	Stressed person	61 (7)	38 (9)	161 (65)	140 (70)	146 (35)	80 (50)	0.40 (0.5)
	P	0.79	0.486	0.594	0.889	0.129	0.818	0.705
Senior managers	Normal person	60 (7)	39 (11)	146 (55)	134 (43)	171 (43)	144 (47)	0.46 (0.5)
	Stressed person	64 (10)	45 (12)	106 (39)	104 (38)	156 (29)	109 (54)	0.37 (0.2)
	P	0.306	0.306	0.112	0.135	0.425	0.147	0.629

DISCUSSION

The objective of this study was to investigate whether work stress alters the cognitive functions of workers of a Moroccan company. Correlation analysis showed an association between job recognition and RCF execution time (r=0.259) at 1%. To go further, we performed the regression which revealed that recognition at work positively and significantly predicted the execution time of the RCF (B= 5.431; p=0.01). Knowing that work stress results from the interaction between high psychological demand and low decision latitude in addition to low social support (Karasek& al., 1998), the previous result means that recognition at work is a moderating effect of work stress. This confirms the Effort-Reward Imbalance (ERI) model (Siegrist, 1991), which indicates that stress results from the subject's perception of an imbalance in his work situation between his extrinsic efforts (time constraints, responsibilities, etc.) and the rewards received in return (recognition, etc.). Social support was also found to negatively and significantly predict precision score (B=-0.003; P=0.033), but the index of this association is very weak, and it is not even appeared in the hypothesis tests. These did not reveal any significant association between cognitive function scores and work stress for the whole population. This results contrast most of the scientific literature that affirms the impairment of cognitive functions, especially executive, by chronic stress (Demetriou & al., 2021; Deligkaris, 2014; Sandi, 2013). Indeed, during chronic or acute stress, attention, memorization and planning capacities decrease (Oumohand& al., 2020; Cahill& al., 2003; Turner& al., 2017). In addition, high-perceived stress is associated with deterioration in cognitive functioning and may be a risk factor for cognitive decline (Feeney & al., 2018; Katz & al., 2016; Kor-

ten& al., 2017; Munoz & al., 2015; Turner & al., 2017). However, our results support those of another study that found no evidence of executive function impairment in a population-based sample of young adults in association with chronic burnout-related disorders (Castaneda & al., 2011). In addition, other authors have claimed that there is no association between perceived stress and executive functions (Moschl& al., 2022; Schmidt & al., 2019). Similarly, objective chronic stress by assessing capillary cortisol does not affect executive functioning (Jansen & al., 2017; McLennan & al., 2016; Oumohand& al., 2020; Schmidt&al., 2019). However, there are results that have claimed that stress improves memory performance (Cahill& al., 2003;Smeets& al., 2008; Lukasik & al., 2019). Other authors have added that it is associated with better learning and memory (Pulopulos& al., 2014). The absence of the association between job stress and especially executive cognitive functions in the present study can be explained by the fact that only exaggerated forms of stress impair executive functioning (Ronnland& al., 2013; Sandi, 2013). This is also indicated by the inverted U theory between stressors and executive functioning performance (Arnsten, 2009; Shinohara & al., 2018).

By exploring the moderating effect of age, we have found that work stress significantly decreases visual working memory of RCF score in the younger people under 40-age. While it improved the perception of RCF in subjects over the age of 40. In this sense, stress significantly impaired image recognition in young adults (Hidalgo & al., 2019), while it has no effect on visual memory (Smith & al., 2019; Deal & al., 2018), nor on spatial working memory (Murphy & al., 2020). A meta-analysis of the literature indicated that the effects of stress on cognition partially differ between young and older adults (Mikneviciute and al., 2022), and differ according to the type of cognitive tasks (Shields, 2020). For example, acute stress significantly improved the performance of a few working memory tasks; however, it did not influence other executive functions or image recall (Mikneviciute and al., 2022). Similarly, when studying the effect of age, another study found no significant interaction between cognitive functions and variation in capillary cortisol concentration, nor with the estimation of subjective chronic stress (Möschl and al., 2022). Others also found that age moderated the effects of acute stress on cortisol, but negated the effects of stress on memory (Shields & al., 2017), executive functions (Shields & al., 2016), and decision-making (Starcke& Brand, 2016). Similarly, acute stress does not appear to affect long-term memory retrieval or working memory in older adults (Hidalgo & al., 2019). Another study also demonstrated that age has no effect on response accuracy and inhibition in healthy stressed men (Dierolf& al., 2018). However, stress improved both working memory accuracy and reaction time (Luers& al., 2020).

It was found that visual perception of RCF score increased significantly in stressed men. However, other studies have concluded that the negative effects of acute stress on executive functions are somewhat stronger in men than in women (Shields & al., 2016). While another study found no effect of gender on the effect of chronic stress on executive functioning (Möschl and al., 2022). In

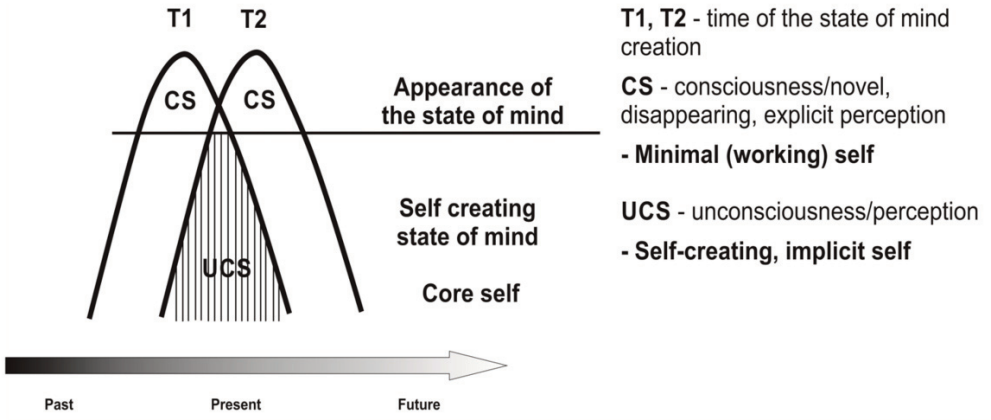

Fig. 4. Mind/brain state: developing (T1) and renewing (T2) mental state in time: the birth of the minimal (working) self
Source: (Pachalska & al., 2012)

addition, stress improved memory span (recovery) only in older women without affecting the executive component (Pulopulos& al., 2015).

Our results are explained by microgenetic theory, especially the importance of mental state, which develops at the base of every cognitive process both under normal life as well as and under the stress (Brown & Pachalska 2022). All concepts (self knowledge) and feelings (impulse, emotion, intent) is based on micro-temporal process in the mind/brain state (see: Fig. 4), which is developing in time (T1) and renewing (T2) in the brain (Brown & Pachalska 2022).

In working memory, images are reproduced in subsequent mental states in the order of memory, i.e., in relation to their resemblance to the coming state, and thus to the possibility of renewing the mental state. In the current state of mind, there are images closer to the perception that takes place, i.e., images from the working memory buffer that have almost reached the character of renewed perception. The brain-mind state in T1 is replaced by the overlapping state T2 before T1 ends in time, i.e., before the next phase occurs. This explains the reoccurrence of the early phases in T1, related to the condition of the body (body and brain), individuality of the person, i.e., Self, character, disposition, capacity of working memory buffers, long-term memory resources and experience, and the durability of basic beliefs, values and personality. Later phases disappear when the whole process of realizing reality is completed to make room for new perceptions. The activity of earlier phases of the mental state in the process of the overlapping of individual phases explains the sense of self continuity in time. It should be emphasized that the early stages of mental state development are components that incorporate later states that are more susceptible to environmental influences. At the same time, the repetition of earlier phases is closely connected with the feeling of a reality that exists (Pąchalska, MacQueen and

Brown 2012). Therefore, in addition to its effects of general health of the particular person, work stress can affect neurocognitive health.

Limitations of the study

In order to understand the relationship between work or chronic stress and cognition as well as their moderating factors, it is advisable to increase the size of the sample and to diversify the cognitive functions studied as well as their tasks.

CONCLUSION

It was found that there are significant links between some cognitive performances and socio-professional characteristics of stressed subjects, namely age, sex and school level. Indeed, work stress improves visual perception of men and older subjects over 40-age. While it reduces visual working memory of younger people under 40-age. Work stress decreases too the ability to concentrate in subjects with higher-level school (over BAC+2). Therefore, in addition to its effects of general health, work stress can affect neurocognitive health.

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Corresponding author:
Samira Arji
N° 4 B, El MenzehII, Bir Rami Est, Kénitra, Morocco.
e-mail: samira.arji@uit.ac.ma
ORCID: 0000-0002-2039-6028