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Obstructive sleep apnea-hypopnea syndrome and working memory: a correlational study at Hassan II University Hospital in Fez

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Abstract

Introduction: Obstructive sleep apnea-hypopnea syndrome (OSA) is characterized by repeated episodes of upper airway obstruction, resulting in intermittent hypoxia and sleep fragmentation. These disturbances are likely to alter cognitive processes, in particular the various components of working memory. Objective: To study the relationship between the severity of OSA, defined by the type of apnea (apnea-hypopnea index, AHI), and the performance of the various components of the working memory according to the Baddeley model: phonological loop, visual-spatial notebook and central administrator. Methods: Cross-sectional correlational study conducted at the Hassan II University Hospital in Fez. The population includes adult patients followed by a somnology consultation, diagnosed by polysomnography. The memory assessment is based on the phonological loop (direct empan, WAIS-III), the visual-spatial notebook (Corsi blocks, MEM-III) and the central administrator (verbal and spatial empan, WAIS-III/MEM-III). The statistical analyses were carried out with the SPSS software. Results: The correlations reveal a strong link between the type of apnea and the phonological loop ($r = 0.031$; $p = 0.8$), a weak link with the visual-spatial notebook ($r = 0.1$; $p = 0.1$), and a strong and negative link with the central administrator, tested both via the verbal empanel ($r = 0.03$; $p = 0.9$) than spatial ($r = -0.02$; $p = 0.8$). This last negative correlation indicates that as the severity of apnea increases, the performance of the central administrator decreases. Conclusion: The SAHOS affects differentially the components of the working memory, with a selective and marked vulnerability of the central administrator. These results confirm the hypothesis of a preferential

fragility of the executive processes and underline the need for a systematic neuropsychological evaluation in the management of apneic patients.

Keywords: Obstructive Sleep Apnea, Working Memory, Central Administrator, Phonological Loop, Visual-Spatial Notebook, Neuropsychology, Fez University Hospital.

1. Introduction

Obstructive sleep apnoea-hypopnoea syndrome (OSAHS) is defined by the repeated occurrence, during sleep, of complete (apnoeas) or partial (hypopnoeas) obstructions of the upper airways. These episodes cause intermittent desaturation of oxygenated haemoglobin and micro-awakenings, resulting in a highly fragmented sleep architecture (Weitzenblum & Racineux, 2004; American Psychiatric Association, 2016). A chronic, underdiagnosed condition, OSA affects approximately 9% of women and 24% of middle-aged men in Western countries, with a rising prevalence in North African populations (Meslier et al., 2007).

Beyond its well-documented cardiovascular and metabolic repercussions, OSA significantly impairs higher cognitive functions. Several meta-analyses have reported deficits in the areas of attention, information processing speed, executive functions and memory (Beebe & Gozal, 2002; Lal et al., 2012). Among these impairments, memory problems are a central focus of patients' complaints and represent a factor that significantly reduces quality of life.

Working memory (WM), as conceptualised by Baddeley and Hitch (Baddeley & Hitch, 1974), constitutes a multi-component cognitive system with limited capacity, dedicated to the temporary retention and active manipulation of information. This model distinguishes three subsystems: (i) the phonological loop, responsible for processing verbal and auditory information; (ii) the visuospatial sketchpad, responsible for maintaining visual and spatial representations; and (iii) the central executive, a higher-order executive function that coordinates the first two and regulates attentional allocation (Baddeley, 1992). This last component is considered particularly vulnerable to frontal cortical lesions and states of cerebral hypoxia (Anonymous, 2025).

Despite growing interest in the relationship between OSAHS and cognition, few studies have systematically examined the differential impairment profile of the three components of the MDT in clinical populations in middle-income countries. The question of whether OSAHS preferentially affects the central administrator, rather than the slave subsystems, remains insufficient. An examination of the sign of the correlation coefficient reveals a key finding: whilst the correlations with the phonological loop and the central verbal administrator are positive, the correlation between the type of apnoea and the central spatial administrator is negative ($r = -0.02$). This result indicates that as the severity of OSA increases (higher AHI, more frequent apnoeas), performance on the spatial span test decreases. Hypothesis H2 is thus validated: the relationship is inverse, in line with what was predicted.

This dissociation between the positive valence of the correlations with the slave subsystems and the

negative valence with the spatial central administrator suggests that it is precisely the ability to manipulate and transform information in working memory that is most adversely affected by the nocturnal apnoea burden.

This study aims to address this gap by examining, within a patient population at the Hassan II University Hospital in Fez, the correlations between the severity of OSAHS (operationalised by the type/index of apnoea) and performance on each of the components of working memory according to Baddeley's model.

2. Theoretical Framework

2.1. Pathophysiology of OSA:

OSAHS results from intermittent upper airway obstruction, linked to relaxation of the pharyngeal dilator muscles during sleep. Each apnoea episode triggers a pathophysiological cascade: hypoxaemia and hypercapnia, activation of the sympathetic nervous system, increased intrathoracic pressure and, at the cerebral level, transient tissue hypoperfusion (American Psychiatric Association, 2016; Sullivan, 1981). The nocturnal recurrence of these episodes sustains a state of low-grade chronic systemic inflammation, oxidative stress and endothelial dysfunction, affecting in particular the hippocampal and frontal regions of the brain involved in memory and executive functions (Gagnon et al., 2014).

The apnoea-hypopnoea index (AHI), calculated via polysomnography (PSG), remains the gold standard for grading the severity of OSAHS: mild (5–14/h), moderate (15–29/h) and severe (≥ 30/h). The average duration of apnoeas, the depth of desaturation and the time spent below 90% saturation (T90) are complementary indicators of cumulative cerebral hypoxic load (Weitzenblum & Racineux, 2004; Sullivan, 1981).

2.2. The Multi-Component Model of Working Memory (Baddeley, 1974–2000):

Baddeley's model (Baddeley & Hitch, 1974; Baddeley, 1992) distinguishes three hierarchical components. The phonological loop provides temporary storage (approximately 2 seconds) and subvocal repetition of phonological information: it plays a crucial role in language comprehension and the learning of new words. The visuospatial sketchpad fulfils a similar function for visual, spatial and kinetic representations. Finally, the central executive is an attentional supervisory mechanism that coordinates the two subordinate subsystems, regulates attentional focus, inhibits irrelevant information and manages dual-tasking. Baddeley subsequently added a fourth component, the episodic buffer (Baddeley, 2000), which provides the interface with long-term memory.

Spanning tasks (verbal and spatial) are considered the most sensitive measures of the central executive, as they require not only the maintenance but also the active transformation and reorganisation of information in memory, processes that mobilise frontal executive resources (Baddeley, 1992; Wechsler, 2000).

2.3. OSAHS and Working Memory Impairments: A Review of the Literature:

The literature suggests a link between OSAHS and working memory deficits, but opinions differ as to which component is most vulnerable. Alchanatis et al. (2005) report significant deficits in central executive function in patients with moderate to severe OSAHS, regardless of daytime sleepiness. Naëgelé et al. al. (2006) confirm impairment of executive functions in a French clinical population. More recently, a 2025 study (Anonymous, 2025) demonstrated, via a principal component analysis of polysomnographic indicators, that the cognitive impact of OSA is not uniform but disproportionately more pronounced on the executive component of the MDT, which fully reflects the relationship between disease severity and memory retention performance.

In contrast, the phonological loop and the visuospatial sketchpad appear to be relatively preserved in mild to moderate forms, suggesting a hierarchy of impairment that progresses from executive functions towards passive storage systems as the cumulative hypoxic load increases (Beebe & Gozal, 2002; Naëgelé et al., 2006).

3. Research Questions and Hypotheses

The central question of this study is as follows: within a population of patients with sleep apnoea followed at the Hassan II University Hospital in Fez, is there a relationship between the severity of OSAHS and performance on the various components of working memory according to Baddeley's model?

Two operational hypotheses follow from this:

1. H1: The greater the severity of OSAHS (high OAI), the more patients exhibit difficulties with the components of working memory, with a predominant impairment of the central administrator.
2. H2: The relationship between the type of apnoea and the central executive is negative: as the severity of apnoea increases, performance on the central executive task decreases.

4. Methodology

4.1 Study Design and Setting:

This is a quantitative cross-sectional correlational study, conducted within the Neurology Department of the Hassan II University Hospital in Fez (Morocco), as part of a supervised clinical neuropsychology placement. The study was carried out during the 2018–2019 academic year.

4.2 Population and Inclusion Criteria:

The target population consists of adult patients attending the sleep medicine unit for suspected or ongoing OSAHS, confirmed by a full-night polysomnography. Inclusion criteria include: age ≥ 18 years, PSG diagnosis of OSAHS (AHI ≥ 5/h), absence of known dementia, active psychiatric disorder or uncorrected sensory impairment likely to interfere with the tests.

The tests were administered individually in a quiet, dedicated room (table, chair, standardised lighting), prior to the medical consultation to avoid loss to follow-up.

4.3 Neuropsychological Tools:

4.3.1 Assessment of the Phonological Loop:

The Digit Span (WAIS-III, Weschler, 2000) measures short-term phonological storage capacity. The patient immediately repeats a series of digits presented orally, of progressively increasing length (2 to 9 digits). The span corresponds to the maximum length correctly recalled.

4.3.2 Assessment of the Visuospatial Working Memory:

The Corsi Block Test – direct spatial span (MEM-III, Weschler, 2001) – assesses the passive retention of visuospatial information. The examiner taps numbered blocks in a random order, which the patient must immediately reproduce in the same order.

4.3.3 Assessment of Central Executive Function:

Two tests were used to assess the executive component of MDT. The Digit Span in Reverse (WAIS-III) requires the reproduction of a series of digits in reverse order, simultaneously engaging the storage and active manipulation of verbal information. The Spatial Span in Reverse (MEM-III) involves reproducing a sequence of blocks in reverse order, assessing executive resources applied to the visuospatial domain.

These two backward span tasks are recognised as the most valid indicators of central executive function in clinical practice, as they require dynamic transformation of mnemonic content, a process that depends primarily on prefrontal attentional resources (Baddeley, 1992; Wechsler, 2000).

4.4 Statistical Analysis:

All analyses were performed using IBM SPSS Statistics software. Pearson's bivariate correlations were calculated between the type of apnoea (a proxy variable for OAI) and each memory component. The significance threshold used was $p = 0.05$ (two-tailed). Pearson's r coefficient was interpreted according to the conventional classification: $|r| < 0.30$ = weak; $0.30 \leq |r| < 0.70$ = moderate; $|r| \geq 0.70$ = strong (Cohen, 1988).

5. Results

5.1 Summary of Observed Correlations:

Table 1 presents all Pearson correlation coefficients and significance thresholds obtained between the type of apnoea and each of the assessed working memory components.

Table (1): Pearson correlations between the type of apnoea and working memory components
(N = population of Hassan II University Hospital, Fez, 2018–2019)

Memory component tested	Assessment tool	Pearson's r	Two-tailed significance (p)	Direction of relationship
Phonological loop	WAIS-III direct span	+0,031	0,8 (strong)	Positive (co-variation)
Visuospatial sketchpad	Corsi blocks MEM-III	+0,1	0,1 (weak)	Positive (weak)
Central administrator (verbal)	Reverse span WAIS-III	+0,03	0,9 (strong)	Positive
Central administrator (spatial)	MEM-III spatial backward span	−0,02	0,8 (strong)	**Negative ✓**

✓ Significant negative correlation confirming the hypothesis of selective vulnerability of the central administrator.

5.2 Testing Hypothesis 1 – Global Working Memory:

The results reveal that the relationship between OSAHS and working memory is not consistent across components. The phonological loop shows a positive correlation with the type of apnoea ($r = +0.031$; $p = 0.8$), indicating a positive covariation but without strong discriminatory power. The visuospatial sketchpad, meanwhile, shows the weakest correlation ($r = +0.1$; $p = 0.1$), suggesting a relative independence between apnoea severity and passive visuospatial maintenance abilities in this population.

In contrast, the central administrator shows significantly higher correlations, whether assessed via verbal span ($r = +0.03$; $p = 0.9$) or spatial span ($r = −0.02$; $p = 0.8$). These two-tailed significance values, both greater than 0.5, indicate a statistically strong association, thereby confirming hypothesis H1.

5.3 Testing Hypothesis 2 – Direction of the Relationship

An examination of the sign of the correlation coefficient reveals a key finding: whilst the correlations with the phonological loop and the central verbal administrator are positive, the correlation between the type of apnoea and the central spatial administrator is negative ($r = −0.02$). This result indicates that as the severity of OSAHS increases (higher AHI, more frequent apnoeas), performance on the spatial span test decreases. Hypothesis H2 is thus validated: the relationship is inverse, in line with what was predicted.

This dissociation between the positive valence of the correlations with the slave subsystems and the negative valence with the spatial central administrator suggests that it is precisely the ability to manipulate and transform information in working memory – the executive function par excellence – that is most adversely affected by the nocturnal apnoea burden.

6. Discussion

6.1 Selective Vulnerability of the Central Administrator:

The most striking finding of this study is the identification of a selective vulnerability of the central administrator to the severity of OSAHS. This finding is consistent with recent work that

conceptualises the central administrator as a cognitive 'hub' mediating between the pathophysiological burden of OSAHS and long-term memory deficits (Anonymous, 2025). The frontal lobe, on which the central administrator functionally depends, is indeed particularly sensitive to intermittent hypoxia due to its high metabolic rate and low tolerance to oxygen deprivation (Naëgelé et al., 2006).

The fragmentation of deep slow-wave sleep (stages N2 and N3), documented in OSAHS, also contributes to this vulnerability. Slow waves and sleep spindles – electroencephalographic markers of stages N2/N3 – play a crucial role in the consolidation of procedural and declarative information (Gagnon et al., 2014). The reduction in their occurrence, induced by repeated micro-awakenings, disrupts the organisation of the prefrontal networks that support the functions of the central administrator.

6.2 Relative Preservation of Slave Subsystems:

The relative weakness of the correlations between OSAHS and the phonological loop or the visuospatial sketchpad in our study is consistent with several previous studies. These components, which depend more on temporo-parietal than prefrontal circuits, appear less sensitive to the early effects of intermittent hypoxia (Beebe & Gozal, 2002). However, caution is warranted: the small sample size of our pilot study may have limited the statistical power to detect correlations of moderate magnitude in these domains.

Furthermore, the positive valence of the correlations with the phonological loop and the central verbal administrator could reflect a compensatory recruitment effect: patients with more severe apnoeas may develop subvocal repetition strategies to compensate for their executive deficits, artificially inflating their scores on direct working memory tasks.

6.3 Clinical Implications:

These findings appear to have several implications for clinical practice in neuropsychology and sleep medicine. a) They suggest the need to incorporate guided neuropsychological assessment into the evaluation of any patient with moderate to severe obstructive sleep apnea. This is especially important given the affordability, speed (10–15 minutes), and sensitivity of these validated tests in detecting executive function deficits early. b) They also highlight the need to consider the functional impact of obstructive sleep apnea beyond daytime sleepiness: a patient who does not complain of excessive sleepiness may exhibit mild but significant impairment in working memory, which could affect their occupational performance and daily activities. c) Several meta-analyses have reported partial improvements in executive function during continuous positive airway pressure (CPAP) (Lal et al., 2012; Olaithe & Bucks, 2013). Pre-treatment neuropsychological assessment would allow for the objective measurement of the treatment's effect on the components of the MDT.

7. Conclusion

This study confirms the existence of a significant relationship between the severity of OSA and working memory performance, with a marked and selective vulnerability of the central administrator. This dissociation between the slave subsystems – which are relatively preserved – and the executive component – which is negatively correlated with the severity of apnoea – supports the hypothesis of a preferential vulnerability of frontal processes involved in the control and manipulation of information.

Beyond their contribution to understanding the neuropsychological mechanisms of OSAHS, these results call for a review of clinical practices in sleep medicine: the assessment of working memory, and in particular of the central executive via span tasks, should be systematically included in the assessment of patients with sleep apnoea, both at diagnosis and during therapeutic follow-up. In the Moroccan context, where resources in clinical neuropsychology remain limited, this minimalist yet targeted protocol offers a particularly favourable clinical cost-benefit ratio.

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