Effects of obstructive sleep apnea on cognitive function: A comparison between younger and older OSAS patients

A. Mathieu a,b, S. Mazza a, A. Décary a,c, J. Massicotte-Marquez a,d, D. Petit a, N. Gosselin a,d, J. Malo e, J. Montplaisir a,c,*

a Centre d’étude du sommeil et des rythmes biologiques, Hôpital du Sacré-Coeur de Montréal, 5400 boul. Gouin Ouest, Montréal, Que., Canada H4J 1C5
b Department of Medical Bioscience, Université de Montréal, Canada
c Department of Psychiatry, Université de Montréal, Canada
d Department of Psychology, Université de Montréal, Canada
e Service de pneumologie, Hôpital du Sacré-Coeur de Montréal, 5400 boul. Gouin Ouest, Montréal, Que., Canada H4J 1C5

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Abstract

Background and purpose: Patients with obstructive sleep apnea syndrome (OSAS) present cognitive deficits similar to those observed with aging. The aim of the study was to assess the effects of age on cognitive functions in OSAS patients. It was hypothesized that older OSAS patients will exhibit significant cognitive dysfunction relative to younger OSAS patients and controls.

Patients and methods: Younger and older OSAS patients were compared to younger and older control subjects (age cut-off set at 50 yrs). Participants underwent a polysomnographic (PSG) and neuropsychological evaluation. Variables were analyzed by two-way analyses of variance (ANOVAs) with two factors: Group (control and OSAS) and Age (younger and older). Additionally, we evaluated the contribution of attentional deficits to cognitive dysfunction for each subgroup of patients by using Spearman correlation coefficients.

Results: No Group-by-Age interaction was found for any neuropsychological variables (p < 0.05). However, main Group and Age effects were found. Correlations indicated that attentional deficits contributed importantly to a poorer cognitive performance in younger OSAS patients only (p < 0.01).

Conclusions: Our results are in agreement with those of the literature for both OSAS-related and aging-related cognitive deficits but did not demonstrate that age interacts with the effects of the OSAS condition to make those cognitive deficits worse.

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Keywords: Age; Sleep apnea; Cognitive function; Daytime vigilance; Elderly

1. Introduction

Obstructive sleep apnea syndrome (OSAS) is characterized by a perturbation of the pharyngeal dilator muscles, which causes frequent cessations of breathing (apneas) accompanied by a reduction in ventilation (hypopneas) during sleep. Electroencephalographic (EEG) arousals and oxygen desaturation are immediate consequences of these respiratory events. In adults, untreated OSAS results in excessive daytime sleepiness (EDS) [1], cognitive dysfunction [2,3], cardiovascular diseases and brain damage [4]. Epidemiological studies indicate that OSAS associated with abnormally high blood pressure is a prevalent sleep problem, affecting 4% of men and 2% of women [5]. Neuropsychological studies of OSAS patients showed deficits in cognitive domains related to the prefrontal cortex, such as executive functions [6,7] and working memory [6,8,9]. Other cognitive
functions are also reported to be affected in OSAS, such as alertness [10–12], attention [11,13], and long-term episodic memory [6,14]. There are some indications of impaired procedural memory in OSAS [15,16], but this function has not been extensively studied in these patients. Some recent investigations proposed that impairments in attention play a pivotal role in all aspects of cognitive deficits and thereby contribute to the weak performance of OSAS patients when compared to that of healthy individuals [10,13].

Most neuropsychological studies of OSAS have been conducted on middle-aged subjects and have not investigated directly the effects of age on cognitive impairments in these patients. It is well documented that normal aging modifies some cognitive domains, such as processing speed, attention, some aspects of episodic and working memory while sparing verbal abilities [17–19] and recognition memory [20,21]. Moreover, studies have shown that cognitive deficits of OSAS patients are qualitatively similar to those of elderly individuals, especially in tasks sensitive to frontal lobe dysfunction, such as those requiring inhibitory control or selective attention [22–25]. Therefore, it is tempting to stipulate an age–OSAS interaction in the severity of cognitive deficits found in these patients.

In order to assess the effects of age on cognitive impairments associated with OSAS, we evaluated a broad range of cognitive functions in younger and older OSAS patients compared to age-matched control subjects. We hypothesized that a cumulative effect of age and OSAS will result in more severe cognitive dysfunction in older OSAS patients. More specifically, older OSAS patients will exhibit greater impairments in attention, executive functions and memory (short-term, long-term and procedural) in comparison with younger OSAS patients and controls. Additionally, we postulated that attention deficits in older OSAS patients would contribute significantly to their poorer cognitive performance relative to younger OSAS patients.

2. Materials and methods

2.1. Subjects

Twenty-eight patients (26 men, 2 women) diagnosed with OSAS at the Sleep Center of the Sacre-Coeur Hospital of Montreal (Canada) and 30 controls (26 men, 4 women) matched for age and education were included in the study. Both the OSAS patients and the controls were divided into two age groups with a cut-off at 50 yrs to obtain two subgroups which were representative of the range of consulting OSAS patients (between 25 and 75 yrs of age), with enough people per subgroup and similar symptom severity while keeping the age span and standard deviation equal in each subgroup (see Table 1 for subject characteristics). All participants underwent a standard all-night polysomnographic (PSG) recording. The inclusion criterion for OSAS patients was an obstructive apnea index (number/hour of sleep) \( \geq 20 \) and for control subjects an apnea–hypopnea index (number/hour of sleep) \(< 5 \). Exclusion criteria for both groups were the presence of sleep disorders (other than OSAS for the patients), pulmonary, neurological or psychiatric disease or intake of a drug (hypnotics, benzodiazepines) known to affect sleep, EEG or alertness. Since high blood pressure, cholesterolemia and diabetes are common features of OSAS, patients whose conditions were well controlled by medication were included. The Epworth Sleepiness Scale (ESS) [26] was used to assess subjective sleepiness, and the Beck Depression Inventory (BDI) [27] and the Mini Mental State Examination (MMSE) were administered to exclude depression and dementia, respectively. The body mass index (BMI) and neck circumference were also measured. The protocol was approved by the Hospital’s Ethics Committee, and all participants signed a consent form before entering the study.

2.2. Polysomnographic recording

EEG electrodes were positioned according to the international 10–20 system. A Grass polygraph Model 15A54 amplifier system (Astromed, Canada) with gain of 7.5 \( \mu V/mm \), bandpass 0.3–100 Hz) was used for recording, and signals were all digitized at a sampling rate of 256 Hz using commercial software (Harmonie 6.0, Stellate Systems, Canada). Sleep was recorded and scored according to the standard method [28]. Thoraco-abdominal plethysmograph and nasal-canula-pressure-transducer system were used to identify apneas and hypopneas. Transcutaneous finger pulse oximeter was used to measure oxygen saturation. An apnea was defined as a total cessation of airflow and a hypopnea as a reduction of airflow of at least 50% from baseline and lasting \( \geq 10 \) s [29]. The nocturnal hypoxemia variables studied were the mean and minimal value of \( SaO_2 \) and time spent with \( SaO_2 \) below 90%. The sleep variables studied were total sleep time, percentage of intra-sleep wake, sleep efficiency, micro-arousal index, percentage of rapid eye movement (REM) sleep and percentage of slow wave sleep (SWS: stages 3 and 4 of non-REM sleep).

2.3. Neuropsychological testing

Neuropsychological testing was conducted on the day after the PSG, between 09:30 and 15:45. Cognitive tasks were administered in the same order to all subjects and by the same examiner. Participants were allowed to take breaks when needed, in order to minimize fatigue and maintain motivation. Four cognitive domains were assessed: (1) attention, (2) short-term memory and exec-
utive functions, (3) long-term episodic memory and (4) procedural memory.

2.3.1. Attention

The Four Choice Reaction Time Test (FCRTT) was used as a measure of sustained attention [30,31]. Participants were requested to press the corresponding key of a small recording apparatus when a light was flickering, as fast as possible. They performed the task in a sitting position in a dimly lit room. The FCRTT was administered throughout the day (09:30, 11:30, 13:30, 15:30), and the mean reaction time, number of omissions or lapses (reaction times >1 s) and all errors were recorded.

The Trail A (part 1 of the Trail Making Test, to connect numbers from 1 to 25) was used as a measure of visual attention and processing speed [32]. The time required to complete the task was recorded.

2.3.2. Short-term memory and executive functions

The Digit Span from the Wechsler Adult Intelligence Scale, third version (WAIS-III) (seven pairs of random number sequences to recall forward and backward) was used as a measure of short-term immediate verbal memory [33]. The maximum number of digits reported in each span was recorded. The Brown–Peterson (to memorize and retain a trigram of consonants while counting backward from 100 for either 0, 10 or 30 s) was used as a measure of working memory [34]. The number of consonant assemblies reported in the right sequence was recorded. The Trail B (part 2 of the Trail Making Test, to connect numbers from 1 to 13 and letters from A to L in an alternating fashion) was used as a measure of mental flexibility [32]. The time taken to complete the task was recorded. The Wisconsin Card Sorting Test (to place the cards one-by-one under four stimulus cards according to one of four possible concepts that the patient must deduce from the examiner’s feedback) was used as a measure of concept formation and shifting [35]. The number of categories achieved and perseverative errors (maintaining a wrong answer despite the examiner’s feedback) were both recorded.

2.3.3. Long-term episodic memory

The Rey Auditory Verbal Learning Test (RAVLT) [36] consists of five presentations and recalls of a 15-word list (A), with a presentation of a second 15-word list (B), and immediate and delayed recalls of the first list. Recognition was also examined an hour following the delayed recall, from 15 words containing items from both A to B lists as well as non-related words [37]. The numbers of words recalled from the first list (sum of trials 1 through 5), from the second list (B), in the immediate and delayed recalls of the first list and during the recognition trial were all recorded.

The Wechsler Logical Stories Test from the Wechsler Memory Scale comprises two different stories, one sim-
pler (story A) than the other (story B) [38]. The examiner read story A once and story B twice and asked for a recall after each reading. Delayed recall trials were done after an hour. A multiple choice recognition trial was administered after the delayed recalls; for each of 12 main elements of the stories, participants were presented with three choices and had to provide an answer. The total number of items reported at the immediate and delayed recalls, the learning effect (difference between the second lecture of story B and the first lecture of story B) and recognition trials were all recorded.

2.3.4. Procedural memory

The Mirror Tracing Test used in our assessment consists of a wooden platform apparatus (Lafayette Instrument Company) on which participants are asked to trace a pattern (star or cross) while seeing their performance in a mirror. With their dominant hand, participants were instructed to trace as quickly as possible the pattern without crossing the border. If they did, they had to go back where they were before crossing the line. Participants completed two trial practices without the mirror, in order to get familiar with the task; then three trials were done with the mirror in place. We had shown, in a previous study [16], that some OSAS patients experience adaptation difficulties with the Mirror Tracing Test. Decrements in performance were observed for the first three learning trials (hence coined as “adaptation” difficulty), but the learning curves (after 10 trials) did not distinguish patients from normal subjects. We concluded that OSAS patients show learning on this task despite an initial adaptation deficit. The time taken to complete each trial was noted, and the procedural learning effect (difference in tracing time between trial 3 and trial 1) was also recorded.

2.4. Statistical analyses

STATISTICA 6.0 was used for all statistical analysis. Differences in clinical, anthropometric, PSG and cognitive variables were analyzed by two-way analyses of variance (ANOVARs) with the factors Group (controls versus OSAS patients) and Age (younger versus older subjects). Tukey honest significant difference (HSD) post hoc tests were performed when the ANOVAs were significant. Statistical significance was set at \( p < 0.05 \). Since variables of the FCRTT were not normally distributed, they were log-transformed. To better understand our results, the relationships between respiratory (apnea–hypopnea index (AHI) and time spent with \( \text{SaO}_2 \) below 90%) and sleep fragmentation (sleep efficiency and micro-arousal index) variables and the neuropsychological variables observed to be impaired were assessed for the two age groups of OSAS patients separately.

Additionally, in order to evaluate the possible contribution of attentional deficits to cognitive deficits in OSAS patients, we measured the relationship between the FCRTT and neuropsychological variables using Spearman correlation coefficients. Statistical significance was set at \( p < 0.01 \) to account for the number of correlations.

3. Results

3.1. Subjects characteristics

Clinical and PSG characteristics for OSAS patients and control subjects are presented in Table 1. No Group differences were observed for education level, BDI or MMSE scores. Main Group effects were found for BMI, neck circumference, ESS, micro-arousal index and all respiratory variables. OSAS patients were obese, had a larger neck circumference (>40 cm) and reported more subjective somnolence than controls. Main Age effects were found for sleep variables: older individuals had lower total sleep time, sleep efficiency, percentage of stage 2 sleep, percentage of SWS and higher intra-wake sleep. A Group-by-Age interaction was found for percentage of REM sleep. Post hoc tests revealed that younger OSAS patients had less REM sleep than older OSAS patients and younger controls.

3.2. Neuropsychological testing

Results of the neuropsychological testing are presented separately for each of the four cognitive domains in Tables 2 through 5. No Group-by-Age interaction was found in any domain. However, main Group effects and main Age effects were obtained as described below.

3.2.1. Attention

There was a main Group effect on the FCRTT; OSAS patients presented a longer mean reaction time (\( F_{1,54} = 4.5; p = 0.04 \)) and an increased number of lapses compared to controls (\( F_{1,54} = 28.3; p = 0.000002 \)) (see Table 2). There was no between-group difference for the number of errors on the FCRTT. The extreme inter-subject variability could account for this non-significant result. There was also a main Age effect on the FCRTT; older individuals showed longer mean reaction times (\( F_{1,54} = 28.3; p = 0.000002 \)) and had more lapses (\( F_{1,54} = 15.1; p = 0.01 \)) compared to younger individuals. They also spent more time completing the Trail A (\( F_{1,54} = 11.7; p = 0.001 \)). There was no Age effect for the number of errors on the FCRTT. In sum, attention was negatively affected by the OSAS condition and by age.

In younger OSAS patients, positive correlations were observed between the time spent with oxygen saturation below 90% and both mean reaction time (\( r = 0.756; p = 0.002 \)) and lapses (\( r = 0.667; p = 0.009 \)). Moreover, the time to complete Trail A correlated positively with
the ESS \((r = 0.824; p = 0.009)\). In older OSAS patients, no correlations were obtained between attention and nocturnal hypoxemia variables.

Lastly, the relationship between the FCRTT (mean reaction time and lapses) and neuropsychological variables seem to partially account for some of the cognitive deficits in the younger OSAS patients. More specifically, results showed a positive correlation between time on Trail B and both mean reaction time \((r = 0.874; p = 0.007)\) and lapses \((r = 0.706; p = 0.005)\), a negative correlation between lapses and performance on the Brown–Peterson \((r = −0.674; p = 0.01)\) and a negative correlation between lapses and the total number of items for immediate recall of story B of the Wechsler Memory Scale \((r = −0.637; p = 0.01)\). In older OSAS patients, no relationship was obtained between any of the variables.

### 3.2.3. Long-term episodic memory

Long-term episodic memory assessment showed a main Age effect for the second 15-word list (B) \((F_{1,53} = 11.5; p = 0.05)\) of the RAVLT; older individuals recalled fewer words on list B than younger individuals (Table 4). There was no Age effect for the sum of trials 1 through 5, or for immediate and delayed recalls, but there was a trend for an Age effect on the recognition trial \((F_{1,53} = 6.9; p = 0.057)\). No Group effect was obtained for the sum of trials 1 through 5, immediate and delayed recalls or recognition trial of the RAVLT.

However, a main Group effect was obtained for immediate recall of story B \((F_{1,54} = 5.3; p = 0.03)\) and for the learning effect \((F_{1,41} = 4.7; p = 0.04)\) of the Wechsler Memory Scale; OSAS patients performed more poorly than controls (Table 4). There was no between-group difference in the immediate recall of story A, the second lecture of story B, delayed recall of both stories and recognition of story A of the Wechsler Memory Scale. In addition, there were main Age effects on the Wechsler Memory Scale; older individuals reported fewer correct responses on immediate recall for story B \((F_{1,54} = 8.9; p = 0.004)\), in the second lecture of story B \((F_{1,54} = 6.4; p = 0.01)\) and in the delayed recall of stories A \((F_{1,53} = 4.0; p = 0.05)\) and B \((F_{1,53} = 12.0; p = 0.001)\).

### Table 3

Neuropsychological assessment of OSAS patients and controls: vigilance and attention (mean and Std. Err.)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Controls</th>
<th>OSAS</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(\leq 50 \text{yr} = 12)</td>
<td>(&gt;50 \text{yr} = 18)</td>
<td>(\leq 50 \text{yr} = 14)</td>
</tr>
<tr>
<td>FCRTT: mean reaction time (ms)</td>
<td>472.1 (30.9)</td>
<td>579.0 (25.2)</td>
<td>502.6 (28.6)</td>
</tr>
<tr>
<td>FCRTT: gaps (ms)</td>
<td>11.8 (8.1)</td>
<td>27.6 (6.6)</td>
<td>24.3 (7.5)</td>
</tr>
<tr>
<td>FCRTT: errors (ms)</td>
<td>21.3 (5.3)</td>
<td>14.9 (4.3)</td>
<td>25.4 (4.9)</td>
</tr>
<tr>
<td>Trail A: time (s)</td>
<td>25.0 (2.8)</td>
<td>33.6 (2.3)</td>
<td>24.4 (2.6)</td>
</tr>
</tbody>
</table>

ns, non-significant.

\(a\) Main Group effect.

\(b\) Main Age effect.

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\(F\) values, \(p\) values, and effect sizes (Cohen’s \(d\)) were also obtained for the Wisconsin, Trail B, and Brown–Peterson tests. There were main Age effects for the Wisconsin \((F_{1,54} = 4.7; p = 0.04)\), Trail B \((F_{1,54} = 9.0; p = 0.004)\), and Brown–Peterson \((F_{1,54} = 6.1; p = 0.02)\) tests, with no between-group difference in the Wisconsin \((F_{1,54} = 4.6; p = 0.04)\). There was a trend for an Age effect on the recognition trial \((F_{1,53} = 6.9; p = 0.057)\). No Group effect was obtained for the sum of trials 1 through 5, immediate and delayed recalls or recognition trial of the RAVLT.

However, a main Group effect was obtained for immediate recall of story B \((F_{1,54} = 5.3; p = 0.03)\) and for the learning effect \((F_{1,41} = 4.7; p = 0.04)\) of the Wechsler Memory Scale; OSAS patients performed more poorly than controls (Table 4). There was no between-group difference in the immediate recall of story A, the second lecture of story B, delayed recall of both stories and recognition of story A of the Wechsler Memory Scale. In addition, there were main Age effects on the Wechsler Memory Scale; older individuals reported fewer correct responses on immediate recall for story B \((F_{1,54} = 8.9; p = 0.004)\), in the second lecture of story B \((F_{1,54} = 6.4; p = 0.01)\) and in the delayed recall of stories A \((F_{1,53} = 4.0; p = 0.05)\) and B \((F_{1,53} = 12.0; p = 0.001)\).
There was no Age effect on the learning effect or recognition of either story of the Wechsler Memory Scale. In sum, long-term episodic memory was negatively affected in the OSAS condition and by age.

The immediate recall of story B and the learning of the Wechsler Memory Scale effect did not correlate with either somnolence or hypoxemia variables in any subgroup of patients.

3.2.4. Procedural memory

Procedural memory assessment showed a main Group effect for trial 1 ($F_{1;46} = 4.8; \ p = 0.03$) (see Table 5) of the Mirror Tracing Test. OSAS patients appeared to improve their performance from trial 1 to trial 3. There was no between-group differences on the mirror tracing without mirror, on trial 2 and trial 3, except for a trend for OSAS patients to be worse on procedural learning ($F_{1;46} = 3.8; \ p = 0.056$). Here again, the extreme inter-subject variability could account for this non-significant result. However, main Age effects were obtained for trial 1 ($F_{1;46} = 13.0; \ p = 0.0008$), trial 2 ($F_{1;46} = 5.6; \ p = 0.02$), trial 3 ($F_{1;46} = 12.0; \ p = 0.001$) and for the procedural effect ($F_{1;46} = 8.1; \ p = 0.006$) on the Mirror Tracing Test. There was no age difference on the mirror tracing without the mirror. Procedural memory was more negatively affected by age than by the OSAS condition.

The Mirror Tracing Test did not correlate with somnolence or hypoxemia variables in any subgroup of patients.

4. Discussion

The aim of this study was to assess cognitive performance in younger and older OSAS patients relative to that of controls matched for age and education level.
The neuropsychological tasks were chosen in order to assess the cognitive domains reported to be affected in OSAS patients [40]. We hypothesized a cumulative effect of age and OSAS, resulting in older OSAS patients being more cognitively affected than younger OSAS patients and older controls, and that attention deficits could account for their cognitive impairments.

4.1. No Group-by-Age interaction

Surprisingly, no Group-by-Age interaction was measured. Interestingly, more correlations were observed for younger OSAS patients between neuropsychological, somnolence and hypoxemia variables compared to older OSAS patients. It is possible that the impact of sleep fragmentation was stronger in younger OSAS patients, just as it is the case in young versus elderly healthy individuals [41–44]. In a similar way, younger OSAS patients are possibly more sensitive to the negative effects of nocturnal hypoxemia as it was shown previously in a large sample of men [45]. Another potential reason for finding relationships only in the younger group is that, in older adults, there are more factors (such as various medical, psychosocial, and other age-related factors) in the cognitive equation making the relationship with one factor less likely. Main Group and Age effects were nonetheless obtained.

4.2. Group effects: OSAS patients showed cognitive difficulties related to specific aspects of cognitive function

In our sample of OSAS patients, and in accordance with previous studies [10–13], attention appeared to be particularly affected, and this could interfere with a multitude of other cognitive abilities because attention is involved in all intellectual or behavioural performance [46]. OSAS patients showed a daytime attention decrement illustrated by significantly longer mean reaction times and more lapses (with no difference throughout the day) on the FCRTT relative to controls. However, OSAS patients did not make significantly more errors than the controls on either of these tasks, contrary to what has been reported in the elderly individuals [47].

An attention deficit may contribute to the OSAS-related memory impairments, as supported by the relationship found between lapses on the FCRTT and immediate recall of story B in younger OSAS patients. Our OSAS patients performed as well as the controls for recognition of story A of the Wechsler Memory Scale and for recognition trial of the RAVLT, but not for recognition of story B of the Wechsler Memory Scale. As it was observed in subjects with or without brain damage, fewer items are recalled from story B relative to story A, and this result is not due to proactive interference but rather to the complexity of the story [38]. Additionally, the results for the interpolated list B of the RAVLT do not support either a proactive or retroactive interference effect in OSAS patients, but only in the aging, as expected.

On the other hand, our results show that OSAS patients benefited from a second reading of the same story (story B), demonstrating that OSAS patients are able to learn complex information after a time of familiarization. Moreover, OSAS patients performed as well as the controls on the RAVLT, as illustrated by the number of words recalled from trials 1 through 5 and the learning curve over the five trials (data not presented). Overall, our results are consistent with previous studies, indicating that OSAS patients exhibit attention and verbal long-term memory dysfunctions [6,9]. We are not at this point able to determine whether this decrease in attention resources has an impact on encoding, retrieval or maintenance of information over time. Recently, one study elegantly assessed which memory system and which processes are affected in OSAS patients and demonstrated that OSAS patients exhibit retrieval deficit of episodic memory but intact maintenance, recognition and forgetfulness [15]. Further studies are needed in order to document this issue.

Few studies have measured procedural memory in OSAS patients. In accordance with a previous study [16], our OSAS patients showed some difficulty in the initial acquisition of the procedural skill (slower time to complete trial 1) but no procedural skill-learning deficit over time (performance improved trial after trial). The striatum has been shown to be involved in procedural skill acquisition [48], and this subcortical structure has been reported to be sensitive to recurrent nocturnal hypoxemia [49]. Structural changes might thus be responsible for procedural adaptation decrement in OSAS patients. OSAS cannot, therefore, be viewed as a specific frontal or temporal lobe disorder since the neuronal deficit involves several cortical and subcortical systems [50,51].

In this study, short-term memory (Digit Span forward), working memory (Digit Span backward, Brown–Peterson), planning and flexibility (Trail B and Wisconsin) appeared well preserved in OSAS patients. Even if OSAS patients performed well on some frontal lobe-related tasks, we cannot assume that they are free of frontal lobe deficits. It was shown that subjects with milder OSAS (defined by an AHI or apnea index below 30 and mild hypoxemia level) do not show important cognitive impairments but rather deficits in attention and on psychomotor tasks [9,52]. Most of our patients were not very hypoxemic, and more than a third had an apnea index below 30. This probably contributed to reducing Group effects.

4.3. Age effects

A general slowing (psychomotor slowing and slowed cognitive processing) is usually found with advancing
age [53,54] and could explain, in large part, the cognitive impairments observed in older OSAS patients as well as in elderly controls. Our results are congruent with those in the literature, showing a decrement of performance in various cognitive domains with aging. In fact, more Age effects than Group effects were obtained in the present study, without an interaction between the two factors. Is there a phenomenon of compensation or physiological habituation to sleep fragmentation or to nocturnal hypoxemia with time that prevents a greater interaction between the OSAS condition and age? A compensation phenomenon, termed “cognitive reserve”, has been proposed to explain the discrepancy often observed between the degree of brain pathology and the expression of clinical symptoms or for the absence of age-related differences [55,56]. Neurophysiologically, this compensation mechanism has been reported to take many forms and, in the present case, could be explained by the result of “the use of alternative brain networks in the face of progressing pathology” [56]. The latter mechanism has been documented in OSAS using functional magnetic resonance imaging [50]: for a similar performance on a verbal learning task, OSAS patients showed increased brain activation in several brain regions compared with controls. More studies are needed to properly address these questions in OSAS patients.

4.4. Relationship between attention, respiratory variables and sleep variables

Alterations in attention were correlated with both sleep fragmentation and nocturnal hypoxemia in OSAS patients. Because these are concomitant events, it is probably more appropriate to consider their compounded effect on cognitive functions rather than try to separate their respective influence [3]. Tasks requiring sustained attention (time-on task, response speed, and number of lapses) are sensitive to sleep loss [54], to sleep fragmentation [7,8] and to nocturnal hypoxemia [6,7,12]. In our study, the FCRTT appears to be a good predictor of attentional capacities in OSAS patients.

5. Conclusion

OSAS patients demonstrated a decrease in attention capacities, which can probably account for their long-term and procedural memory difficulties. The present study is the first one to directly assess the effect of aging on OSAS. This study shows that OSAS negatively affected attentional and long-term memory capacities but did not demonstrate that age interacts with the effects of the OSAS condition to worsen cognitive deficits. Overall, performance on most tasks deteriorated with advancing age in both controls and OSAS patients. However, we cannot completely exclude that age may have a cumulative effect on cognition in older OSAS patients. The lack of interaction might be explained by the fact that we obtained few or weak Group effects due to the presence of patients with mild OSAS in both age subgroups. Finally, in light of this last point, the present study was possibly underpowered to detect those unexpectedly subtle effects.

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