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Steady Car Engine Noise Does Not Affect the Cognitive Abilities of Sleep Apnea Syndrome Patients

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Traffic accidents are more frequent for sleep apnea syndrome (SAS) patients than in the population at large. The mechanisms that underlie this observation are poorly defined. Our working hypothesis was that in SAS patients the steady noise of a car engine might alter cognitive capacities that may be involved in driving, thus increasing the risk of traffic accidents.

To test this hypothesis we designed a prospective randomized controlled trial. Eighteen SAS patients (apnea-hypopnea index [SEM] 62 [6] h^{-1}) and 18 healthy controls were studied. All the participants were evaluated in random order both in basal conditions and after exposure to the steady noise of a car engine recorded on a compact disc. Their level of vigilance was evaluated (Steer-Clear®) as well as their reaction time (PVT 192®). Attention, coordination, and memory were measured using the following tests: Wechsler Memory Scale (digit span), the Wechsler Intelligence Scale (digit symbol), and Lezack's Trail Making tests A and B. The SAS patients were slightly younger than the control group (mean 50 [7] vs 57 [11] years, respectively; *P*=.05). The patients showed a lower level of vigilance than the controls both in basal and engine noise conditions (*P*<.05). No differences between groups were found for the other variables studied. Exposure to steady car engine noise had no effect on the tests of either group. In conclusion, the results of our study do not support the hypothesis that steady car engine noise significantly alters the cognitive ability of SAS patients.

Key words: *Coordination. Daytime sleepiness. Reaction time. Vigilance.*

El ruido monótono no afecta a las capacidades cognitivas en pacientes con síndrome de apnea del sueño

Los accidentes de tráfico son más frecuentes en pacientes con síndrome de apnea del sueño (SAS) que en la población general. Los mecanismos que subyacen a esta observación están poco definidos. Nuestra hipótesis de trabajo fue que en pacientes con SAS el ruido monótono generado por el motor de un coche puede alterar las capacidades cognitivas potencialmente relacionados con la conducción y, de esta forma, incrementar el riesgo de padecer accidentes de tráfico.

Para probar esta hipótesis se diseñó un trabajo prospectivo, aleatorio y controlado. Se incluyó a 18 pacientes con SAS (índice de apnea-hipopnea 62 ± 6 h^{-1}) y 18 controles sanos. Todos los participantes fueron evaluados (de forma aleatoria) en condiciones basales y estando sometidos al ruido del motor de un coche que había sido previamente grabado en un disco compacto. Se evaluaron el nivel de vigilancia (Steer-Clear®) y el tiempo de reacción (PVT 192®). La atención, coordinación y memoria se exploraron mediante los siguientes tests: dígitos directos e inversos de la escala de memoria de Wechsler, clave de números de la escala de inteligencia de Wechsler y el *trailmaking* tests A y B de Lezack.

Los pacientes fueron ligeramente más jóvenes que los controles (50 ± 7 frente a 57 ± 11 años; p = 0,05). Comparados con los controles, los pacientes mostraron un nivel de vigilancia inferior tanto en situación basal como con ruido (p < 0,05). El resto de las variables estudiadas no fueron diferentes entre los grupos. La exposición a un ruido monótono no modificó los tests realizados en ningún grupo.

En conclusión, los resultados de nuestro estudio no apoyan la hipótesis de que el ruido monótono generado por el motor de un coche altere de forma significativa la capacidad cognitiva en pacientes con SAS.

Palabras clave: *Coordinación. Somnolencia diurna. Tiempo de reacción. Vigilancia.*

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Introduction

Traffic accidents are more frequent for sleep apnea syndrome (SAS) patients than in the population at large.[1-4] The mechanisms that underlie this observation are poorly defined. SAS patients present excessive daytime sleepiness and impaired cognitive abilities.[5-9]

Previous studies have concluded that these alterations could explain, in part, the high prevalence of traffic accidents in SAS patients. Nevertheless, such studies have failed to demonstrate that the level of daytime sleepiness (measured on the Epworth scale)[1,2,10] or the results of cognitive tests evaluating vigilance, reaction time, memory, or coordination are associated with a greater risk of traffic accidents.[2]

Car travel frequently induces sleep in healthy subjects. In fact it has been demonstrated that steady noise induces sleep[11,12] and worsens the results of healthy subjects on cognitive tests.[13-16] Based on these observations our working hypothesis was that the steady noise of a car engine could worsen the results of cognitive tests to a greater extent in SAS patients than in normal subjects and would therefore help to explain the increase in traffic accidents in the former. To test this hypothesis we designed a prospective randomized controlled trial to evaluate the effect of the steady noise of a car engine on cognitive variables potentially related to the driving ability of SAS patients.

Material and Methods

Design of Study

In this prospective randomized controlled trial we ran several cognitive tests in silence and in the presence of steady noise. The steady noise, previously recorded on a compact disc, was that of a car engine operating at constant highway speed. The order in which the tests were run (with or without noise) was randomized. The study was approved by the ethics committee of our hospital. After instruction regarding the nature and aims of the study, all participants (patients and healthy control subjects) gave their informed consent.

The sample size was based on the results of previous research carried out in our laboratory demonstrating that SAS patients presented alterations on several cognitive tests.[2] The principle variable was reaction time. We estimated that the worsening of reaction time caused by noise would be 50% greater in the patients than in the control group. An α error of .05 and a β error of .01 were accepted. With these premises we calculated that 18 subjects in each group would be required.

Population

Eighteen male SAS patients treated in the sleep unit of our hospital and 18 healthy control subjects matched for age were studied prospectively. SAS was defined as the presence of daytime sleepiness associated with disordered breathing during sleep. All the SAS patients *a)* had an apnea-hypopnea index greater than 20 per hour of sleep, obtained by standard polysomnographic testing (Ultrasom Nicolette, Madison, WI, USA); *b)* had a valid driving license; *c)* were 65 years of age or older, and *d)* had given informed consent. The exclusion criteria were the following: psychiatric disorders, drug dependency, diagnosed epilepsy, narcolepsy, restless legs syndrome, ingestion of psychotropic drugs within 15 days before the tests, rotating work shifts, hypacusis, and/or fewer than eight years of schooling. This last requirement was to ensure that the subjects be able to take the cognitive tests. The control subjects (all male) were recruited from nonmedical personnel or visitors to our hospital and were subject to the same inclusion and exclusion criteria as the patients, except regarding the presence of SAS. Patients' family members were also excluded. SAS was ruled out in the healthy controls following the criteria of Kapunai et el.[17] None of the controls habitually snored or suffered daytime sleepiness.

Cognitive Testing

All the participants were tested at the same time of day (9:00 AM). The level of vigilance, reaction time, attention, coordination, and memory were determined with noise and without it (basal condition). The level of vigilance was evaluated using the Steer-Clear® test[18] (Healthdyne Technologies, Marietta, GA, USA). In this 30-minute test the subject sits at a computer and by hitting the space bar on the keyboard tries to avoid colliding with obstacles that appear randomly on a virtual, moving road on the monitor screen. Reaction time was evaluated using the Psychological Vigilance Test (PVT 192® , Department of Psychiatry, University of Pennsylvania, USA). This 10-minute test quantifies to the millisecond the time taken to respond to visual stimuli.[19] Attention and immediate recall were evaluated using the Digit Span subtests (forward and reverse number recall) of the Wechsler Memory Scale (WMS)[20] (Psychometric Software, Melbourne, FL, USA). The forward number recall test requires the subject to listen to 7 series of numbers and then try to repeat the series in the same order. The first series is composed of 3 digits, in the following series the number of digits progressively increases. In the reverse number recall test the subject tries to repeat the numbers in reverse order. Visuomotor coordination and attention were evaluated using the Digit Symbol-Coding subtest of the Wechsler Adults Intelligence Scale (WAIS)[20] (Psychometric Software, Melbourne, FL, USA). In this test the subject studies a chart with a series of 9 digits at the top (1 to 9) each of which has a corresponding symbol. Then the subject is shown a series of digits and must try to put the corresponding symbol to as many digits as possible in 90 seconds. Attention and information processing were evaluated using Lezak's Trail Making Test (part of the Halstead-Reitan Battery, Psychological Assessment Resources, Lutz, FL, USA). This test is composed of two parts. In the first part (A) the subject is shown a randomly ordered group of numbers from 1 to 25 and must reorder them to make a sequence from lowest to highest. In the second part (B) the subject is shown a randomly ordered group of numbers from 1 to 13 and a randomly ordered group of letters from A to L. The subject must reorder the numbers to form a sequence from lowest to highest, each number with its corresponding letter in alphabetical order. In both parts the time required to complete the task is recorded.[21]

Statistical Analysis

Results are shown as means (SEM). The statistical significance of the differences between patients and control subjects (both with and without steady car engine noise) was calculated using Student *t* tests for independent samples. The effect of noise on each group was calculated using the Student *t* test for paired samples. To calculate the effect of noise on patients and on controls, the mean of the differences (with and without steady noise) was compared for each variable using the Student *t* test for unpaired variables. A value of $P<.05$ was considered significant.

TABLE 1
Results for the Cognitive Variables Evaluated in Basal Condition (With No Noise Added) and During Exposure to Steady Car Engine Noise*†

	Patients			Controls		
	Basal	Noise	Pre-post	Basal	Noise	Pre-post
Steer-Clear®, % collisions	2.8(1.2)	2.5(1.3)	–0.3(0.5)	0.5(0.1)‡	0.8(0.3)‡	0.3(0.2)
Reaction time, milliseconds	290(15)	312(37)	22(33)	286(10)	305(18)	19(14)
Number recall	9.1(0.5)	9.6(0.5)	0.6(0.2)	8.8(0.5)	9.4(0.5)	0.6(0.4)
TMTA, seconds	58(5)	54(5)	–5(4)	53(4)	53(3)	–0.4(3)
TMTB, seconds	122(11)	152(18)	28(11)	118(13)	127(11)	9(9)
Digit Symbol-Coding	33(3)	32(4)	–2(2)	39(3)	38(3)	–1(2)

*TMTA indicates Trail Making Test A; TMTB, Trail Making Test B.
†Results are expressed as means with SEM between parentheses.
‡P<.05 between groups in the same experimental conditions.

Results

The patients were slightly younger than the controls (50[7] vs 57[11] years, respectively; P=.05) and, as anticipated, more obese (34[1] vs 26[1] kg/m^2, P<.001). The apnea-hypopnea index ranged from 29 to 105 h^{-1}, with a mean value of 62(6) h^{-1}.

Table 1 shows the results for all variables evaluated in the study.

Only the Steer-Clear® results were different for patients and controls in both conditions: with no car engine noise (basal) and with noise. Noise did not alter the results of either group in any of the tests used. Nor were there differences between groups regarding mean change (from basal to noise) of the variables evaluated (Table 1).

Discussion

The results of this prospective randomized controlled trial did not support our working hypothesis that the steady noise of a car engine may impair cognitive ability more in SAS patients than in healthy individuals.

SAS is associated with neuropsychological alterations such as daytime sleepiness and impaired attention, memory, or coordination.[5-9] In theory these alterations may increase the risk of having a traffic accident. In fact, studies have demonstrated that the prevalence of traffic accidents among SAS subjects is greater than normal.[1-4] Nevertheless, previous studies in our hospital were not able to identify any relation between the degree of daytime sleepiness or cognitive performance on several tests, including some used in this study, and the risk of traffic accidents.[2] In order to investigate these apparently contradictory observations, we proposed a new working hypothesis: the noise generated by the engine of a moving car may magnify the cognitive alterations of SAS patients and therefore increase the risk of traffic accidents. This hypothesis was based on the fact that steady noise induces sleep in normal subjects[11,12] and impairs their cognitive abilities.[13-16] The results of the present study have not supported this hypothesis. This may be due to the following factors:

1. The design of the study was inappropriate. The fact that noise did not impair the cognitive abilities in either group studied points in this direction. The studies we reviewed that show a relation between steady noise and cognitive performance used louder noise than was used in our study. We used the noise generated by a car engine, which is less intense.

2. Factors other than acoustic ones occur while a person is driving and may affect cognitive performance. One of the most obvious is the vibration of the car. Future experiments that include these additional factors (perhaps with louder noise) may demonstrate more precisely the relation between traffic accidents and SAS.

3. The tests used were insufficiently sensitive to slight differences in absolute value. This possibility can not be ruled out as some of the tests used seemed to show a tendency toward poorer performance during exposure to steady noise (reaction time, determined by Trail Making Test B) (Table 1).

4. There was a ceiling effect in the evaluation of some of the variables.

In the present study only the results of the Steer-Clear® test were different for the two groups, both in the presence and absence of steady noise. The Steer-Clear® test primarily evaluates vigilance, which is known to be impaired in SAS patients.[2,18] However noise had no effect on the tests of either group, which underscores the importance of considering the four factors mentioned above.

In summary, the results of our study do not support the hypothesis that the steady noise of a car engine significantly impairs the cognitive abilities of SAS patients. Investigation into the comparatively greater number of traffic accidents experienced by SAS patients requires future studies in which real driving conditions are simulated more accurately by including other variables.

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