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# Contribución Original

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## Effect of the volatile coffee components on memory in sleep deprived students

Efecto de los componentes volátiles del café sobre la memoria en universitarios privados de sueño


# Abstract

**Introduction:** The volatile coffee components may have positive effects on memory, as proved with coffee intake.

**Objective:** To describe the effect of volatile coffee components on short and long term memory after sleep deprivation.

**Methods:** In all, 38 college students (66% female with mean age 20 ± 2 years), divided into two treatment groups (Tx1 = 12 subjects without sleep deprivation to measure short-term memory, Tx2 = 13 subjects with sleep deprivation to measure long-term memory) and a control group (n = 13). Three subtests of the NEUROPSI battery; attention and memory were used.

**Results:** In the word list recall test, the second (p = 0.044) and third trial (p = 0.044) showed differences in which Tx1 group (second trial M =12.91 ± 1.5, third trial M = 13.83± 1.1) recalled more words than the control group (second trial M=11.76 ± 1.5, third trial M =12.53 ± 1.5), likewise, they showed a higher score (p = 0.023) in the Rey-Osterrieth figure test (Tx1 = 31.27 ± 3.52 vs Control =26.61 ± 5.6). No differences were found in long-term memory.

**Conclusions:** The volatile components of coffee improve verbal and visuospatial short-term memory, but not long-term memory after sleep deprivation.



## Keywords

*Coffee, components oolatile, short-term memory, sleep deprivation.*

# Resumen

**Introducción:** Los componentes volátiles del café, pueden tener los mismos efectos positivos sobre la memoria, como se ha demostrado con su ingesta.

**Objetivo:** Conocer los efectos de los componentes volátiles del café que se desprenden durante su tostado sobre la memoria de corto y largo plazo posterior a la privación de sueño.

**Métodos:** 38 estudiantes universitarios (66% mujeres, con edad promedio de 20 ± 2 años), divididos en dos grupos de tratamiento (Tx1 = 12 sin privación de sueño para medir la memoria a corto plazo, Tx2 = 13 con privación de sueño para medir la memoria a largo plazo) y un grupo control (n = 13). Se emplearon tres pruebas de la batería NEUROPSI atención y memoria.

**Resultados:** En la prueba de lista de palabras, se encontraron diferencias en el segundo (p = 0.044) y tercer ensayo (p = 0.044), en los cuales el grupo Tx1(segundo ensayo M=12.91 ±1.5, tercer ensayo M=13.83 ±1.1) recordó el mayor número de palabras que el control (segundo ensayo M=11.76 ±1.5 , tercer ensayo M= 12.53 ±1.5) asimismo, obtuvo la mayor puntuación (p = 0.023) en la prueba de la Figura de Rey-Osterreith (Tx1 = 31.27 ±3.52, control = 26.61 ±5.6). No se encontraron diferencias en la memoria a largo plazo.

**Conclusiones:** Los resultados sugieren que los componentes volátiles de café mejoran la memoria verbal y visoespacial a corto plazo, pero no la memoria a largo plazo posterior a la privación de sueño.

## Palabras clave

*Café, componentes volátiles, memoria de corto plazo, privación de sueño.*

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# Introduction

Coffee is one of the stimulant substances of highest consumption around the world[1,2] not only because of its pleasant flavor and aroma, but also for its physiological effects on health. The mechanism that explains the relationship between the coffee intake and its positive effects on memory in humans includes various hypotheses. Some of these propose that an acute intake of coffee increases energy levels[3] and general cortical arousal[4,5] it is also suggested, that it is particularly the caffeine the substance that increases the metabolism of brain areas related to working memory.[6-8]

The active components of coffee are potentially bioavailable[9], when they get release as volatile oils (29% of caffeine and other antioxidant)[10] in the smoke that emerges from the coffee beans during roasting. Exposure to these components may have effects similar to those caused by the administration of caffeine reported in studies with sleep deprived animals, in whom it was observed a relaxing effect, lowering stress levels in the execution of tests.[11]

One way to offset the damage caused by sleep deprivation is through coffee intake. Some studies show that it decreases the cognitive deterioration, proper of neurological aging.[12,13]

The same line, when exposing subjects to the aroma of roasted coffee, it is observed change in the alpha brain waves[14,15] and the expression of genes such as the NGFR, trkC, GIR, the thiol-specific antioxidant protein and the heat shock 70 kDa protein 5, that have shown an important role in antioxidant and anti-stress functions.[16] These studies suggest that the properties of the volatile compounds of roasted coffee could have positive effects on the human brain. For the relaxing effects, the release of trophic factors or the cortical activation associated with memory, this study proposes that the volatile components that emerge during the roasting of coffee have a positive effect on verbal and spatial short-term memory and on long-term memory after sleep deprivation.

# Materials and methods

## Subjects

Participants were 38 students from a public University, 13 men and 25 women, with an average age of 20 (2) years old, in a range of 17 to 27 years. The inclusion criteria were: not to drink more than two cups of coffee a week and sleep an average of 7 hours (± 30 min) of nocturnal sleep. Exclusion criteria were: not consuming any type of psychoactive substance and not having a report of psychiatric or neurological diagnosis. Participants were divided into two treatment groups and one control group *(Figure 1).* The first group Tx1 (n = 12) was exposed to the volatile compounds of roasted coffee during short-term memory tests, previous to sleep deprivation. The second group Tx2 (n = 13) was exposed to the volatile compounds of roasted coffee during the long term memory tests after 24 hours of sleep deprivation. The third group was formed by the control group (n = 13).

## Materials and procedure.

The scores in the Verbal Learning Test of Spain Complutense[17] were used to establish the baseline of memory between the groups. To measure short and long term memory, three tests of the neuropsychological battery NEUROPSI attention and memory[18] were used, which are described below:

a. Short-term memory tests:
   1. Word list recall: a list of 15 words are read aloud by the applicator. As soon as the reading is over, the subjects are prompted to write the words they remember at that moment. This test consists of three trials. The total score is calculated by obtaining the average of correct answers in the three

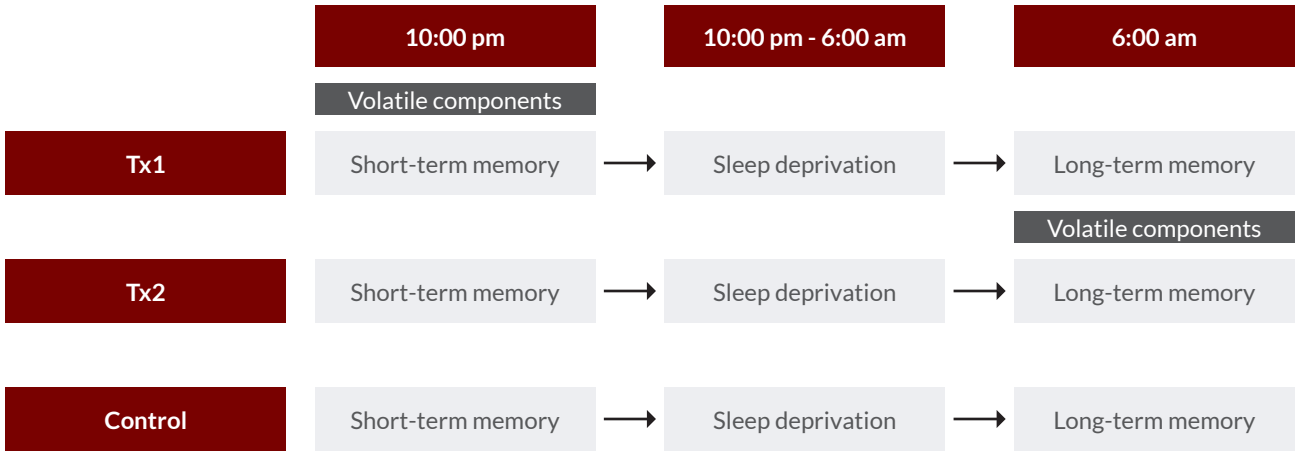


*Figure 1. Tests Application procedure. Note: "Tx1", Treatment group one: subjects were exposed to volatile compounds from roasted coffee during the short-term memory tests, prior to sleep deprivation "Tx2", Treatment Group two: subjects were exposed to volatile compounds from roasted coffee during long-term memory tests, after sleep deprivation, "Control group", Group without exposure to volatile compounds from roasted coffee.*

trials.

2. Encoding of names: through the use of slides, 5 photographs of people are presented to the subjects while mentioning their names, at the end, subjects are asked to write down the names that they can remember.
3. Rey-Osterrieth: Consists of a figure of 18 lines. The rating is based on criteria such as shape, size, and location.

b. Long-term memory tests

1. They were the same tests mentioned above, but only measuring the long-term memory after a night of sleep deprivation.

Each group was evaluated on different days. Short-term memory tests were applied in the night and lasted 15 minutes approximately. Then continued with sleep deprivation. Long-term memory tests were applied the following morning and lasted 10 minutes. The same procedure was used for the three groups. The Tx1 group was exposed to the volatile coffee components while being roasted at the same time the short-term memory tests were applied. The Tx2 group was exposed to the volatile components of coffee during the execution of long-term memory tests. The control group did not receive any treatment. Tests were applied in an 8m wide by 7m long classroom. The amount of the coffee beans used was 200 g, which were roasted at a temperature of 175°C for 20 min, then they were removed and changed for other grains at the same temperature for 15 min, until the aroma permeated throughout the classroom. Participants entered the room at the beginning of the second roast. For the results analysis, a one-way ANOVA statistical test was used for comparison between groups.

# Results

Comparison between groups of short term memory
In the word list recall test for the verbal memory test, significant differences were found in the second and third trial. In this sense, the Tx1 Group recalled on average a greater number of words compared to the control group and the Tx2 Group *(Figure 2).* Also in *Figure 2*, it is observed that as the number of trials increases, the number of words recalled in short-term memory tasks also increases.

In the visuospatial memory test, through the King-Osterrieth figure test, significant differences were found, in which the Tx1 Group obtained a high score compared to other groups *(Figure 3).* As for the encoding names test, there were not significant differences between the groups ($p > 0.05$).

Comparison between groups of long-term memory.
In the world list recall test for the long-term

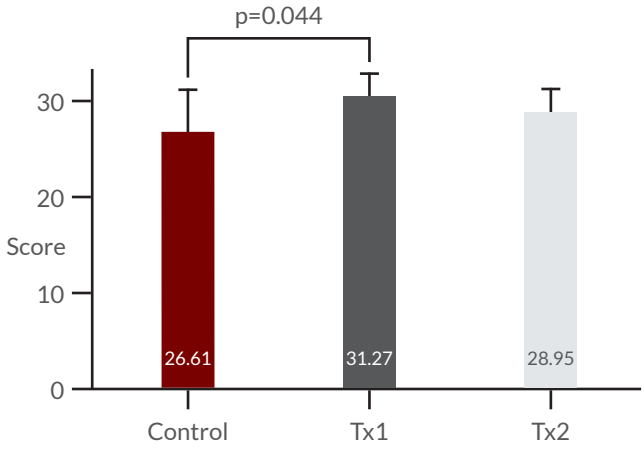


*Figure 3. Difference between groups in the Rey-Osterrieth figure test for short-term memory.*

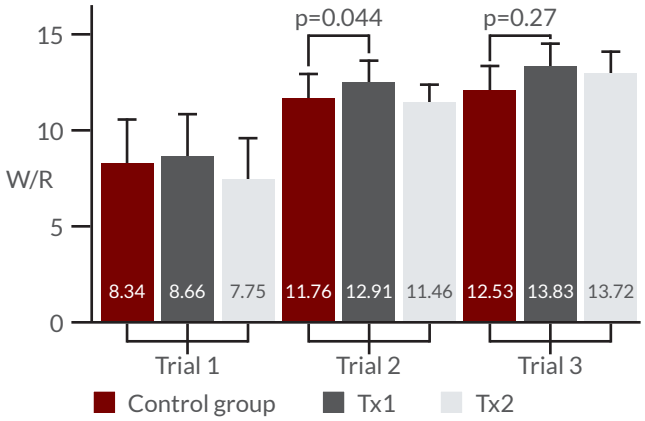


*Figure 2. Difference between groups in the word list test for long term memory.*

memory test after sleep deprivation, no significant differences were found (p =0.42), between Tx1, Tx2, and control groups (M = 12. 16± 2.16, Tx2 M = 11.46 ±2. 19, M = 10.91 ± 2.39 respectively). Similarly, no significant differences were found in the encoding of names test (p = 0.98: Tx1 = 4. 25± 2.30, Tx2 = 4.15 ± 2.44 and control = 4.30 ±2. 28), and neither in the King-Osterrieth figure test (p = 0.59: Tx1 = 13 37± 3.43, Tx2 = 15.30 ± 2.44 and control = 14.23 ±3. 62).

# Discussion

The volatile components that emerge during coffee beans roasting, include a variety of antioxidants as well as one third of the caffeine contained in coffee beans.[10] Exposure to these components seems to have positive effects on cognitive processes relatively equivalent to the results obtained previously in animals stressed by sleep deprivation, in whom a relaxing effect was found.[16] However the results obtained in this study indicates that this effect is only related to the short term memory and not to the long term memory. In this matter, our results suggest that cortical structures that regulate the short-term memory, like the frontal areas of the cerebral cortex, are more sensitive to the effects of volatile components of coffee than the structures that regulate the long term memory, like the hippocampus.

Previous studies have shown that acute coffee consumption increases energy and cortical arousal levels[4] as well as the metabolic level of frontal cortical areas associated with working memory.[5] While regular and moderate intake of coffee has shown to improve long-term memory and reduce the deterioration of the hippocampus activity[8] by increasing its dendritic pyramidal branches.[7] Correspondingly, exposure to volatile components seems to have similar effects to the acute consumption of coffee but not to their usual intake. A possible explanation might be the difference in the metabolic mechanisms, between the exposure to the volatile components of coffee during roasting and the metabolic process that continues through its intake.

Further studies could contemplate the measurement of mediating variables, such as the electrophysiological variables to measure the effects of relaxation, the influence of neurotrophic factors or the proteins expression like the NGFR, which is related with growth and neural communication [16], to explain the mechanisms of association between the volatile components of coffee and the neurocognitive human processes.

# Conclusions

The verbal and visuospatial short-term memory, both improve with the exposure to volatile components emerging during coffee grains roasting, however no improvement is observed in long-term memory after sleep deprivation.

This study suggest that the properties of the volatile compounds of roasted coffee could have positive effects on the human brain.

**Relevant conflicts of interest**
The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

**Financial disclosures**
Didn't exist financial sources for the realization of this scientific study.

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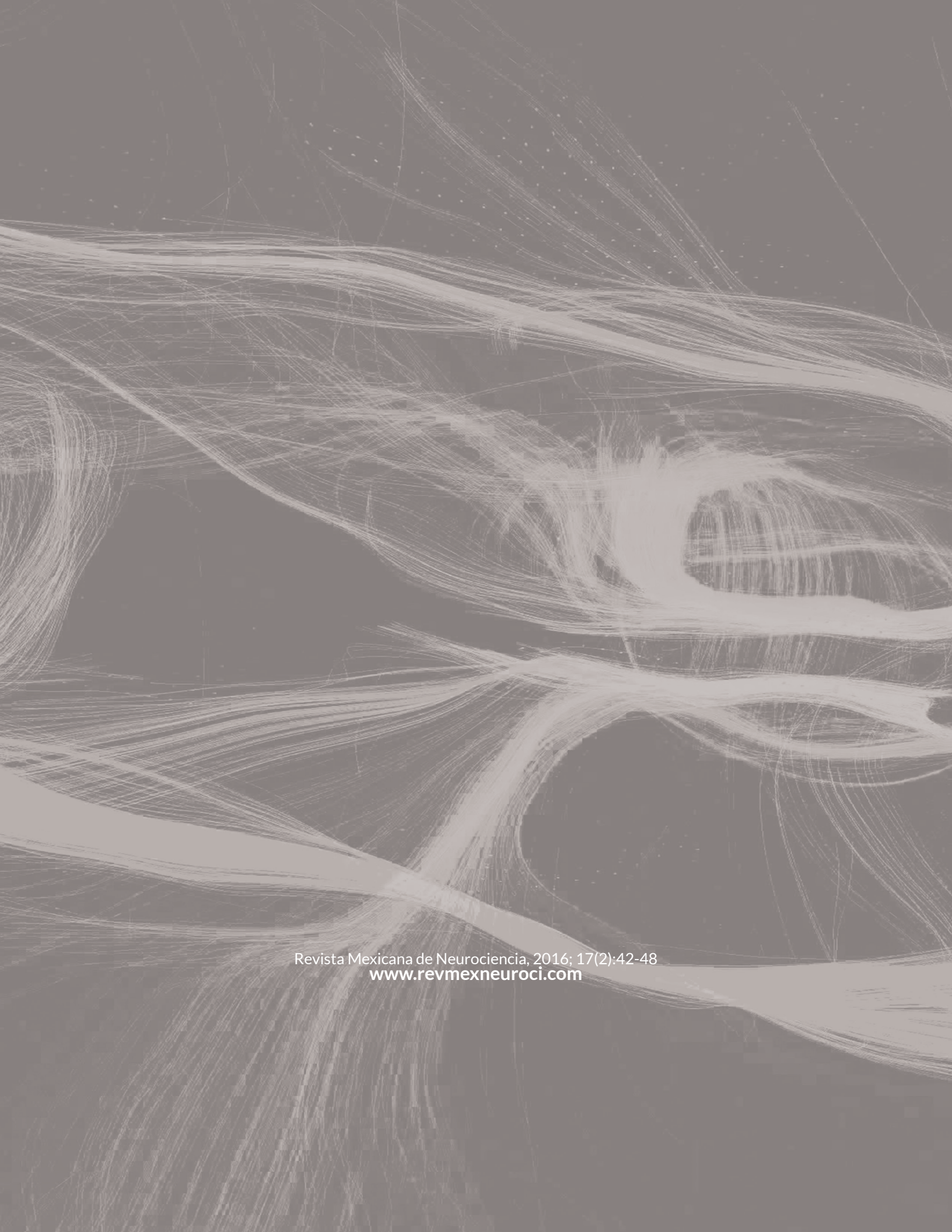
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