UNIVERSIDAD COMPLUTENSE
MADRID

RESEARCH PROJECT THE EFFECTIVENESS OF PRANAN DEVICES IN NEUTRALIZING THE HARMFUL EFFECTS OF ELECTROMAGNETIC FIELDS ON THE BRAIN BIOELECTRICAL ACTIVITY

Effect of external inhibition (using Phiwaves and Phione devices) in electromagnetic exposures to radio frequencies emitted by mobile phones on the EEG brain bioelectrical activity

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PRANAN TECHNOLOGIES

Effect of external inhibition in electromagnetic exposures to radio frequencies emitted by mobile phones on the EEG brain bioelectrical activity

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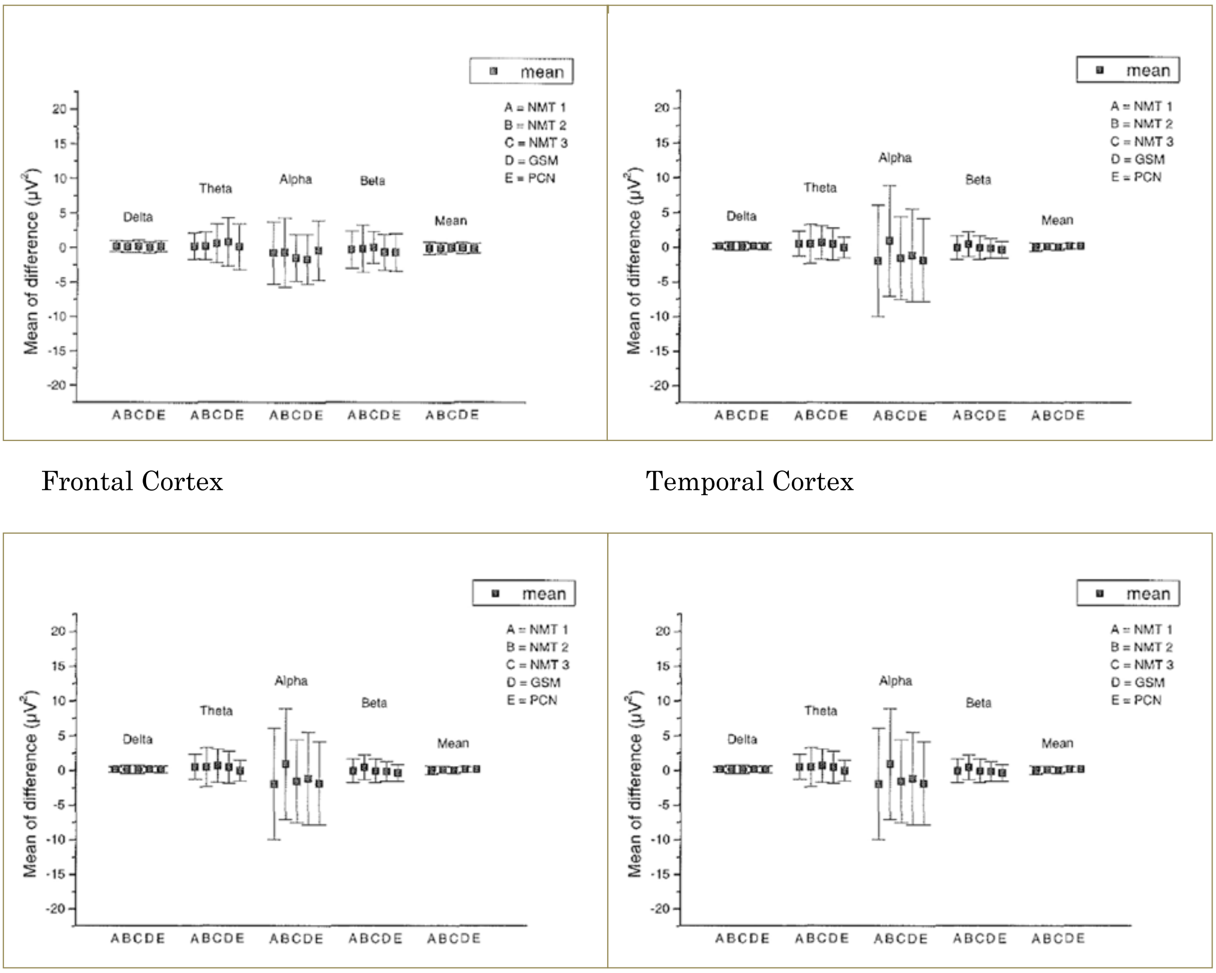
INTRODUCTION

The use of mobile phones is an implanted custom throughout our modern society which involves a great daily time of use. There is great concern among people on the influence the daily and continued exposure to such radio frequencies emitted by these devices may have on the brain. However various studies have considered that the power emitted by radio frequency of mobile phones is so low that it does not affect biological systems (1-3) (Anderson et al, 1995, Balzano et al, 1978, Spiegel 1982), other studies however, conducted with both animals and humans, demonstrate the importance of electromagnetic exposure to low frequencies (50-60 Hz) in the EEG activity (4-6) (Bell et al, 1992, Lyskov et al, 1993.)

Numerous research works conducted by EEG in the waking state have found certain brain oscillations changes depending on their use in different frequency bands. Different authors conclude that brief exposures to low electromagnetic radio frequencies do not cause any changes in the brain oscillations (7-9) however others consider that may cause changes in the brain electrical activity, primarily in the alpha frequency band (8-13 Hz) on the back areas of the brain (10-11) (Cook, Saucier, Thomas, Prato, 2006 and Curcio et al 2003). Reiser (12) (1995) furthermore found changes in EEG signals in exposures to radiation of 900 MHz. However Roschke and Mann (13) (1996) found no changes within the same frequency, but Hietanen and colleagues (14) (2000), who found EEG differences within different frequencies of electromagnetic radiation found no such differences with the different cell phones they used (between 900 and 1800 MHz). Others believe that, although there are modifications within certain frequencies, such changes cannot be associated with abnormal EEG patterns (14) Hietanen et al, (2000). Notwithstanding the above, in this same study it was found an increase in delta band of all mobile phones during exposure to 900 MHz radiofrequency (Figure, 1) (14) Hietanen et al, (2000).



Frontal Cortex

Temporal Cortex

Parietal Cortex

Occipital Cortex

Figure 1.- Average differences in absolute energy of the different bands during exposure to different mobile phone types (analog and digital) at frequencies of 900 MHz (A, B, C, D) and 1800 MHz (E). The significant differences occurred in the delta band total energy in NMT mobile phones. (Hietanen et al, 2000).

As the different forms of presentation of electromagnetic waves, Huber (15) (2002) found changes in the alpha range during exposure to modulated pulses but not in continuous wave exposure. Croft (16) (2002) found that exposure to electromagnetic fields decreased activity of the delta band (1-4 Hz) on the right hemisphere areas while alpha band (8-12 Hz) increase was found later on the central areas. Kramarenko (17) (2003) used an EEG telemetry, and he found that during exposure of 20-40 seconds to 900 MHz, subjects receiving telephone signals showed increased delta wave activity on the frontotemporal contralateral areas. Hinrikus (18) (2007) found an increase in the rate of alpha and beta bands in subjects exposed to electromagnetic fields of 450 MHz

In a study carried out by exposure to mobile phone radio frencuency, analyzing all bands energy (1-32 Hz), it was found an increased number of subjects in whom that same energy decreased on both frontal and occipital areas, although with a higher degree of decrease on posterior areas (occipital cortex) and especially in alpha and beta bands (Figure 2) (19) D'Costa et al, 2003.

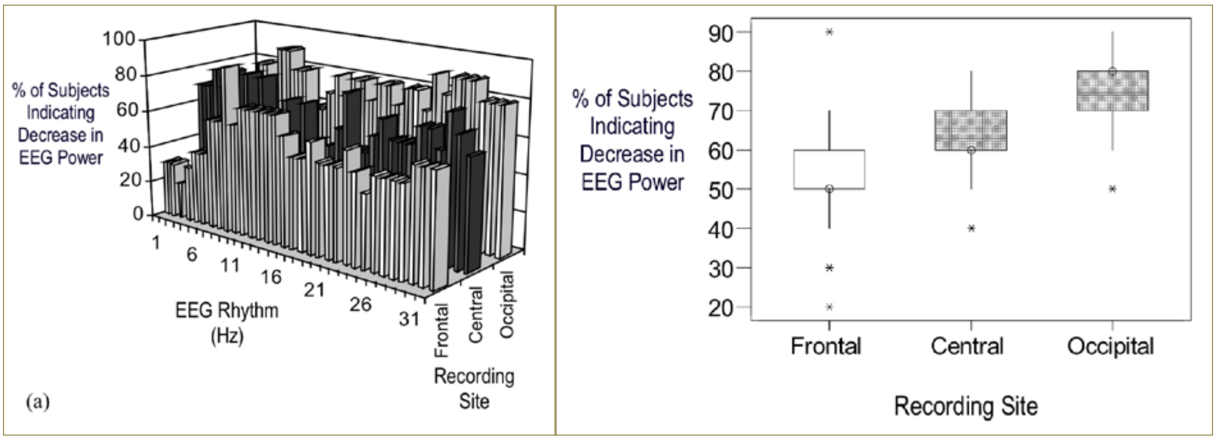


Figure 2.- a)Average of the difference between radio frequency exposure and non-exposure of each subject in each one of the bands (1-32 Hz) and b) percentage of subjects who showed a EEG rhythms decrease on the frontal, central and occipital areas. (D'Costa et al, 2003).

A study conducted by synchronization / desynchronization at temporal level, between 200-400 milliseconds showed existence of delta band increase while among 600-800 milliseconds a decrease occurred in alpha band (Figure 3) (20) Krause et al 2000).

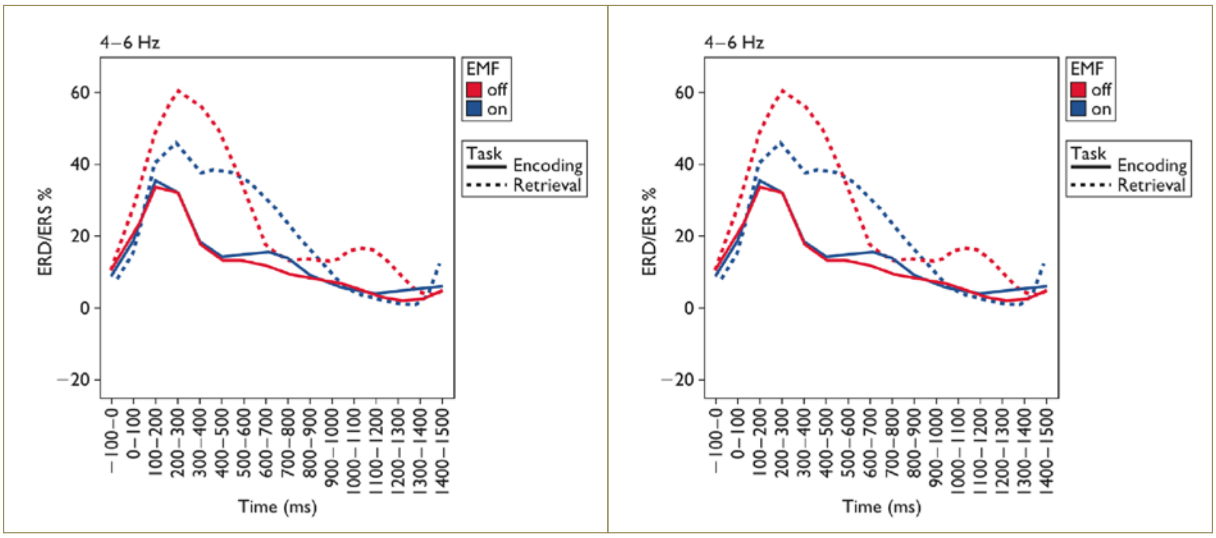


Figure.3 Average ERD/ERS values for frequency bands between 4 ± 6Hz and 10 ± 8 Hz depending on time and electromagnetic emission (on and off) (Kaurse et al, 2000)

Furthermore, studies conducted with various cognitive tasks, have also found significant differences during exposure to electromagnetic fields. Freude, Eulitz and colleagues (21,22) (1998a, b, 2000) reported some modulation of the EEG during the realization of some tasks, but their results are not consistent. Krause (19) reported EEG changes in healthy volunteers exposed to an electromagnetic field in the alpha band of 902 MHz and especially during a memory task, and in a second work, they obtained similar results in subjects performing a visual memory task. However, they were unable reproduce the results in a later study (23 Krause, 2004). Jech (24) (2001) found changes in response to visual tasks. Papageorgiou (25) (2004) found that the energy in the EEG basal line was higher in men, while exposure to certain electromagnetic frequencies decreased the EEG energy in men and increased it in women. Furthermore, in a small pilot study, Krause (26) (2006) studied the effect of the mobile phone electromagnetic fields in the EEG signals in 15 children performing an auditory memory task. The authors found that mobile phone signal affected the responses at frequencies of 4.8 Hz.

In connection with evoked potentials Hamblin et al (27) (2004) found a decrease in the amplitude and latency of a sensory component (N100) and a decrease in latency in a post cognitive component (P300) during active electromagnetic exposure while an auditory task was performed. However, the same authors, in a later study found no evidence that acute exposure to a cell phone during auditory and visual tasks affected brain activity (Hamblin et al (28) (2006)). Papageorgiou et al (29) (2006) found an increase in the amplitude of P50 component caused by low frequency stimuli and a decrease caused by high frequency stimuli.

In studies carried out during cognitive activities, especially memory, Hinrichs and Heinze (30) (2004) found that exposure to a radio frequency electromagnetic field did not affect memory retrieval tasks, although event related magnetic fields were affected. Maby et al (31) (2006) found that, when subjects were exposed to electromagnetic fields generated by a mobile phone, while receiving an auditory stimulus, an increase in the amplitude of the P200 wave in the frontal area was produced.

Several studies demonstrate the impact of mobile phones in different brain rhythms, in this sense different authors (32-34) Vecchio et al, 2007, 2010, 2012 found a lower decrease, widely distributed in the brain alpha band, and a faster motor response to different stimuli after exposure to mobile phone during to a period of 45 minutes, which, according to these authors, can contribute to a significant improvement of brain neuronal efficiency. Moreover, they found significant differences depending on the subjects` age, they in fact found that in the elderly the interhemispheric coherence frontoemporal level of the alpha band increased much more than in young people after exposure to mobile phone frequency.

The results are widely varied and there is no unanimous agreement in the assessment of the incidence of exposure to mobile phones radio frequency electromagnetic field in modifying brain oscillations, although the existence of such modification in the different bands analyzed has been proved. Recently Marino and Carrubba (35), in a study by meta-analysis conducted on 55 works related to the incidence of radiofrequency electromagnetic fields generated by mobile phones in different brain rhythms or the effect of cognitive processing of visual and auditory stimuli in brain evoked potentials, of which 37 were in favor and 18 against the induced effects by radiofrequencies emissions from mobile phones, conclude that works posing positive effects did not considered “family-wise error rate”, the presence of “spike artifacts” in the EEG, or confused the role of different electromagnetic fields emitted by mobile phones. Among the works against, methodological data are found not to have been taken into account as controls or capacity of the analysis conducted. All works mistakenly assume that the brain maintains a balance between inter and intra brain areas, it also seems unlikely the reproduction of electromagnetic emissions from mobile phones in brain activity among other things, which leads these authors to conclude that the scientific question about the pathophysiology of incidence of electromagnetic fields emitted by mobile phones in relation to measures of cerebral electrical activity is still in question.

OBJECT

The purpose of this work is to assess the effectiveness of the technology patented by Pranan Technologies for isolation in external electromagnetic fields on EEG brain rhythms during rest state and during a cognitive activity carried out using mobile phones.

MEANS AND PROCEDURE

Subjects

A pilot study was conducted with twenty young subjects aged 25 - 45, with university studies and without any health condition that could affect the central nervous system. The main study was conducted with 20 subjects aged between 20 and 38 with an average age of 32.8 years in which 6 were men and 14 were women.

Experimental design

Electroencephalography (EEG) records of 3 minutes duration were made in open eyes condition at basal state and with a cognitive task of words memorizing in the two experimental conditions (with and without electromagnetic fields isolation devices) with the Phione device attached to the back of the mobile phone and carrying Phiwaves device in the shirt or jacket pocket and with no devices..

Procedure

Firstly the EEG recording was made without the electromagnetic fields isolation devices (Phione and Phiwaves) patented by Pranan Technologies and with mobile phone activated in the eyes open condition in basal state, then the recording was made with the electromagnetic fields isolation devices (Phione and Phiwaves), after that, the third record was made without the electromagnetic fields isolation devices (Phione and Phiwaves) with cognitive task of words memorizing and finally the recording was made with a similar task of other words memorizing with the electromagnetic fields isolation devices (Phione and Phiwaves). Each recording was made for a three minutes period. The registrations were carried in a soundproof room and in the darkness. During the EEG records, the subject was comfortably seated in a chair with eyes closed for the eyes open condition in basal state and in the eyes open condition with words audition both without and with electromagnetic fields isolation devices (Phione and Phiwaves).

During the EEG recording the subject was maintained with open mobile phone in the first study and in the second study with open mobile phone and the electromagnetic fields isolation devices (Phione and Phiwaves) patented by Pranan Technologies company.

EEG Technics

The EEG was recorded with 32 Neuronic channels and Medicid computer using a standard electrocap of 10/20. We used 32 channels (Fz, pFz, Cz, pCZ, Pz, Oz, Fp1, Fp2, F3, F4, F7, F8, PF3, PF4, PC3, C4, PC4, T1, T2, T3, T4, T3A, T4A, T5, T6, P3, P4, O1 and O2). The electrodes impedance remained below 5kΩ. The electro-oculogram (EOG) was recorded with two pairs of electrodes located in the horizontal (right) and vertical (left) directions to register the ocular movement. Data were recorded using a reference electrode located on the mastoid (right). The sampling rate was 1000 Hz. The amplifier band frequency was between 0.05 to 100 Hz set.

EEG analysis

With EEG records, devices cleaning was made visually and threshold, eye movements correction was made, channels rejection was made by no smoothness and by amplitude and interpolation of rejected channels.

The delta values were calculated between 1 and 4 Hz, theta between 4 and 8 Hz, alpha between

4 and 13 Hz and beta between 13 and 20 Hz. EEG amplitude values for each band were calculated band wide. With the amplitudes individual values, sources analyses were performed with the LORETA method.

One of the methods to solve the inverse problem (IP) is the low-resolution electric tomography, in english Low Resolution Brain Electromagnetic Tomography (LORETA) Pascual Marqui et al. (33) (1994), placing anatomic restrictions in the solutions permitted. The current sources are restricted to areas where there is gray matter on the individual RM or to estimated areas of probability of existence of gray matter according to RM Probabilistic Atlas of the Neurological Institute of Montreal (PMA, Evans et. A., (34) 1993, Collins et al., (35) 1994; Mazziotta et al. (36) 1995). LORETA chooses the H matrix as the Laplacian operator, which causes it to select the softest as the best solution in the sense of the second-order derivative. In this case, it is common to introduce anatomical restrictions from addressing restricted IP to those grid points belonging to gray matter.

Statistics

With individual LORETA values, we calculated the average for EEG bands in Basal State (BS) and in the memory task under conditions of active phone only (ST) and phone with EMF inhibitor (T+ICEM), that is, phone and Phione and Phiwaves devices. To find the significant differences between the two experimental conditions within EEG bands we used the Hotelling T2 dependent, with freedom degrees of 3-19, and a 0.5 α (10.71860), α 0.01 (17.38501) and α 0.001) and alpha 0.001 (29.26070 for delta, theta, alpha and beta bands. These analyses were performed using the Statistics Neuronic software.

RESULTS

Basal State

The activity in voxels referred in the averages are the corresponding to the peak activity (red colour) and the lowest energy in yellow, green and cyan blue. The most discrete activity is not described and it corresponds to the rest of the brain cortex (cobalt blue colour). Figure 4 shows the maps of the average of the neuronal activity generators in the EEG delta, theta, alpha and beta bands when registered with phone only (ST) and when with phone and using electromagnetic fields inhibition devices (T+ICEM) at basal state (EB).

In the delta band (0.5Hz - 4.0Hz) maximum energy is projected on the right superior temporal gyrus (AB: 48, coordenates X = 40, Y = 68, Z = 88, voxels = 2.9742), other areas of high neuronal activity are the right insula (red), left insula, left temporal gyrus (yellow); brain stem, hippocampus formation, uncus, cingulate region, superior parietal lobe, parahippocampal gyrus, lateral and medial occipitotemporal, inferior and medial temporal, medial frontal, supramarginal, bilateral precentral, brain stem (green), thalamus, precuneus and post central bilateral gyrus (cyan blue) in the ST condition, and in the T+ICEM condition (phone with Phione and Phiwaves devices), the highest neuronal activity is projected on the left superior temporal gyrus, AB: 38, X = 140, Y = 68 and Z = 88; voxels = 2.83142), other areas of high neuronal activity are the right superior temporal gyrus, left lower frontal and bilateral precentral, lingual gyrus and bilateral cuneus (yellow), hippocampus formation, cingulate region, bilateral parahippocampal gyrus, lateral and medial orbitofrontal cortex, lateral occipitotemporal cortex and bilateral lingual and brain stem (green) (see Figure 4).

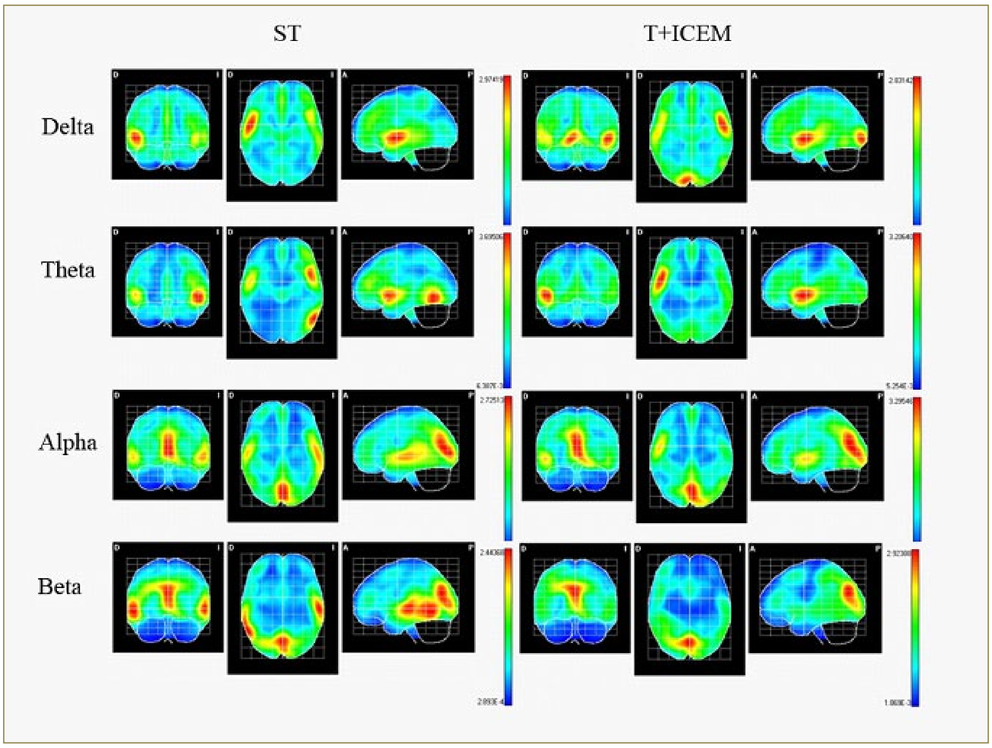


Figure 4. Coronal and half sagital horizontal view of the LORETA solutions average of the generators projections of neuronal energy in the phone only condition and phone with magnetic fields inhibitor in basal state. ST: Phone only. T+ICEM: phone and electromagnetic fields inhibitor devices (Phione and Phiwaves).

In the theta band (4Hz-8Hz) the highest neuronal energy is projected on the left lateral occipito-temporal gyrus (AB:37, X= 40, Y=64 and Z=152 voxels =3.6951), the highest neuronal energy projection is projected on the inferior frontal gyrus, middle temporal, upper right (red), upper parietal lobe, left angular gyrus, upper frontal gyrus, right medial and precentral, and post central gyrus, medial frontal and bilateral cingulate region (green) in the ST condition and in the T+ICEM condition, the highest neuronal energy is projected on the upper right temporal gyrus (AB:48, X=40, Y=68, Z= 8; voxel =3.2064), the highest brain energy is also projected on precentral gyrus and right insula (red) precentral, upper temporal, insula, upper left parietal lobe, medial and lower temporal gyrus, lower frontal, lingual, lateral and medial occipitotemporal, cingulate region, bilateral occipital pole and brain stem (green) and post central, and bilateral hippocampus formation (cyan blue, Figure 4).

In alpha band (8-13Hz) the highest cerebral energy is projected on left cuneus (AB:17, X=92, Y=80, Z=172; voxels =0.2829), the neuronal energy is projected on the left cuneus, precuneus and bilateral temporal gyrus (red), supramarginal and left medial temporal gyrus (yellow), upper parietal lobe, lower frontal, lower temporal, lower occipitotemporal, parahippocampal gyrus, occipital pole, upper parietal lobe, insula and bilateral cingulate region, supramarginal gyrus, right middle temporal (green) and in middle frontal and bilateral precentral gyrus (cyan, Figure 4) in ST condition, in T+ICEM condition, the maximum neuronal energy is projected on right cuneus (AB:18, X=88, Y=96, Z=160 and voxels =3.2955) energy is also projected on left cuneus, lingual gyrus, precentral and right upper temporal and bilateral precuneus (red), post central and medial temporal gyrus, upper parietal lobe, bilateral cingulate region, medial occipital and right angular gyrus and left lower temporal gyrus (green) and medial orbitofrontal, medial frontal and bilateral thalamus gyrus, angular and left precentral gyrus and brain stem (cyan blue, see figure 4).

In the beta band (13-20 Hz) the highest neuronal energy is projected on the right medial temporal gyrus (BA 37, X=32, Y=68, Z=144; voxels =2.4437); the brain energy is also projected on the upper temporal gyrus, cuneus and bilateral precuneus, lingual and left supramarginal gyrus (red), upper parietal lobe and right upper occipital gyrus (yellow), upper parietal lobe, left upper occipital gyrus, right supramarginal gyrus, medial occipital, angular and bilateral postcentral gyrus (green), medial and lower frontal gyrus and bilateral cingulate region (cyan blue, see Figure 4) in ST condition, in T+ICEM condition the highest energy is projected in bilateral cuneus with higher energy in left (AB17, X=88, Y=100, Z=164, voxels =2.92388), right precuneus, bilateral lingual (red), precuneus, right upper occipital gyrus (yellow), upper temporal, lower and occipital gyrus, left insula, right temporal gyrus, medial temporal, angular, medial occipitotemporal gyrus, occipital pole, bilateral upper parietal lobe (green), lower temporal gyrus, left insula, upper temporal gyrus, precentral, medial and right upper frontal gyrus, supramarginal and postcentral gyrus, bilateral cingulate region (cyan blue color, see figure 4).

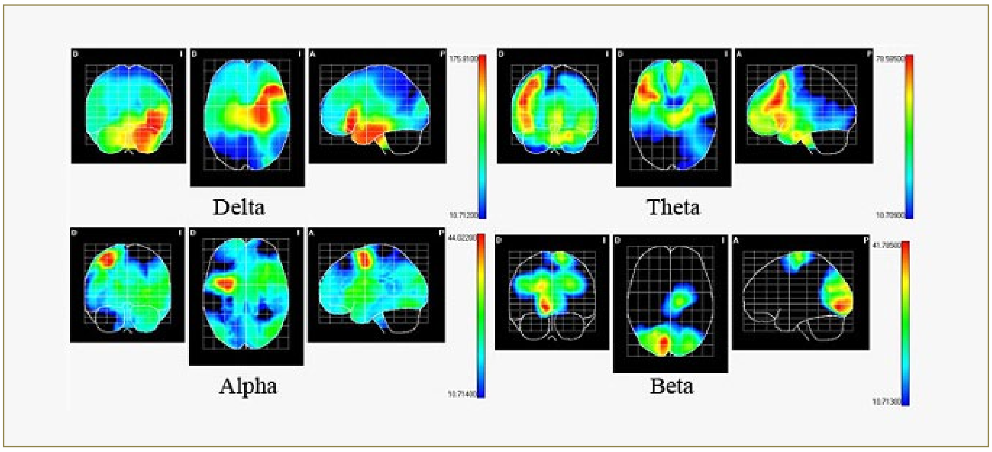


Figure 5. Coronal and midsagittal horizontal view of significant differences of LORETA solutions of the generators projection of neuronal activity in phone only condition and phone with electromagnetic fields inhibitors (Phione and Phiwaves) in the basal state.

Figure 5 shows the mapping of the significant differences in EEG bands in the two experimental conditions in BS. When activity is recorded EEG exhibits, in the delta band, energy reduction in BS with ICEM (Phione and Phiwaves) in the limbic region (hippocampus formation, hippocampus gyrus, uncus, bilateral cingulate region), insula, subcortical areas (thalamus, caudate nucleus, bilateral putamen), brain stem. In the rest of the cortex the energy is alternating (see Figure 5, Table 1). In the theta band, there is an energy reduction in the BS with ICEM on limbic areas (hippocampus gyrus, hippocampus formation, bilateral uncus), subcortical areas (left putamen), on temporal and occipital areas reduction is observed on the left. In the rest of the cortex energy reduction is alternating (see Figure 5 and Table 2). In the alpha band energy reduction with the ICEM in BS trend is alternating tending to energy increase on both cortical and subcortical areas (See Figure 5 and Table 3). In the beta band, energy reduction with ICEM in BS is projected on frontal areas (upper and medial frontal gyrus, bilateral precentral) and alternating on occipital and parietal areas (Figure 5, Table 4).

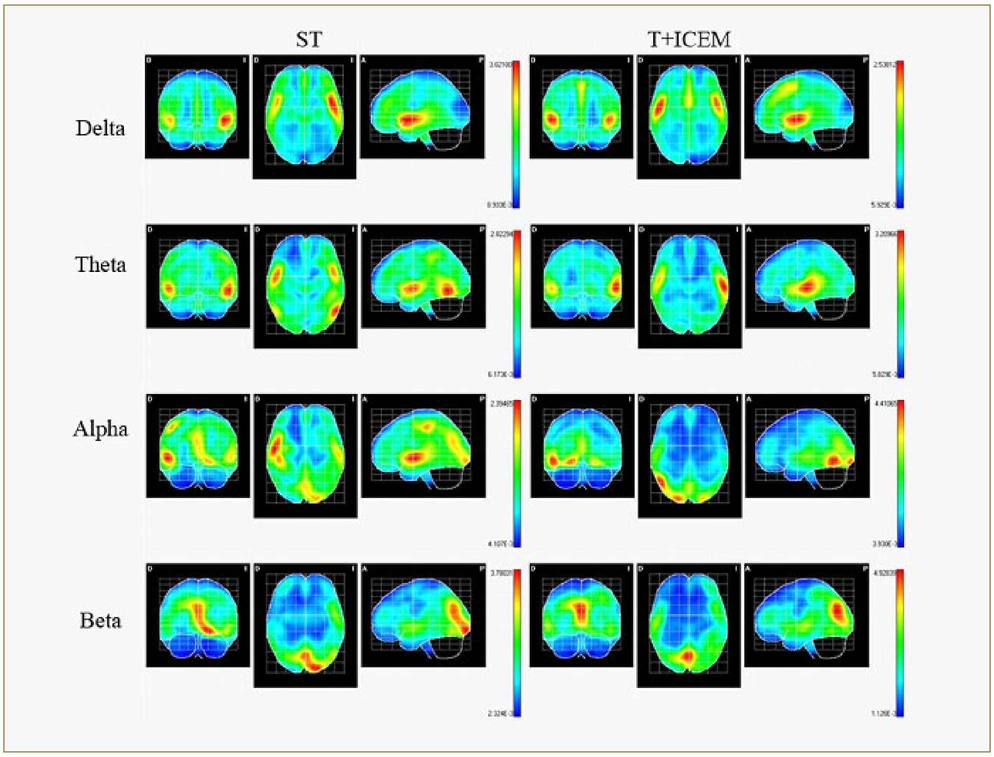


Figure 6. Coronal and midsagittal horizontal view of the average of LORETA solutions of the generators projection of neuronal activity in phone only condition and phone with magnetic fields inhibitor in memory task. ST: Phone only. T+ICEM: phone with electromagnetic fields inhibitors (Phione and Phiwaves).

Figure 6 shows the mapping of the generators averages of the neuronal activity in EEG delta, theta, alpha and beta bands registered with phone only (ST) and with phone and electromagnetic fields inhibitor (T+ICEM) in words memory task. In the delta band (1 Hz-4 Hz) in ST condition of words memory task highest energy is projected on the left upper temporal gyrus (AB: 48, coordinates X=140, Y=66, Z=86; voxels =3.02100), bilateral precentral gyrus (red), left central post gyrus (yellow), upper, middle and lower temporal structures, medial and lower frontal and orbitofrontal, limbic lobe (hippocampus gyrus and hippocampus formation, uncus, cingulate region), bilateral upper parietal lobe, brain stem (green), occipital structures (upper gyrus and occipital pole) and bilateral thalamus (green, see Figure 6), and in the T+ICEM words memory condition, energy is projected onto the right medial temporal gyrus (AB:38, X=140, Y=68 and Z=88, voxels =2.53812), left medial temporal gyrus, precentral, lower frontal, and bilateral insula (red), bilateral medial frontal gyrus (yellow), medial and lower temporal gyrus, post central, lateral and medial occipitotemporal, hippocampus formation, cingulate region, bilateral upper parietal lobe, brain stem (green), uncus, hippocampus formation, cuneus and bilateral parahippocampal gyrus (green) (see Figure 6).

In the theta band (4Hz, 8Hz) in the ST words memory task condition the highest neuronal energy is projected on the left lateral occipitotemporal gyrus (AB:37, X=140, Y=64 and Z=152 voxels=2.82294), upper temporal and bilateral precentral gyrus, medial temporal and left lower frontal gyrus (red), right medial temporal gyrus (yellow), medial frontal gyrus, medial and upper occipitotemporal gyrus, angular, supramarginal, parahippocampal, upper parietal lobe, hippocampus formation, cingulate region, bilateral precuneus, right lower frontal gyrus, brain stem (green), upper frontal gyrus, bilateral thalamus (cyan blue), and in the T+ICEM words memory task condition the energy is projected on the bilateral upper temporal gyrus (AB:48, X=40, Y=68, Z=88, voxel=3.2064) with more energy on the left (red), medial temporal, lower, medial, supramarginal, angular, precentral, postcentral, medial front gyrus, upper parietal lobe, cingulate region, bilateral precuneus (green), cuneus, thalamus, orbito frontal, medial occipital, parahippocampal, bilateral lower frontal gyrus, left upper occipital gyrus and brain stem (green) (see Figure 6).

In the alpha band (8Hz-13Hz) in the ST words memory task condition, the highest energy of the brain is projected on the bilateral upper temporal gyrus with maximum projection on the right (AB:48, X=36, Y=72, Z=92, voxels=2.39465), insula, cuneus, bilateral lingual gyrus, left precuneus, right post central (red), upper temporal, medial and lower, upper, medial and lower frontal, orbitofrontal, precentral, lateral and medial occipitotemporal, angular, supramarginal, precentral gyrus, upper parietal lobe, bilateral occipital pole (green), occipital gyrus, right occipital pole, left hippocampal formation, thalamus, uncus bilateral cingulate region (cyan blue, see Figure 6), and in the T+ICEM words memory task condition the highest neuronal energy is projected in right medial temporal gyrus (AB:37, X=40, Y=64, Z=152 and voxels=3.2955), right lateral occipitotemporal gyrus (red), right cuneus (yellow colour), lingual and upper temporal gyrus, cingulate region, bilateral precuneus occipital pole, precentral, medial and upper occipital gyrus, right upper parietal lobe, left cuneus (green colour), medial orbitofrontal and medial frontal, post central, angular, bilateral supramarginal gyrus, lower frontal, medial and upper right occipital gyrus, precentral gyrus, medial temporal, left upper parietal lobe (cyan blue, see Figure 6).

In the beta band (13Hz-20Hz) in the ST words memory task condition, energy is projected on bilateral lingual gyrus more strongly on the left (AB:18, X=108, Y=64, Z=184 and voxels=3.78031), bilateral precuneus (red), left lateral occipitotemporal gyrus (yellow), upper and medial temporal gyrus, middle and upper occipital gyrus, medial occipitotemporal gyrus, precuneus, cingulate region, bilateral upper parietal lobe, lower frontal, orbito frontal, left lower occipital gyrus (green) and upper and lower temporal gyrus, post central, bilateral medial frontal, medial occipital pole, insula and right lower frontal gyrus (cyan blue), and in the T+ICEM words memory task condition the highest neuronal energy is projected on the bilateral precuneus gyrus with stronger projection on the right (AB:7, X=88, Y=100, Z=160 and voxels=4.92839), bilateral cuneus and right upper parietal lobe (red), upper parietal lobe, occipital pole, lower frontal, lateral and medial occipitotemporal, medial temporal, bilateral precentral, postcentral, angular, left medial frontal gyrus, supramarginal and right upper temporal gyrus (green), medial frontal, supramarginal, left upper temporal gyrus, post central, angular, medial frontal, right lower temporal gyrus and brain stem (cyan blue, see Figure 6).

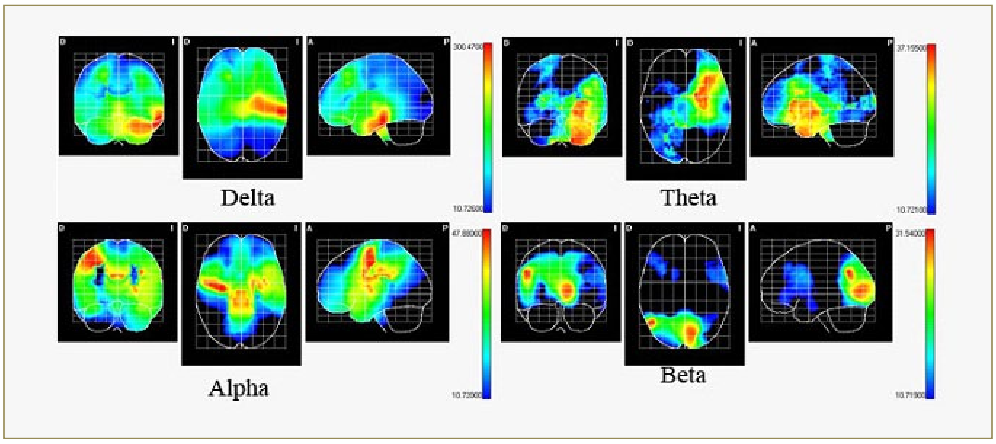


Figure 7. Coronal and midsagittal horizontal view of the significant differences of LORETA solutions of the generators projection of neuronal activity in phone only condition and phone with electromagnetic fields inhibitors (Phione and Phiwaves) in memory task.

Figure 7 shows the mapping of significant differences in EEG bands in the two experimental conditions in the task of words memorizing where the reduction energy is higher than in the BS condition when using the ICEM (Phione and Phiwaves). In the delta band a reduction of energy is observed when using the ICEM (Phione and Phiwaves) in almost the whole cerebral cortex (see Figure7, Table 5). In the theta band energy reduction in memory task and using the ICEM (Phione and Phiwaves) is projected on subcortical areas (thalamus, caudate nucleus, accumbens and globus pallidus). In the rest of the cortex energy reduction is alternating with tendency to its reduction when using the ICEM (Phione and Phiwaves) (see Figure 7, Table 6). In the alpha band energy reduction with the ICEM (Phione and Phiwaves) is projected on the temporal lobe (medial temporal and bilateral upper gyrus and left lower gyrus, parietal, post central gyrus, bilateral angular, left supramarginal and bilateral upper parietal lobe), left insula. In the rest of the cortex energy reduction is alternating with decreasing tendency (see Figure 7, Table 7). In the beta band instead, contrary to the other bands in words memory task, the energy increases when using the ICEM (Phione and Phiwaves) (See Figure 7, Table 8).

GLOBAL ANALYSIS

1.- In relation to the bands we see that the ICEM (Phione and Phiwaves) primarily inhibits slow bands, with the highest incidence in the delta band and has no greater impact on fast bands, mainly on the beta band, where the effect is the opposite, as it increases. These results are associated with neuronal function improvement by understanding that generalized slow waves are associated with hypofunctioning processes while fast bands have a function associated with increased brain activity.

2.- From the perspective of the brain asymmetry the ICEM (Phione and Phiwaves) primarily inhibits HI in the words task, typical of this hemisphere, in the slow bands. This result indicates an neurofunctional improvement of HI which could result in improved verbal cognitive functions associated with such hemisphere.

3.- From the topographical perspective we see that the ICEM (Phione and Phiwaves) inhibits front and medial brain structures in slow bands, medial brain structures in the alpha band and posterior cerebral structures in the beta band. This could have a huge impact in more complex cognitive processes associated with those brain areas. On the other hand it sets an anteroposterior patterning in the organization of the functional dynamics of the brain oscillations that might demonstrate new processes of brain function both in the basal state and during cognitive testing.

4.- From the point of view of global inhibition we found that the ICEM (Phione and Phiwaves) inhibited about 80% of brain areas in slow bands, enabling a global neurofunctional improvement able to keep the brain in top condition against different brain or behavioral activities. This data is key to demonstrating a significant improvement at the neurofunctional level determining neuronal better efficiency in any situation where the brain has to give a cognitive response.

5.- Significant differences are found in the inhibition of different EEG oscillations in different brain structures between the basal state and the memorization of words, there is greater inhibition during the task of memorizing words globally, being the inhibition with ICEM (Phione and Phiwaves) more specific and intense. This has an important relevance since the use of mobile phone is always conducted using verbal language, if the ICEM (Phione and Phiwaves) is capable of inhibiting more and better during listening words, the possibility of neurofunctional improvement during verbal cognitive functions performed with mobile use will be much more efficient while using the ICEM (Phione and Phiwaves).

6.- Significant differences in the Basal State: significant differences, with overall reduction on delta and theta bands in limbic, subcortical and thalamic areas, responsible of emotional and memory processes while in alpha and beta bands increases are observed alternately produced on cortical areas with the ICEM (Phione and Phiwaves). This result in the basal state allows understanding the ICEM effect in terms of improving the global functional dynamics of the brain in resting state (Phione and Phiwaves).

7.- Significant differences in words memory: significant differences of the EEG bands in the two experimental conditions in the task of memorizing words; the reduction of energy is higher than in the basal state condition when using the ICEM (Phione and Phiwaves). In task of words memorizing there is a reduction of energy when using the ICEM in almost all the cerebral cortex in the delta band, while in the theta band energy reduction is primarily localized in subcortical areas; in the alpha band energy reduction using the ICEM (Phione and Phiwaves) is projected mainly on the temporal parietal lobe. Finally, in the beta band energy increases when using the ICEM (Phione and Phiwaves). These results allow to understand the significant improvement in the neuronal efficiency during verbal cognitive tasks performed with the mobile phone.

CONCLUSIONS

The ICEM (Phione and Phiwaves) has a significant effect on all tested brain bands, being its highest incidence in the slow bands, both in the delta band as in the theta band. Fast bands manifest different behaviors in which significant reductions in certain brain structures alternate combined with significant activations on other brain areas. Furthermore, the ICEM incidence (Phione and Phiwaves) affects most brain areas with a high incidence in the left hemisphere, especially in the task of words memory. The ICEM use results in improved functional capacity during cognitive tasks and improved overall brain functions in the basal state. The effect of the ICEM (Phione and Phiwaves) has such magnitude, neurofunctional consistency and significant differences on a large majority of brain areas that we can justify its effectiveness in modifying certain brain oscillations and its effectiveness as an inhibitor of electromagnetic fields.

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		T²Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Left lateral orbitofrontal gyrus	47	175.8100	*	132	48	60	**0.2144**	0.1971
Right lateral orbitofrontal gyrus	11	88.1525	*	72	50	75	**0.2998**	0.2616
Left medial frontal gyrus	10	78.4506	*	118	11	47	**0.7701**	0.6955
Left medial frontal gyrus	9	54.1824	*	61	112	54	0.7091	**0.7907**
Right upper frontal gyrus	9	57.8071	*	76	111	40	**0.5504**	0.3759
Left medial frontal gyrus	9	41.5305	*	95	53	37	**0.9309**	0.8110
Right medial frontal gyrus	11	46.0245	*	87	59	37	**1.2469**	1.1208
Left lower frontal gyrus	47	168.7566	*	129	71	68	1.5479	**1.7765**
Right lower frontal gyrus	47	64.2233	*	45	67	68	**1.9101**	1.7938
Right precentral gyrus	4	69.6996	*	37	102	100	**0.6247**	0.5954
Left precentral gyrus	3	19.8718	***	112	149	129	**0.3139**	0.2202
Left medial temporal gyrus	20	125.5968	*	127	33	71	0.2480	**0.2542**
Right medial temporal gyrus	21	67.64566	*	38	72	120	1.0253	**1.1519**
Left upper temporal gyrus	38	135.3494	*	127	38	70	0.3629	**0.3737**
Right upper temporal gyrus	48	75.0223	*	48	87	117	0.4699	**0.5151**
Left lower temporal gyrus	20	116.5758	*	49	46	108	**0.6601**	0.5494
Right angle gyrus	39	23.7066	*	43	96	142	0.3196	**0.5906**
Right upper parietal gyrus	7	10.9194	***	62	124	162	0.2875	**0.5624**
Right postcentral gyrus	6	77.7968	*	42	116	89	1.0372	1.0120
Left postcentral gyrus	6	17.7565	***	112	113	121	0.0915	**0.1391**
Left occipital pole	18	67.1676	*	126	88	184	0.0883	**0.1103**
Left upper occipital gyrus	19	74.0265	*	123	96	180	0.2312	**0.3652**
Left lower occipital gyrus	18	55.6119	*	125	76	175	0.3987	**0.6186**
Left lower occipital gyrus	19	55.6406	*	126	79	172	0.3929	**0.6776**
Left medial occipital gyrus	18	66.3751	*	122	84	176	0.3829	**0.6776**
Left Cuneus	17	23.1756	**	99	80	156	**0.8286**	0.5660
Right Cuneus	17	13.3266	***	83	83	156	**0.8533**	0.8249
Right medial temporo-occipital gyrus	30	67.9237	*	72	59	129	**0.2895**	0.2736
Left medial temporo-occipital gyrus	19	63.9166	*	123	85	172	0.3363	**0.5381**
Right lateral temporo-occipital gyrus	20	107.0667	*	59	44	116	**0.6020**	0.5096
Left lateral temporo-occipital gyrus	30	158.9847	*	118	47	116	**0.6788**	0.5708
Left hippocampal gyrus	36	163.9821	*	114	41	104	**1.0538**	0.9306
Right hippocampal gyrus	36	128.9790	*	70	36	104	**0.8314**	0.7046
Left hippocampus formation	36	167.6633	*	114	50	104	**0.9708**	0.8596
Right hippocampus formation	36	124.8787	*	68	56	104	**0.6092**	0.5226
Right uncus	28	118.7807	*	71	41	88	**0.6096**	0.5076
Left uncus	28	165.1794	*	116	45	88	**0.7871**	0.7318
Left cingulate region	24	53.2444	*	95	103	64	**1.2930**	1.1564
Right cingulate region	24	54.3773	*	84	102	64	**1.1699**	1.0432
Left insula	47	169.7718	*	125	71	68	**1.0639**	0.9491
Right insula	47	65.8044	*	51	60	68	**1.6162**	1.4532
Left thalamus	NA	106.1918	*	97	73	108	**0.4708**	0.4474
Right thalamus	NA	11.3866	*	86	70	108	**0.5431**	0.5113
Left caudate nucleus	NA	63.3937	*	108	69	71	**0.1088**	0.0982
Right caudate nucleus	NA	34.5297	*	74	64	68	**0.0930**	0.0865
Left putamen	NA	78.8673	*	119	68	104	**0.0118**	0.0111
Right putamen	NA	34.1000	*	61	69	104	**0.0123**	0.0119
Left cerebellum	NA	153.4959	*	108	34	107	**0.5347**	0.4751
Right cerebellum	NA	93.2919	*	72	49	184	0.552	**0.6528**
Brain stem	NA	159.2816	*	104	43	104	**1.0192**	0.9094

Table 1. Average and significant differences (Hotelling`s T2) of LORETA solutions in delta band in the basal state with phone only and with electromagnetic fields inhibitor. AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable "for Brodmann areas".

MI: Highest Intensity. X ST: average phone only. X T+ICEM average phone with electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **, <0.05: ***.

		T²Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Right medial frontal gyrus	11	78.5850	*	40	96	64	0.9910	**1.4230**
Left medial frontal gyrus	11	34.1647	*	115	68	28	**1.0187**	0.6129
Right upper frontal gyrus	8	69.1370	*	63	127	76	**0.9508**	0.8345
Left upper frontal gyrus	9	47.1442	*	104	68	25	**0.5881**	0.5364
Left medial frontal gyrus	10	46.6050	*	84	85	29	0.6665	**0.8042**
Right medial frontal gyrus	10	49.4515	*	96	88	28	0.6511	**0.6954**
Right lower frontal gyrus	45	70.6003	*	43	89	56	0.6505	**1.2182**
Left lower frontal gyrus	11	53.8518	*	96	63	49	**1.0514**	0.7978
Right precentral gyrus	6	59.1974	*	46	99	77	1.7607	**2.0866**
Left precentral gyrus	6	41.8293	*	145	83	84	**1.9817**	0.8940
Right lateral orbitofrontal gyrus	47	63.8885	*	49	64	65	1.2909	**1.7261**
Left lateral orbitofrontal gyrus	47	50.2793	*	129	56	23	**2.4541**	1.1374
Left upper temporal gyrus	21	54.6956	*	139	56	84	**2.6497**	1.3213
Right upper temporal gyrus	38	66.3884	*	46	57	72	1.8768	**2.2858**
Right medial temporal gyrus	22	40.1039	*	32	64	102	2.2304	**2.3539**
Left medial temporal gyrus	21	39.8577	*	136	38	80	**0.8036**	0.4223
Left lower temporal gyrus	20	45.3479	*	118	31	95	**0.7489**	0.5448
Right lower temporal gyrus	20	30.3492	*	64	31	97	**0.6929**	0.58904
Left lateral temporo-occipital gyrus	37	33.8518	*	128	36	97	**0.6844**	0.5916
Right lateral temporo-occipital gyrus	37	31.4157	**	60	43	107	**0.8371**	0.6718
Left medial temporo-occipital gyrus	18	13.1588	***	105	69	151	0.5948	**0.6352**
Left lingual gyrus	18	10.7125	***	67	76	171	0.0600	**0.1471**
Left cuneus	17	11.0547	***	96	84	188	0.4117	**0.7538**
Left occipital pole	18	12.0767	***	124	88	185	**0.2700**	0.2092
Right cingulate region	33	54.5384	*	87	63	51	**1.0599**	0.8354
Left cingulate region	33	56.5301	*	99	74	34	0.8833	**0.9305**
Left hippocampus formation	36	63.8149	*	112	43	99	**1.1200**	0.8308
Right hippocampus formation	28	65.0335	*	112	45	96	**1.0650**	0.7673
Left parahippocampal gyrus	36	63.1207	*	109	43	99	**1.0678**	0.7909
Right parahippocampal gyrus	36	52.8644	*	114	35	92	**0.8134**	0.5744
Left uncus	28	63.1238	*	112	42	93	**0.9763**	0.6857
Right uncus	28	44.1452	*	72	47	96	**0.8529**	0.7190
Right insula	47	69.4126	*	47	66	72	2.0837	**2.6097**
Left insula	47	53.3240	*	132	63	84	**2.6190**	1.3101
Brain stem	NA	56.3175	*	12	46	113	**1.2441**	1.0152
Left thalamus	NA	35.4116	**	94	70	104	0.0506	**0.4012**
Right thalamus	NA	35.5421	**	88	73	104	**0.4972**	0.4013
Left putamen	NA	21.6232	**	120	66	84	**0.2616**	0.1358

Table 2. Average and significant differences (Hotelling`s T2) of LORETA solutions in theta band in the basal state with phone only and EMF inhibitor (Phione and Phiwaves). AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (WFP). AB: Brodmann areas. NA: Not applicable "to Brodmann areas. X ST: average phone only. XT+ICEM average phone and electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

		T^2Hotelling		Coordinates			MI Voxels	
AAL	**AB**	**MI Voxels**		**X**	**Y**	**Z**	***X* ST**	***X* T+ICEM**
Right medial frontal gyrus	6	44.0220	*	56	136	88	0.5427	**0.6590**
Left medial frontal gyrus	6	12.1486	**	107	102	28	0.2121	**0.2530**
Right upper frontal gyrus	6	39.4492	*	66	134	86	0.5727	**0.6700**
Left upper frontal superior gyrus	6	18.9636	**	98	92	21	0.1253	**0.1486**
Right lower frontal gyrus	11	17.4389	**	61	67	29	**0.6753**	0.5536
Left lower frontal gyrus	11	26.7050	**	127	81	70	**0.4499**	0.2378
Left lateral orbitofrontal gyrus	47	25.3728	**	132	58	72	**1.3851**	0.7080
Right lateral orbitofrontal gyrus	11	19.1039	**	77	48	28	0.1501	**0.1867**
Right orbitofrontal gyrus	11	18.8151	**	88	51	58	0.5772	**0.7415**
Left medial orbitofrontal gyrus	11	15.5185	**	97	50	37	0.4836	**0.7179**
Right precentral gyrus	6	32.9817	*	60	132	100	0.5426	**0.7582**
Left precentral gyrus	6	29.9811	*	141	92	88	**0.0687**	0.0481
Left medial temporal gyrus	37	24.2206	**	145	62	150	1.5365	**1.7959**
Right medial temporal gyrus	37	23.0721	**	37	92	165	**0.4922**	0.3125
Left lower temporal gyrus	20	18.4705	**	124	25	85	**0.1863**	0.1115
Left upper temporal gyrus	22	24.9160	**	137	58	72	**1.3442**	0.6739
Right parahippocampal gyrus	29	19.0163	**	84	80	136	0.1577	**0.1866**
Left hippocampus formation	36	17.4626	**	119	49	96	**0.3753**	0.2838
Right hippocampus formation	37	16.2674	***	64	74	128	**0.0365**	0.0335
Left parahippocampal gyrus	36	17.3767	*	108	45	98	**0.5360**	0.4554
Left uncus	34	22.2310	*	120	56	87	**0.1567**	0.1085
Right uncus	34	11.1654	*	75	43	101	**0.4721**	04652
Right cingulate region	24	22.2515	**	84	104	92	0.1822	**0.2062**
Left cingulate region	24	21.4830	**	92	101	91	0.1410	**0.1611**
Right cuneus	18	14.7675	**	81	93	158	2.0801	**2.6346**
Left cuneus	18	19.2530	**	101	93	163	1.7171	**2.0338**
Left upper occipital gyrus	18	24.3036	**	116	88	180	0.8111	**1.0076**
Right upper occipital gyrus	19	18.3474	**	61	92	174	0.645	**0.6870**
Right medial occipital gyrus	19	26.2637	**	44	97	173	**0.4277**	0.3920
Left lower occipital gyrus	19	22.0008	**	123	60	180	1.1439	**1.7835**
Left lateral temporo-occipital gyrus	19	27.6266	**	131	60	166	1.1523	**1.8243**
Left medial temporo-occipital gyrus	19	26.0185		120	60	164	0.0177	**1.4295**
Right medial temporo-occipital gyrus	19	12.8121	***	81	82	169	2.1402	**2.4537**
Left occipital pole	18	23.1244	**	115	88	183	0.7962	**1.0048**
Left lingual gyrus	18	18.0914	**	115	59	173	1.2385	**1.9166**
Right upper parietal lobe	7	20.2243	**	101	110	162	1.7768	**2.0349**
Right precuneus	7	18.0717	**	87	101	147	1.7576	**2.2833**
Left precuneus	7	20.2431	**	99	111	158	1.8280	**2.1941**
Left insula	45	29,5161	*	120	83	69	**0.1360**	0.0812
Right insula	45	14.6128	***	48	64	83	1.2372	**1.9787**
Right caudate nucleus	NA	30.3688*		73	96	93	0.0060	**0.0079**
Left caudate nucleus	NA	24.9371	**	100	85	88	0.0267	**0.0300**
Globus pallidus	NA	18.0841	***	75	68	69	0.0329	**0.0455**
Left putamen	NA	29.4678	*	116	76	76	**0.0725**	0.0516
Right putamen	NA	22.0007	**	64	84	93	0.0189	**0.0272**
Left acumbens nucleus	NA	24.2573	**	103	62	84	**0.0692**	0.0662
Left thalamus	NA	24.6348	**	100	84	92	0.0465	**0.0521**
Right thalamus	NA	25.3015	**	73	90	101	0.0427	**0.0535**
Left globus pallidus	NA	26.7628	**	106	72	88	**0.0401**	0.0352
Right cerebellum	NA	12.7465	***	64	51	136	**0.0883**	0.0509
Brain stem	NA	2.8054	***	78	37	116	0.3384	**0.3712**

Table 3. Average and significant differences (Hotelling`s T2) of LORETA solutions in alpha band in the basal state with phone only and with electromagnetic filelds inhibitor (Phione and Phiwaves). AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable "to Brodmann areas. MI: Highest Intensity. X ST: average phone only. XT+ICEM average phone with electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

		T^2Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Left upper frontal gyrus	6	31.3758	*	104	147	104	**0.2504**	0.1470
Left medial frontal gyrus	6	29.1909	**	100	148	101	**0.2152**	0.1580
Right medial frontal gyrus	6	17.4773	**	89	144	1064	**0.2778**	0.1140
Left precentral gyrus	6	29.3188	**	108	143	108	**0.3154**	0.1292
Right precentral gyrus	4	16.0563	***	84	148	112	**0.1335**	0.0710
Right medial temporal gyrus	37	16.7967	***	47	92	155	**0.9838**	0.8895
Right upper parietal lobe	7	31.3408	*	67	97	153	0.7580	**0.9112**
Left upper parietal gyrus	7	23.6219	**	118	116	170	0.7219	**0.7391**
Right angular gyrus	39	22.1447	**	42	108	158	1.0550	**1.300**
Left angular gyrus	39	27.1283	**	121	107	169	1.1842	**1.2047**
Right precuneus	7	26.8773	**	75	96	158	1.3689	**1.5904**
Left precuneus	7	16.8754	***	98	87	156	1.7665	**2.0256**
Right supramarginal gyrus	40	11.6370	***	52	95	117	0.3506	**0.3610**
Right lingual gyrus	18	41.7850	*	80	66	168	**0.5733**	0.5102
Left lingual gyrus	18	27.2495	**	92	74	174	2.0658	**2.2186**
Right upper occipital gyrus	18	34.9310	*	76	100	181	**0.9314**	1.0312
Left upper occipital gyrus	19	30.0304	*	119	105	176	0.8258	**0.9185**
Right medial occipital gyrus	18	36.0928	**	75	76	165	**1.1314**	1.0160
Left medial occipital gyrus	19	27.6447	**	123	108	174	0.7743	**0.8096**
Right cuneus	18	36.2287	**	75	74	183	0.8995	**0.9487**
Left cuneus	17	26.3815	**	92	77	178	2.0583	**2.2430**
Right occipital pole	17	33.0150	**	75	73	190	0.6405	**0.7636**
Left occipital pole	17	15.4503	***	105	92	190	0.4378	**0.5298**
Left lower occipital gyrus	37	16.6574	***	134	92	166	0.6299	**0.9153**

Table 4. Average and significant differences (Hotelling's T2) of LORETA solutions in the beta band in the basal state with phone only and with electromagnetic fields inhibitor (Phione and Phiwaves). AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable "to Brodmann areas. MI: Highest Intensity. X ST: average phone only. X T+ICEM average phone with electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling's T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

		T²Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Left medial frontal orbital gyrus	11	154.4326	*	97	55	79	**0.2411**	0.1895
Right medial frontal orbital gyrus	11	144.6867	*	89	56	68	**0.6963**	0.4876
Right orbital frontal orbital gyrus	47	163.8232	*	80	52	84	**0.0621**	0.0505
Left lateral frontal orbital gyrus	47	169.9168	*	114	47	78	**0.5939**	0.4485
Left lower frontal gyrus	47	81.8278	*	133	56	53	**0.6394**	0.4466
Right lower frontal gyrus	47	97.8246	*	42	72	78	**2.3919**	2.0684
Right medial frontal gyrus	8	174.3843	*	64	121	61	**0.9507**	0.8995
Left medial frontal gyrus	46	150.8128	*	129	114	69	**0.9539**	0.6817
Right precentral gyrus	6	102.3423	*	42	71	85	**2.4488**	2.3672
Left precentral gyrus	6	140.3675	*	140	77	94	**2.4000**	1.8985
Left medial temporal gyrus	21	300.4700	*	148	52	116	**1.2686**	0.7951
Right medial temporal gyrus	21	134.7858	*	30	54	123	**0.9838**	0.6637
Left lower temporal gyrus	20	296.9939	*	149	48	116	**1.0679**	0.6659
Right lower temporal gyrus	20	135.4613	*	28	63	130	**1.2934**	0.8003
Left upper temporal gyrus	22	148.7979	*	129	52	74	1.3955	**1.8652**
Right upper temporal gyrus	22	105.6242	*	51	51	81	**13360**	1.1913
Right angular gyrus	39	47.4570	*	32	104	12.	**1.0049**	0.7430
Left upper parietal gyrus	7	31.0488	*	124	128	139	**0.6171**	0.5042
Right upper parietal gyrus	7	45.3010	*	66	127	163	**0.3952**	0.2828
Right supramarginal gyrus	40	79.7287	*	21	89	122	**0.8715**	0.6714
Left supramarginal gyrus	40	115.6559	*	152	88	120	**1.6607**	1.2774
Right postcentral gyrus	3	96.7545	*	46	84	100	1.0655	**1.0943**
Left postcentral gyrus	3	157,5428	*	129	92	105	**0.2592**	0.2154
Left lateral temporo-occipital gyrus	37	139.7782	*	55	44	107	**0.853**	0.7366
Right lateral temporo-occipital gyrus	37	270.1758	*	124	44	108	**0.9711**	0.7269
Right medial temporo-occipital medial gyrus	19	146.2973	*	60	60	126	**0.4720**	0.3913
Left medial temporo-occipital medial gyrus	19	109.5050	*	111	60	124	**0.4322**	0.3591
Right upper occipital gyrus	19	29.8715	**	77	124	165	**0.4501**	0.3738
Left upper occipital gyrus	19	12.8406	***	111	123	165	0.3400	**0.3484**
Right medial occipital gyrus	19	20.3643	**	107	119	170	**0.405**	0.3169
Left occipital pole	18	10.8465	**	129	80	184	**0.0910**	0.0724
Left lower occipital gyrus	19	12.2854	***	129	62	176	**0.4100**	0.2900
Right lower occipital gyrus	19	13.3306	***	49	60	176	**0.5661**	0.4793
Left parahippocampal gyrus	36	268.7651	*	118	44	105	**1.1315**	0.8634
Right parahippocampal gyrus	35	180. 0552	*	71	47	108	**1.0316**	0.8642
Left hippocampus formation	36	265.9258	*	117	43	102	**1.1602**	0.8856
Right hippocampus formation	36	170.3820	*	66	47	105	**1.0997**	0.9284
Right uncus	28	181.6162	*	73	42	105	**1.0878**	0.9075
Left uncus	28	249.2402	*	112	43	93	**1.0617**	0.8143
Left cingulate region	28	142.8557	*	94	60	71	**0.4845**	0.3828
Right cingulate region	33	112.3027	*	84	60	61	**0.6277**	0.5028
Left insula	47	156.5597	*	132	74	99	**1.5819**	1.2380
Right insula	47	104.1597	*	51	68	87	**1.3508**	1.2820
Right thalamus	NA	188.1956	*	84	80	104	**0.4845**	0.4136
Left thalamus	NA	182.5255	*	96	80	101	**0.4556**	0.3870
Right globus pallidus	NA	124.8201	*	72	69	88	**0.1151**	0.0960
Left globus pallidus	NA	149.8222	*	108	64	94	**0.1041**	0.0819
Right caudate nucleus	NA	148.3870	*	82	80	81	**0.0351**	0.0286
Left caudate nucleus	NA	142.2962	*	99	80	75	**0.0449**	0.0353
Right acumbens nucleus	NA	154.9400	*	105	60	85	**0.1466**	0.1254
Left acumbens nucleus	NA	154.9400	*	105	60	85	**0.1466**	0.1254
Right putamen	NA	100.1871	*	66	71	81	**0.0376**	0.0299
Left putamen	NA	118.7338	*	114	76	82	**0.1688**	0.1440

Left cerebellum	NA	46.4500	*	63	56	145	**0.2713**	0.2230
Right cerebellum	NA	37.8948	*	116	55	143	**0.1937**	0.1671
Brain stem	NA	245.3900	*	105	43	107	**1.1112**	0.87748

Table 5. Averge and significant differences (Hotelling`s T2) of the LORETA solutions in the delta band with phone only and with electromagnetic fields inhibitor (Phione and Phiwaves) in the word memory task situation. AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable “to Brodmann areas. MI: Highest Intensity. X ST: average phone only. XT+ICEM average phone only with phone electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

		T²Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Left medial frontal gyrus	46	29.8092	*	127	96	74	**0.1933**	0.1330
Right upper frontal gyrus	8	14.5227	***	68	140	74	0.2310	**0.2562**
Left lower frontal gyrus	47	31.6075	*	136	51	57	**0.2105**	0.1196
Right precentral gyrus	4	19.1067	**	62	148	116	**0.2573**	0.2172
Left precentral gyrus	6	18.6241	**	143	89	82	**0.8688**	0.3140
Right lateral frontal orbital gyrus	47	31.6075	*	136	51	51	**0.2105**	0.1196
Left medial temporal gyrus	21	36.0793	*	1004	25	89	**0.0305**	0.0235
Right medial temporal gyrus	37	13.7006	***	43	68	160	**1.7281**	1.0336
Left lower temporal gyrus	20	32.0309	*	120	24	105	**0.1847**	0.1570
Right lower temporal gyrus	37	147037	***	46	61	160	**1.7106**	1.1243
Right post central gyrus	3	17.8001	**	56	145	116	**0.2448**	0.2142
Upper parietal lobe	7	13.8179	***	68	1455	150	0.0853	**0.2347**
Right angular gyrus	39	12.0161	***	36	130	120	0.4436	**0.1282**
Left supramarginal gyrus	40	14.2237	***	152	94	133	1.4310	**1.5986**
Precuneus	17	11.5159	***	68	92	146	**0.2066**	0.1360
Left lateral temporo-occipital gyrus	37	31.1516	*	116	31	108	**0.0226**	0.0192
Right lateral temporo-occipital gyrus	19	14.7735	***	45	61	160	1.1243	**1.7672**
Right medial temporo-occipital gyrus	19	28.5462	**	60	76	156	**0.0694**	0.0455
Right occipital pole	18	30.8841	*	60	87	191	**0.0747**	0.0329
Right upper occipital gyrus	19	21.0232	**	56	90	186	**0.1757**	0.0694
Cuneus	18	12.5800	***	67	88	156	**0.0132**	0.0074
Left lower temporal gyrus	37	14.7037	***	46	61	160	**1.7106**	1.15.70
Left upper temporal gyrus	20	31.8730	*	127	33	71	**0.2434**	0.1670
Right hippocampus formation	36	30.5701	*	116	58	99	0.2800	**0.3464**
Left parahippocampal gyrus	36	30.9513	*	112	28	93	**0.4106**	0.3277
Right parahippocampal gyrus	29	28.3790	**	88	76	133	**0.0327**	0.0253
Left hippocampus formation	34	30.5701	*	116	58	99	0.2800	**0.3464**
Right hippocampus formation	35	16.6760	**	64	74	129	**0.0507**	0.0416
Left uncus	28	31.4291	*	110	44	85	**0.4470**	0.3369
Right uncus	28	11.1588	***	76	40	84	**0.0855**	0.0761
Left insula	47	34.9951	*	120	83	67	**0.6601**	0.4401
Left acumbens nucleus	NA	27.1565	**	102	60	86	**0.1059**	0.0815
Left caudate nucleus	NA	26.9943	***	108	75	74	**0.0388**	0.0301
Right caudate nucleus	NA	14.3884	***	76	91	97	**0.0437**	0.0353
Left thalamus	NA	26.2191	**	108	84	120	**0.0554**	0.0390
Right thalamus	NA	16.2041	***	84	72	88	**0.0689**	0.0564
Left putamen	NA	34.9874	*	120	63	95	0.0094	**0.0298**
Globus pallidus	NA	34.2947	*	112	65	93	**0.0330**	0.0261
Left cerebellum	NA	19.4687	**	96	58	129	**0.1571**	0.0929
Right cerebellum	NA	11.7813	***	45	48	170	0.0590	**0.1063**
Brain stem	NA	30.3198	*	104	24	97	**0.0646**	0.0501

Table 6. Average and significant differences (Hotelling's T2) of LORETA solutions in theta band in words memorizing with phone only and with electromagnetic fields inhibitor (Phione and Phiwaves). AAL: Anatomical label cooresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable "to Brodmann areas. MI: Highest Intensity. X ST: average phone only. XT+ ICEM: average phone with electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

		T^2Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Right medial frontal gyrus	6	47.8800	*	60	116	100	**0.2145**	0.1193
Left medial frontal gyrus	44	32.8175	*	142	103	74	**0.8057**	0.6810
Right lower frontal gyrus	47	30.7541	*	43	76	80	**1.7010**	1.3832
Left lower frontal gyrus	47	36.1521	*	131	77	75	**0.8183**	0.5759
Left medial frontal gyrus	31	29.3535	**	101	116	104	0.1354	**0.1527**
Right medial frontal gyrus	31	26.7010	**	88	116	103	0.5175	**0.5860**
Left upper frontal gyrus	6	26.4751	**	117	132	90	**0.8201**	0.6713
Right upper frontal gyrus	6	37.5079	*	68	123	95	**0.2396**	0.1429
Left lateral orbitofrontal gyrus	47	34.8229	*	133	56	72	**0.9680**	0.7163
Right lateral orbitofrontal gyrus	47	30.5812	*	47	57	71	**1.4038**	0.9097
Left medial orbitofrontal gyrus	11	25.9293	*	95	53	68	**0.3212**	0.2618
Right medial orbitofrontal gyrus	11	26.2367	*	87	54	66	**0.3848**	0.3111
Right precentral gyrus	6	45.9144	*	44	131	95	**0.7814**	0.3801
Left precentral gyrus	6	34.1656	*	145	104	88	**0.6367**	0.4830
Right medial temporal gyrus	20	26.7980	*	143	57	101	**1.1166**	0.7568
Left medial temporal gyrus	21	30.1062	*	143	46	86	**0.6567**	0.3593
Left upper temporal gyrus	38	34.9416	*	133	56	75	**1.0540**	0.7427
Right upper temporal gyrus	38	30.7608	*	45	59	75	**1.6880**	1.1798
Left lower temporal gyrus	20	24.9047	*	144	40	95	0.5132	0.3540
Right postcentral gyrus	43	24.2451	**	33	108	100	**1.1762**	0.9193
Left postcentral gyrus	43	33.9436	*	153	98	102	**0.8310**	0.5127
Left supramarginal gyrus	40	29.8160	*	130	90	113	**0.3142**	0.2548
Left angular gyrus	39	19.4898	**	135	114	126	**0.8309**	0.7290
Right angular gyrus	39	11.0137	***	45	114	125	**1.1032**	0.7063
Right precuneus	7	33.6979	*	68	107	140	**1.2525**	1.4717
Left precuneus	7	27.1675	*	96	105	145	**1.0903**	1.3334
Right upper parietal lobe	7	36.6603	*	83	109	134	**1.1686**	1.3053
Left upper parietal lobe	7	36.7296	*	95	109	132	**1.0040**	1.1033
Right cuneus	18	30.7287	*	44	64	77	**1.9733**	1.4043
Left parahippocampus gyrus	29	19.0289	**	96	83	137	0.2148	0.3180
Right parahippocampus gyrus	29	12.6815	***	85	76	139	0.1069	0.1969
Left hippocampus formation	28	20.8407	**	112	52	97	0.3752	0.3936
Left cingulate region	23	41.4694	*	96	97	125	**0.1394**	0.1597
Right cingulate region	23	42.8689	*	84	100	107	0.0547	**0.0596**
Right uncus	28	28.6435	**	56	52	81	**0.6639**	0.4877
Left uncus	28	29.2886	**	120	52	86	**0.2955**	9.2397
Left insula	47	36.0813	*	131	70	72	**1.0330**	0.8140
Left caudate nuclus	NA	34.7966	*	102	84	90	0.0217	**0.0267**
Right caudate nucleus	NA	31.0894	*	82	88	90	**0.0115**	0.0107
Left glubus pallidus	NA	30.8064	***	106	69	87	**0.0459**	0.0426
Right globus pallidus	NA	19.1520	***	68	69	86	**0.1087**	0.0838
Left putamen	NA	41.2339	*	119	76	99	**0.0365**	0.0285
Right putamen	NA	20.7433	*	65	70	84	**0.1324**	0.0983

Left thalamus	NA	33.5393	*	100	80	100	0.1977	**0.2063**
Right thalamus	NA	33.7454	*	86	80	101	0.2425	**0.2588**
Brain stem	NA	26.5512	*	93	67	103	0.2892	0.3399

Table 7. Average and significant differences (Hotelling`s T2) of LORETA solutions in alpha band in the words memory task with phone only and with electromagnetic fields inhibitor (Phione and Phiwaves). AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable "to Brodmann areas." MI: Highest Intensity. X ST: average phone only. XT+ICEM average phone with electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

		T^2Hotelling		Coordinates			MI Voxels	
AAL	AB	MI Voxels		X	Y	Z	*X* ST	*X* T+ICEM
Right medial frontal gyrus	46	12.4471	***	52	97	71	**0.1317**	0.1214
Left medial frontal gyrus	10	12.0808	***	132	100	80	**0.5508**	0.5061
Right lower frontal gyrus	47	11.5631	***	39	62	58	0.3163	**0.4175**
Left lower frontal gyrus	44	13.5457	***	152	93	75	0.6058	**0.8011**
Left precentral gyrus	6	14.4365	***	154	100	8	0.2191	**0.2892**
Right medial temporal gyrus	37	30.1415	*	41	101	151	1.1685	**1.3386**
Left lower temporal gyrus	21	10.9504	***	152	48	97	**0.7785**	0.5934
Right lower temporal gyrus	37	17.7490	**	40	66	160	1.4138	**2.2663**
Right angular gyrus	39	31.5400	*	40	104	152	1.2277	**1.4023**
Lóbulo upper parietal gyrus	7	21.7667	**	75	101	155	2.0175	**2.8405**
Lóbulo upper parietal gyrus	7	19.3536	**	96	120	166	1.3642	**1.8532**
Right precuneus	7	22.3650	**	76	94	155	2.0145	**2.9036**
Left precuneus	7	24.7995	**	100	86	157	2.5784	**3.3975**
Right medial occipital gyrus	18	30.9294	*	39	102	154	1.2369	**1.4103**
Left upper occipital gyrus	18	22.0616	**	100	97	165	2.3557	**3.1810**
Right upper occipital gyrus	19	11.9301	***	2	88	174	1.1695	**1.6906**
Right lingual gyrus	17	25.6678	**	88	82	171	3.0913	**4.1878**
Left lingual gyrus	17	29.8586	*	100	75	169	3.0074	**3.2498**
Left medial occipito-temporal gyrus	18	29.9391	*	100	76	165	2.8482	**3.2762**
Right medial occipito-temporal gyrus	18	25.9578	**	88	82	116	3.1257	**4.2936**
Right lateral occipito-temporal gyrus	19	15.3407	***	47	60	160	1.1209	**2.1961**
Left lateral occipito-temporal gyrus	18	10.9447	***	115	58	180	**3.2786**	2.5561
Right cuneus	18	25.7196	**	88	85	170	2.4415	**3.3354**
Left cuneus	17	29.3847	*	97	78	166	3.0532	**3.6597**
Left occipital pole	18	20.6180	**	107	73	189	**2.5095**	1.7711
Right parahippocampal gyrus	26	20.8696	**	77	83	150	1.4502	**2.1701**
Left parahippocampal gyrus	29	23.1891	**	104	81	150	1.5553	**2.0312**
Left cingulate region	23	13.7348	***	91	100	139	1.3238	**1.8274**
Right cingulate region	23	13.6967	***	94	100	139	1.1890	**1.6416**
Right caudate nucleus	NA	11.7193	***	76	85	76	**0.0167**	0.0048

Table 8. Average and significant differences (Hotelling`s T2) of LORETA solutions in the beta band on only phone and electromagnetic fields inhibitor (Phione and Phiwaves) in the words memory task. AAL: Anatomical label corresponding to probabilistic MRI atlas of Montreal (PMA). AB: Brodmann areas. NA: Not applicable "to Brodmann areas." MI: Highest Intensity. X ST: average phone only. XT+ICEM average phone with electromagnetic fields inhibitor (Phione and Phiwaves). Hotelling`s T2: Significant activity peak value in voxels. <0001: *, <0.01: **. <0.05: ***.

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