

# Effect of Mobile Phone Emissions on HD- EEG Signals and Preventive Measures

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## Research Article

**Keywords:** Electroencephalography (EEG), Mobile Phone Radiations, brain, Radiofrequency Radiations (RFR), Envirochip

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## **Effect of Mobile Phone Emissions on HD- EEG signals and preventive measures**

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Keywords: Electroencephalography (EEG), Mobile Phone Radiations, brain, Radiofrequency Radiations (RFR), Envirochip.

1 **Abstract:**

2 **Background:** Mobile Phones and other wi-fi devices have become an integral part of our life. Now that we  
3 have so much dependency on technology, it's become almost impossible to extricate ourselves from this.  
4 Considering the widespread use of these devices and the public's concerns for health and safety, it is important  
5 to find out the possible harm caused by these Radiofrequency Radiations (RFR) emitted by Mobile Phones and  
6 other wi-fi devices, ways to protect ourselves from this harm and use of technology responsibly.

7 Many renowned agencies and researchers have completed and published several studies detailing out possible  
8 health risks associated with the exposure to Radiofrequency Radiations emitted from these devices. World  
9 Health Organization/ International Agency for Research on Cancer had classified radiofrequency  
10 electromagnetic fields as Group-2B, possibly carcinogen in 2011<sup>1</sup>.

11 The present study has analyzed the effect of Mobile Phone Radiations exposure on human brain activity in  
12 healthy human volunteers and the efficacy of one of the products named Envirochip which claims to reverse  
13 the impact on Brain waves when it is fixed on the Mobile Phone being used.

14 **Result:** A total of 30 healthy participants were enrolled in this study, out of which, data of 29 subjects was  
15 analyzed as data of one subject was removed due to noise in the recorded data. The experiment was  
16 designed to take the EEG data with six different conditions (baseline/normal data without any device,  
17 baseline data when Mobile Phone was kept near head of the subject, data while Mobile Phone was ringing  
18 (with and without Envirochip) and data when a call was made on the Mobile Phone (with and without  
19 Envirochip).

20  
21 Electroencephalography (EEG) was recorded for 80 minutes with five minutes interval between each  
22 condition for each subject. Cleaned data was extracted from the Net station tool and power spectrum  
23 analysis was done

24  
25 **Conclusion:** There was increased activity in the alpha, beta, theta and gamma bands of EEG during  
26 Radiofrequency exposure from Mobile Phones. Fixing the Envirochip on Mobile Phone showed statistically

27 significant improvement in the effects of the Mobile Radiations on EEG brain activity in the alpha and theta  
28 bands. However, changes observed in gamma and beta bands were not significant statistically.  $P < 0.05$  was  
29 considered statistically significant.

30

### 31 **Background:**

32 In today's world, it is hard to imagine life without the Internet, Mobile Phone and other wireless devices. These  
33 devices have become our daily companion for everything we do, be its office work, banking and payments,  
34 children's studies or staying in touch with our loved ones staying in remote locations.

35 While Technology seems to have become a blessing for us, at the same time it can be a curse also when it  
36 comes to the impact of these Radiofrequency Radiations on health and well-being. Effect of Radiofrequency  
37 Radiations / Electromagnetic Radiation can be classified as:

- 38 • Thermal Effects
- 39 • Non-Thermal Effects

40 The thermal effects are caused due to the heat that is generated due to the absorption of radiation. The Specific  
41 Absorption Rate (SAR) value has been fixed and specified for mobile phones to limit the thermal effects.  
42 However, more research is going on to study the Non-Thermal effects of these radiations which are far more  
43 harmful than the Thermal effects. The Non-Thermal effects may range from burning and tingling sensation  
44 near the head, fatigue, heart palpitations, lack of concentration, nausea, dizziness, delayed reaction time, sleep  
45 disturbance, loss of memory, headache, effect on heart and brain etc.

46 Since the brain has greater exposure to these Radiofrequency Radiations than the rest of the body while  
47 using Mobile Phone, it becomes all the more important to analyze the effect of these RFR on brain activity  
48 or EEG. A study revealed that pulsed radiations from Mobile Phone use can trigger human brain evoked  
49 potentials (EPs)<sup>2</sup>. Another study showed that when a Mobile Phone is placed on the ear, its radiations are  
50 electrically detected by the brain, resulting in increased cortical activity<sup>3</sup>.

51

52 A study published in PubMed in 2004 concluded that excessive use of the mobile phone is a risk factor for

53 developing a higher prevalence of fatigue, headache, dizziness, tension and sleep disturbances<sup>4</sup>. It is evident  
54 from the results of the study that the percentage of participants showing symptoms of headache was the  
55 highest which shows a great impact on the brain. A randomized crossover study found that just 50 minutes  
56 of exposure to cell phone radiations directly alters the production of brain glucose metabolism in adult<sup>5</sup>.

57

58 According to an article published in the National Library of Medicine, 18 epidemiological studies provided  
59 evidence that EMFs from cell/mobile phones can produce neuropsychiatric effects including headache,  
60 memory changes, and EEG changes<sup>6</sup>.

61

62 There have been many other well-researched and published studies that claim that there is an increase in the  
63 alpha and beta activities after exposure to the Electromagnetic Fields (EMFs)<sup>7,8,9,10</sup>. A study also found that  
64 the alterations in the theta and gamma bands were correlated with EMFs induced working memory deficit<sup>11</sup>.  
65 A recent study published in Frontier in Neuroscience found that there was increased activity in the theta,  
66 alpha, beta and gamma bands during EMF exposure<sup>12</sup>. The study concluded that EMF exposure can impair  
67 human health, performance, cognitive function and brain activity.

68

69 Also, there are a few studies on the subject that claim that the effect on the brain is not attributed to mobile  
70 radiations or the result is inconclusive.

71

72 The present study was aimed to investigate the effects of mobile phone radiations on brain activity when  
73 participants were exposed to RFR of Mobile Phones and to examine the efficacy of Envirochip in  
74 neutralizing the same. Changes in the frequencies of these EEGs can be interpreted as scientific evidence of  
75 an indication of the impact of the exposure to Radiofrequency Radiation used in mobile communication on  
76 brain activity<sup>13</sup>.

77

78 **Materials and Methos:**

79

80 **Subjects:**

81 The study was performed on 30 healthy subjects having age between 18-40 years (mean: 36.43±5.85). The  
82 study was conducted at the All India Institute of Medical Sciences, New Delhi, India. All enrolled subjects  
83 were healthy and it was ensured that none of them had any ailment like vision and hearing complications. They  
84 were also interviewed about coffee/ tea intake, last night's sleep quality and any kind of work/home related  
85 stress before their data was taken because these factors may affect the results. None of the participants had any  
86 history of neurological diseases. Participants voluntarily agreed to participate in the research and their EEG  
87 was recorded in all the conditions including with Envirochip and without the Envirochip. Written consent was  
88 obtained from all the subjects before initiating the study. Subjects and technicians were blinded to the  
89 conditions (baseline, with the phone, with Envirochip etc.) of the study. The Procedure of the study was  
90 approved by the institutional ethics committee, All India Institute of Medical Sciences, New Delhi. The study  
91 has been registered by the clinical trial registry of India (CTRI/2017/07/009090, registered on: 21/07/2017).

92

93 **Equipment and procedures:**

94

95 **EEG system:**

96 Brain activity was recorded using high density EEG (Philips Neuro (EGI Inc.), USA) with Hydrocele  
97 Geodesic sensor net (HCGSN 300), based on a 10/10 international system. This system constitutes 128  
98 channel dense array (Tucker; 1993), the sampling rate was set at 250 Hz. We used different sized nets (51-  
99 54 cm, 54-56 cm, and 56-58 cm) as per the head circumference of the subjects. The electrode impedance  
100 was kept below 50 k $\Omega$  in accordance with the recommendations of the manufacturer. The vertex (Cz)  
101 electrode was used as a recording reference. For the transmission of the signal from the scalp to the electrode,  
102 the electrolyte (KCl) was applied. Electrodes were used as an interface between the subjects and the EEG  
103 system for the recording of the specific brain activity. A specific amplifier (Net Amps 300) was used to  
104 display the low noise and high sensitivity of EEG waves. The band pass filter was set as 1.0 Hz to 70 Hz  
105 and the notch was kept as 50 Hz to remove the electrical noise., Net Station software was used during  
106 recording and analysis was performed in Net Station Tools, EEGLAB and BESA (Brain Electrical Source  
107 Analysis 6.0) tools.

108

109 **Mobile Phone and Envirochip application:**

110

111 A standard android mobile phone (black) of 2500 mAh battery was used and the Envirochip was fixed at the  
112 backside of the mobile phone at the specified location (Figure 1a and Figure 1b; Manufacturer: Syenergy  
113 Environics Ltd). The mobile phone was held using the specific band called blindfold next to the left ear of  
114 the subjects. The same mobile phone was used for all the participants to eliminate the possibility of any  
115 deviation in the subject's conditions. As per the manufacturer, the Envirochip when fixed at a certain location  
116 on the electronic devices works by changing the nature (waveform) of emitted RFR from systemic to  
117 random, rendering them non-bio-effective and neutralizing the harmful impact of the Mobile Phone  
118 radiations on the human body.

119

120 **Experimental design:**

121 Total six sessions were performed for each subject; the average duration of the total protocol was  
122 approximately 80 minutes per subject. Five minutes interval was given between any two consecutive sessions  
123 to reduce the heat generated by skin contact and the android Mobile Phone and to nullify the effect of  
124 accumulated exposures. Normal brain activity was recorded in all the subjects to establish the baseline.

125 In another session, the baseline was recorded with a Mobile Phone affixed next to the subject's left ear with  
126 the help of a blind mask. The same Mobile Phone was used for the whole study. No other wireless apparatus  
127 was present in the near field and far-field of the mobile device, no credit /debit cards were kept in the subject's  
128 pocket. All the subjects were instructed to remove all the ornaments/ jewelry/ other metals from their body  
129 which might affect the recording of the EEG data.

130

131 The mobile phone was placed next to the left ear in each case and was held in place with the help of the  
132 blind mask. The third and fourth categories of recording involved the Mobile Phone affixed next to the  
133 subject's ear while the phone was ringing and in call mode. In both the conditions, EEG was recorded with  
134 and without the Envirochip [i.e. ring with Envirochip (RMC), ring without Envirochip (RWC), call with  
135 Envirochip (CMC) and call without Envirochip (CWC)];. Rings and Calls were made with another android

136 Mobile Phone. For the measurement of resting state EEG, the recording was performed in a supine position,  
137 maintaining the task free state in all the subjects. It was ensured that no other sound was present in the room  
138 which might affect the brain activity/EEG of the subject, at the time of testing.

139

#### 140 **EEG data analysis:**

141

142 After the recording, EEG data was analyzed using Net Station 5.0 tool offline. All prominent artifacts (eye  
143 movement, muscle, electrical noise) were detected and removed visually. A total of 20 noise-free epochs (1  
144 second each) were selected. Following this, Independent Components Analysis (ICA) in EEGLAB (Swartz  
145 Centre for Computational Neuroscience, San Diego, USA) was performed for the further cleaning of data  
146 by removal of electrocardiographic and muscle generated artifacts. Power frequency plots of the selected  
147 epochs for different sessions were plotted along with their topographical maps (Figure 2a, 2b, 2c, 2d, 2e and  
148 2f). As a primary outcome of the study, power spectral analysis of different bands (theta, alpha, beta and  
149 gamma) was performed using Fast Fourier Transformation (FFT) algorithm. The FFT was performed using  
150 the Brain Electrical Source Analysis software package (BESA 6.0). The data was analyzed by differentiated  
151 assessment of the EEG frequencies in the theta (4- 7Hz), alpha (8-13 Hz), beta (14-30 Hz), and gamma (31-  
152 70 Hz) bands.

153

#### 154 **Statistical Analysis:**

155

156 The statistical analysis was performed using Sigma Plot (version: 13.0, SYSTAT Software Inc., Chicago,  
157 USA). Shapiro-Wilk test was used to check the normality of the data. As the data was skewed, the Friedman  
158 test was applied to compare more than two parameters in a group while the Wilcoxon rank sum test was  
159 used to compare the difference and changes between two variables. A significance level ( $p < 0.05$ ) was set  
160 for all the statistical analyses.

161

#### 162 **Results**

163



164 Out of 30 subjects, 29 subjects (10 (34.5%) females and 19 (65.5%) males; age:  $26.48 \pm 5.95$ ) were taken for  
165 the final analysis. One subject was excluded due to excess electrical noise in more than half of the channels.  
166 The frequency of all the bands (theta range: 4-7 Hz, alpha range: 8-13 Hz, beta range: 14-30 Hz, Gamma  
167 range: 31-70 Hz) was taken for the final presentation. Data was pooled and demonstrated the mean of all the  
168 conditions as a baseline, baseline with a mobile phone, RMC (Ring with Envirochip), RWC (Ring without  
169 Envirochip), CMC (Call with Envirochip) and CWC (Call without Envirochip). A total of six conditions  
170 were checked to analyze the significant impact of the Mobile Radiations on brain activity and the efficacy  
171 of Envirochip in correcting the same.

172

### 173 **Comparison between all conditions of theta waves:**

174

175 In this study, we have found significant changes ( $p=0.029$ ; Table 1) between all the six conditions for theta  
176 wave activity of all the participants. When we compared normal baseline and baseline with the phone to  
177 CMC (call with Envirochip), significant changes were observed between them ( $z= -2.768$ ;  $p=0.006$  and  $z=-$   
178  $2.087$ ;  $p=0.037$ ; Table 2) respectively. No significant results were observed in any other condition as shown  
179 in Table 2. Graphical representation with the specific frequency range (at 6 Hz) has been shown in Figure  
180 2a, 2b, 2c, and 2d as a baseline, baseline with the phone, CWC (call without Envirochip) and CMC (call  
181 with Envirochip) respectively and the figure depicts the association of brain activity in the particular theta  
182 range. Detailed data of mean and standard deviation of all the conditions are shown in Supplementary Table  
183 1 and Supplementary Table 2.

184

### 185 **Comparison between all conditions for the alpha wave:**

186

187 We have compared all the conditions for the alpha wave and found highly significant changes ( $p=0.007$ ;  
188 Table 1) between all the six conditions. While comparing CMC (call with Envirochip) and CWC (call  
189 without Envirochip), we found highly significant changes between these two ( $p=0.003$ ; Table 2). Also, we  
190 found significant changes between RMC (ring with Envirochip) and RWC (ring without Envirochip) and  
191 between baseline with Phone and RMC (ring with Envirochip) conditions. (Table 2). Figures 2a, 2b, 2c, 2d,

192 2e and 2f represent the specific frequency range at 10 Hz which was associated with alpha brain activity.  
193 Detailed data of mean and standard deviation of all the conditions are shown in Supplementary Table 1 and  
194 Supplementary Table 2.

195

#### 196 **Comparison between all conditions for beta and gamma waves:**

197

198 There were no significant changes in the beta wave when we compared all the conditions within the group  
199 ( $p=0.629$ ; Table 1 and Table 2) while the gamma frequency band showed a trend towards significance in  
200 within-group comparison ( $p=0.075$ ; Table 1). We also compared two groups to see the changes in beta and  
201 gamma wave, we found some trend toward significance between RMC (ring with Envirochip) and RWC (ring  
202 without Envirochip) ( $p=0.080$ ; Table 2) in the beta band and between CMC (call with Envirochip) and CWC  
203 (call without Envirochip) ( $p= 0.068$ ; Table 2) in theta band activity graph as shown in figure 2a,2b,2c, 2d,  
204 2e and 2f at 22 Hz and 50 Hz respectively. However, none of the changes were statistically significant in the  
205 Beta and gamma band. Detailed data of mean and standard deviation has been shown in the supplementary  
206 Table 5.

207

#### 208 **Discussion**

209

210 The increase in brain activity in alpha and theta bands indicates enhanced excitability of the brain during  
211 Radiofrequency exposure from the Mobile Phone. The subjects received six exposures with an interval of 5  
212 minutes between each measurement and the same Mobile Phone was used to analyze the difference in the  
213 results. Several experiments, empirical observations and evidence establish that radiations emitted from  
214 Mobile Phones pose serious threats to human health and cognitive functions<sup>14,15,16</sup>. The results of this study  
215 demonstrated that RFR emitted by Mobile Phones can be the reason for the changes in brain activity. It was  
216 also demonstrated that the application of Envirochip on the Mobile Phone can reduce the increased brain  
217 activity mainly in alpha and theta bands induced by RFR exposure from the Mobile Phone. The results of  
218 the present study have the same findings as previous EEG studies in the research field confirming and

219 extending their observations. Previous research has shown increases in alpha activity by EMF exposure<sup>17</sup>.  
220 Further, the alterations in the theta waves demonstrated here also confirm results of the previous  
221 studies<sup>11</sup>.

222

223 The present study revealed that prolonged exposure to the Radiofrequency Radiations emitted by Mobile  
224 Phones can affect brain activity and Envirochip has the potential to reduce the excitability in alpha and beta  
225 bands. However, this was just a primordial study interpreting conclusively the changes in brain waves by  
226 radiation and, hence, effects of Enviro Chip warrant further study using several other indices of human  
227 health and a large study population.

228

229 The findings of the present study are important for today's working environment as Mobile Phones have  
230 become an essential part of our daily life. Seeing that their use has increased considerably, the dimensions of  
231 the problem are more. Since we can't stop using technology to our advantage, we have to find ways to protect  
232 ourselves from harm.

233 It is also suggested to read the Mobile Phone's manuals, use handsfree and follow the recommended talk time  
234 and distance guidelines mentioned in the Mobile Phone manual.

235

#### 236 **Declarations:**

237

#### 238 **Ethics approval and consent to participate**

239 The Protocol of the study was approved by the institutional ethics committee, All India Institute of Medical  
240 Sciences, New Delhi and all methods were performed in accordance with the relevant guidelines and  
241 regulations. Informed consent was obtained from all subjects and/or their legal guardian(s).

242

#### 243 **Consent for publication**

244 The authors give their consent for publication of the manuscript and all the data given in the manuscript.

245

#### 246 **Availability of data and materials**

247 All data are included in the manuscript.

248

### 249 **Competing interests**

250 The authors declare no competing interests.

251

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254

### 255 **Authors' contributions**

256 Research idea and study design: AP, MT; Manuscript writing: RD, SS, SR; Data Extraction and preparation  
257 of figures: RD, DJ. Manuscript revision for important intellectual content: all authors. All authors reviewed  
258 the manuscript and given their potential inputs.

259

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262

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**Figure 1 (a) and figure 1 (b): EnviroChip(White and black colour) on the back side of mobile phone**



1(a)



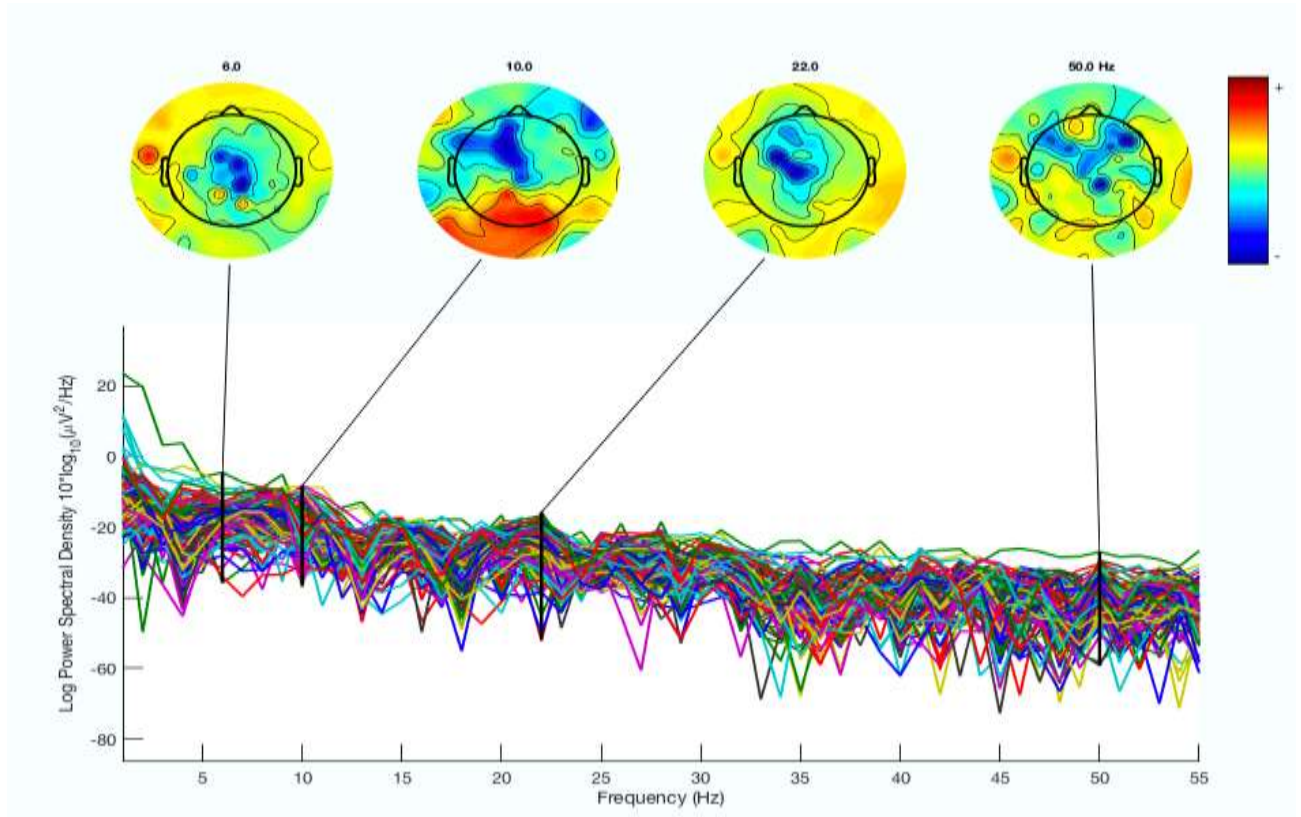
1(b)

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352 **Figure 2a: Baseline data:** Activity of Theta (4- 7Hz), Alpha (8-13 Hz), Beta (14-30 Hz), and Gamma  
353 (31-70 Hz) bands in all healthy subjects.

354 **Blue**- least activity **Green**- low activity **Yellow**- normal activity and **Red**- highest activity in brain.

355

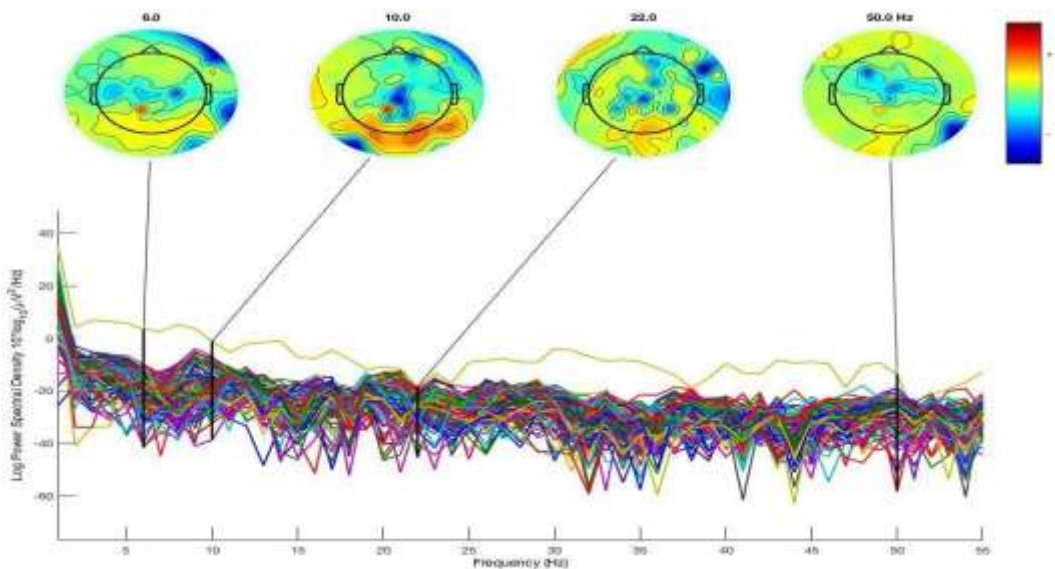


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358 **Figure 2b:** Activity of Theta, Alpha, Beta and Gamma waves at **baseline with phone** in all healthy  
359 subjects.

360 **Blue**- least activity **Green**- low activity **Yellow**- normal activity and **Red**- highest activity in brain.

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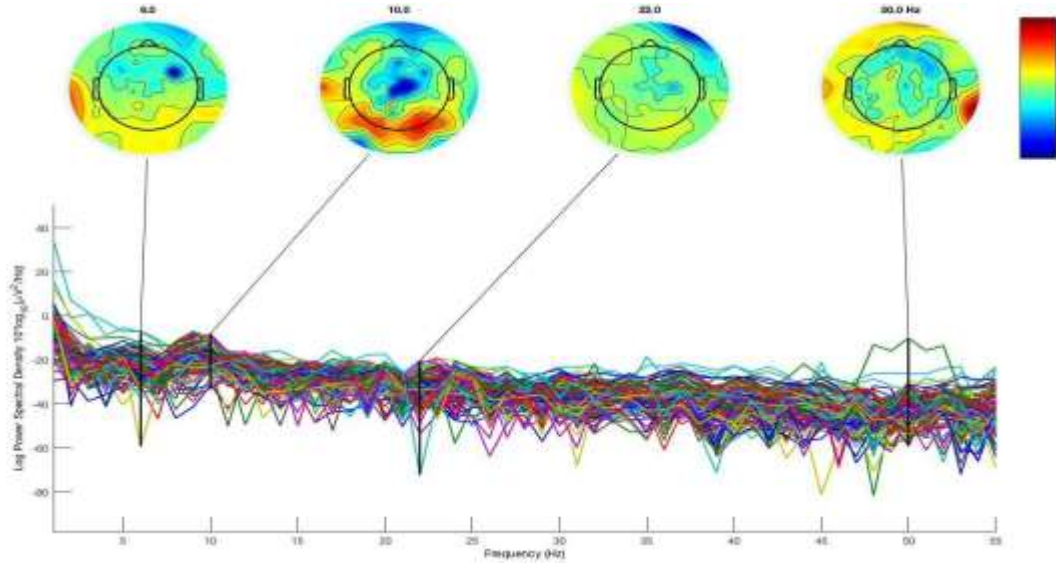




363 **Figure 2c:** Activity of Theta, Alpha, Beta and Gamma waves at **Call without Envirochip (CWC)** in all  
364 healthy subjects.

365 **Blue**- least activity **Green**- low activity **Yellow**- normal activity and **Red**- highest activity in brain.

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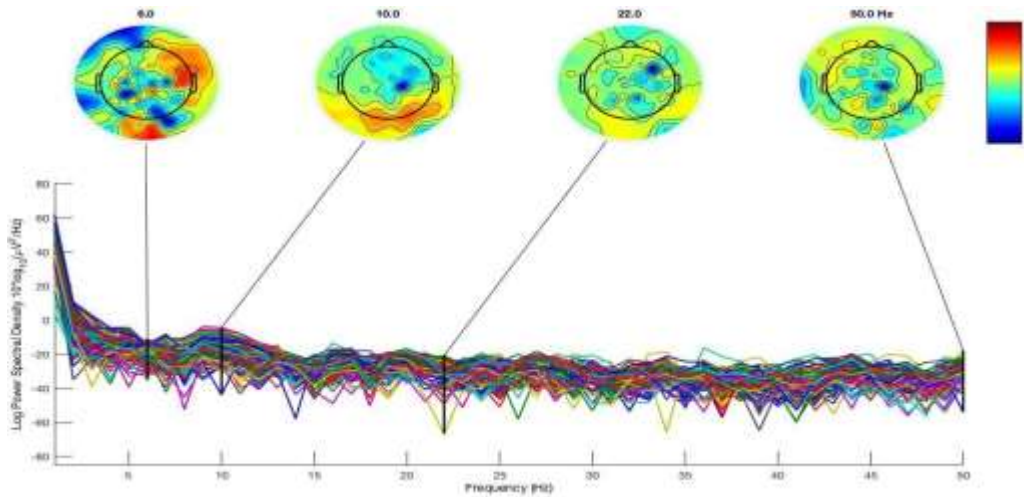
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375 **Figure 2d:** Activity of Theta, Alpha, Beta and Gamma waves at **Call with Envirochip (CMC)** in all healthy  
376 subjects.

377 **Blue**- least activity **Green**- low activity **Yellow**- normal activity and **Red**- highest activity in brain.

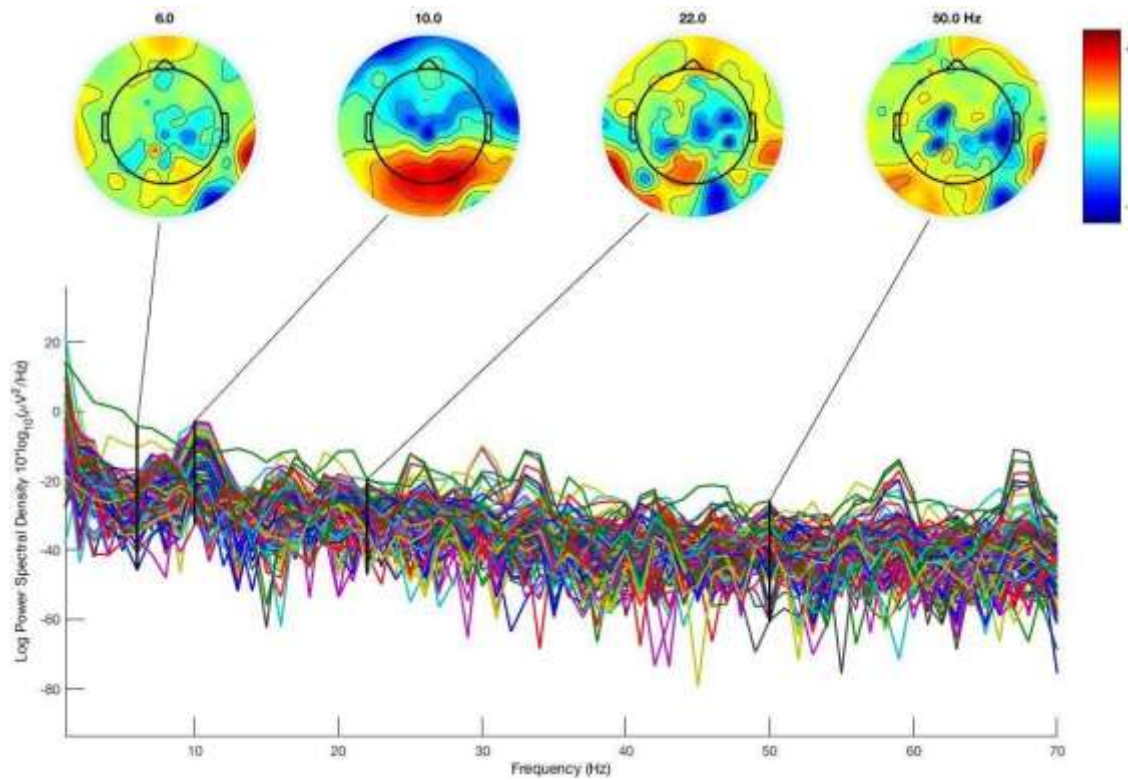
378

379



**Figure 2e:** Activity of Theta, Alpha, Beta and Gamma waves at **Ring without Envirochip (RWC)** in all healthy subjects.

**Blue**- least activity **Green**- low activity **Yellow**- normal activity and **Red**- highest activity in brain.



**Figure 2f:** Activity of Theta, Alpha, Beta and Gamma waves at **Ring with Envirochip (RMC)** in all healthy subjects.

**Blue**- least activity **Green**- low activity **Yellow**- normal activity and **Red**- highest activity in brain.

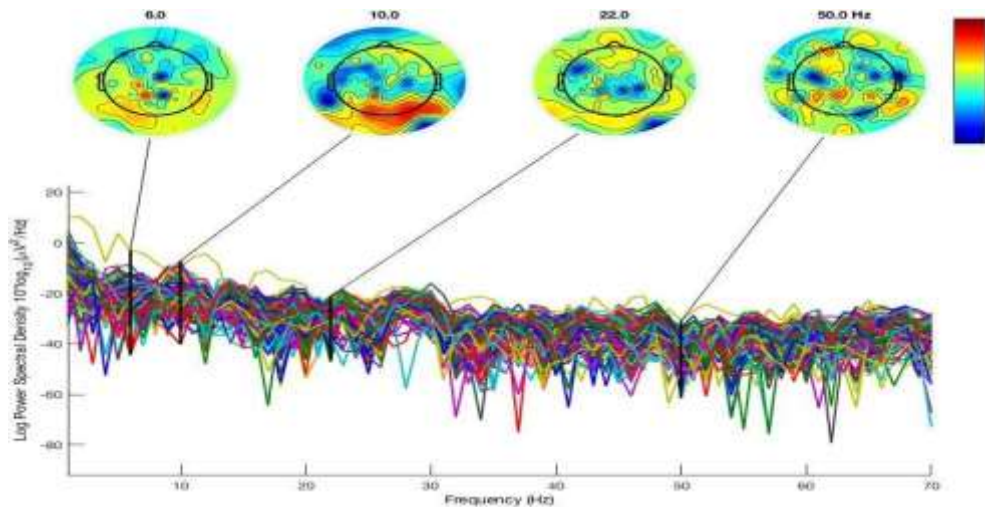


Table 1: Power spectrum frequency of different waves (alpha, Theta, Beta and Gamma)

Variables	Theta Wave				Alpha Wave			
	Median	Minimum	Maximum	P-value	Median	Minimum	Maximum	P-value
Baseline	26.09	9.75	81.47	0.029*	39.08	4.16	180.72	0.007*
Baseline with mobile phone	26.02	5.06	130.93		31.46	4.48	252.76	
CMC	34.46	13.72	99.58		50.05	9.89	122.67	
CWC	24.58	8.22	104.60		36.97	5.24	93.35	
RMC	28.70	9.61	92.53		45.08	8.54	157.59	
RWC	29.50	12.40	112.37		46.58	7.45	161.25	
Variables	Beta wave				Gamma wave			
	Median	Minimum	Maximum	P-value	Median	Minimum	Maximum	P-value
Baseline	15.45	3.78	31.11	0.629	4.41	0.23	8.43	0.075
Baseline with mobile phone	15.12	4.21	50.27		3.56	0.13	8.58	
CMC	15.55	7.21	35.68		3.86	0.47	25.35	
CWC	14.41	6.55	72.92		3.57	0.22	6.72	
RMC	17.09	7.23	37.16		4.44	0.78	16.50	
RWC	15.33	6.69	14.05		4.14	0.87	19.14	

(Data represented as Median (minimum - maximum), CMC =Call with mobile phone chip, CWC=Call without mobile chip, RMC= Ring with mobile phone chip, RWC= Ring without mobile chip, \* significant p value<0.05)

Table 2: Comparison between baseline to baseline-phone, CMC to CWC and RMC to RWC

Variables	Theta wave		Alpha wave		Beta wave		Gamma wave	
	Z-score	P-value	Z-score	P-value	Z-score	P-value	Z-score	P-value
Baseline vs Baseline phone	-0.530	0.596	-0.31	0.754	-0.724	0.469	-1.730	0.084
CMC vs CWC	-1.676	0.094	-2.97	0.003**	-0.227	0.820	-1.822	0.068
RMC vs RWC	-1.070	0.284	-1.957	0.050*	-1.708	0.088	-0.519	0.604
Baseline vs CMC	-2.768	0.006**	-0.94	0.347	-0.811	0.417	-0.410	0.682
Baseline vs CWC	-0.616	0.538	-1.005	0.315	-0.141	0.88	-0.133	0.184
Baseline vs RMC	-0.876	0.381	-1.91	0.056	-1.287	0.198	-0.876	0.381
Baseline vs RWC	-0.746	0.456	-0.789	0.430	-0.205	0.837	-0.411	0.681
Baseline_phone vs CMC	-2.087	0.037*	-1.26	0.206	-1.135	0.256	-1.297	0.194
Baseline_phone vs CWC	-0.951	0.341	-0.162	0.871	-0.249	0.804	-0.119	0.905
Baseline_phone vs RMC	-1.762	0.078	-1.957	0.050*	-1.524	0.127	-1.546	0.122
Baseline_phone vs RWC	-1.654	0.098	-1.049	0.294	-0.357	0.721	-1.654	0.098

(Data represented as Z score. vs= versus, CMC =call with mobile phone chip, CWC=Call without mobile chip, RMC=Ring with mobile phone chip, RWC=Ring without mobile chip,

\*\* highly significant (p<0.005), \* significant p value<0.05)

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryTables.docx](#)