

## EFFECT OF ELECTROMAGNETIC WAVES EMITTED FROM MOBILE PHONE ON HIGHER MENTAL FUNCTIONS

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**Background:** In the present era, mobile phones (MP) have become an integral part of life. Electromagnetic waves (EMW) emitted from mobile phone affect the health of human beings. When a person is using the mobile phone, it is in close proximity of head, and the electromagnetic radiation emitted from them, may penetrate the brain. **Objectives:** So, It was planned to study the effect of electromagnetic waves emitted from mobile phone on higher mental functions by applying Rey Auditory Verbal Learning Test (RAVLT). **Material and Methods:** The study was carried out in 40 normal healthy adults, 20 males and 20 females, in the age group of 18-40 years, who were using mobile phone for the last 5 years or more, with per day exposure of more than 30 minutes. Subjects with history of neurological disorders, ear diseases, and narcoleptic medications were excluded. The Rey Auditory Verbal Learning Test was performed before and after exposure to mobile phone, GSM 900, for 10 minutes. Statistical analysis was done by Paired "t" test using SPSS 20.

**Results:** The mean age of subjects was  $26 \pm 6.02$  years. Mean /day exposure to MP was  $58.23 \pm 17.37$  minutes. Trial 1 score was increased significantly ( $<. 05$ ) from  $5.68 \pm 1.83$  to  $6.48 \pm 2.15$ ) after exposure to MP. Trial 5 score (from  $12.55 \pm 2.15$  to  $12.70 \pm 2.14$ ) and Trial 6 score (from  $11.93 \pm 2.49$  to  $12.38 \pm 2.72$ ) showed no significant improvement after exposure to MP. Trial 7 score was ( $11.33 \pm 2.68$ ) before exposure and reduced insignificantly to ( $11.10 \pm 3.50$ ) after exposure to MP. The recognition score and errors in recognition were almost same before versus after MP exposure. There was insignificant variation between males and females in different scores of RAVLT before and after exposure to MP.

**Conclusion:** Higher mental functions are affected by EMW emitted from MP.

Key words: Electromagnetic waves, Mobile Phone, Working Memory, Attention.

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### Introduction:

These days, it is difficult to think the life without mobile phone (MP). At some places, use of mobile phone is banned to the culprit for giving him punishment<sup>1</sup>. Although MP are integral part of modern communication, ill effects of electromagnetic radiation (EMR) emitted from MP cannot be ruled out. MP emits electromagnetic waves (EMW) in the frequency range of 100-2000 MHz. Part of EMR may penetrate the brain and may affect brain functions<sup>2</sup>. Extensive researches have been undertaken to explore the effects of EMR emitted from MP on cognition<sup>3, 4</sup>. But results remain divided as no significant effect<sup>5</sup>, negative effects<sup>6, 7</sup> or facilitatory effects<sup>2, 8</sup> on brain functions, requiring attention and

manipulation of information in working memory and in those tasks which depends on prefrontal cortical functions<sup>4</sup>. It is stated that EMR emitted from MP can accelerates dementia and early onset of Alzheimer disease<sup>9</sup>. So, it was planned to study the effects of EMW emitted from MP on higher mental functions by applying Rey Auditory Verbal Learning Test<sup>10</sup> (RAVLT).

RAVLT is an efficient neurological method for examination of verbal episodic declarative memory. It provides scores for assessing immediate memory, new verbal learning, susceptibility to inference (proactive and retroactive), retention of information for period of time, and memory recognition. RAVLT is a sensitive indicator of verbal memory deficit and

neurological conditions<sup>11</sup> like Temporal lobe epilepsy, Alzheimer disease, Schizophrenia, Parkinson's disease, Autism, Depression, Dementias, Alcoholic amnesia, Traumatic and vascular amnesia and Impairment of aging. RAVLT is sensitive tool to differentiate these clinical disorders. Scores achieved in RAVLT for verbal learning and verbal episodic declarative memory correlates well to the executive functions<sup>12</sup>.

#### **Material and Methods:**

The study was carried out in 40 healthy subjects (20 males and 20 females) in the age group of 18-40 years, who were using the MP from 30 minutes to one hour per day for the last 5 years or more. Subjects with history of head trauma, hearing disorder, neurological or psychological disorder and intake of drugs like Benzodiazepine and opiates were excluded from the study. Subjects chosen were at least of 10<sup>th</sup> grade of education. Whole of the procedure was explained to the subjects. Written consent was taken. Study was approved from the institutional Ethical Committee. Subjects were prohibited for using any medication, caffeine or MP at least one hour before the test.

**RAVLT:** The RAVLT consists of five presentations (at a constant rate of 1 word per second) of list (list A) having 15 unrelated words, with free recall procedure following each presentation. Thereafter second list (list B) of 15 words was presented, followed by recall test. Then sixth recall trial of list A (STM recall) was done. Following 20 minutes delay, seventh recall trial was done for delayed recall. Recognition was examined by asking from subject, which of the 50 words (having 35 new words and 15 words from list A) read aloud were from list A (15 possible words) and which were not (35 possible false answers)<sup>10</sup>. Scoring was done by giving one point for each correct word recalled<sup>12</sup>.

#### **Exposure to mobile phone:**

Recording of RAVLT was done first in resting condition before exposure to mobile phone. Then person was exposed to electromagnetic radiation (EMR) emitted from mobile phone (GSM type, Samsung model GT-N7100, 902 MHz, SAR limit 2.0 W / Kg, average power emitted 0.125-0.25 W / cm<sup>2</sup>) for ten minutes (duration of usual phone call). For exposure, examiner was reading a fixed text from newspaper into one mobile phone. This text was heard by subject through another mobile phone held in classical calling position of use (antenna was oriented to temporal parietal region and microphone towards mouth) at a distance of 1.5 cm from tragus of ear. Right ear was found to be dominant ear as this ear was used by subjects to hear the mobile phone<sup>13</sup>. RAVLT was again done after the exposure to mobile phone.

#### **Statistical analysis:**

Statistical analysis was done using paired "t" test. Values obtained were expressed as mean and standard deviation (SD). P value if found to be less than 0.05 was taken as significant.

#### **Result:**

Study was conducted in forty healthy subjects in the age group of 18-40 (mean 26.6 ± 6.03) years with body weight varying from 40 to 95 (mean 63.13±11.48) kg and height ranging from 152 to 190 (mean 165.75 ±8.62) cm. Subjects were using the mobile phone for the last 5-9 years, per day exposure was >30 min, duration of / call varies from 10 min. to 30 min. No complaint was reported by any subject in relation to use of mobile phone. Trial 1 score was increased significantly (p < . 05) from 5.68± 1.83 before MP exposure to 6.48± 2.15 after exposure to MP. Trial 5 score (from 12.55 ± 2.15 to 12.70 ± 2.14) and Trial 6 score (from 11.93 ± 2.49 to 12.38 ± 2.72) showed insignificantly significant improvement after exposure to MP. Trial 7 score was (11.33 ± 2. 68) and (11.10 ± 3.50) before and after exposure to MP respectively. There was not much

difference in recognition score and errors in recognition before versus after MP exposure. There was insignificant variation between males and females in different scores of AVALT before versus after exposure to MP.

#### **Discussion:**

RAVLT is sensitive way to find out mild cognitive deficit and used to rule out memory deficit in different clinical conditions. Scores of RAVLT of verbal learning and verbal declarative memory correlate well to executive function<sup>10</sup>. This test provides measures of immediate memory, efficiency of learning, short and long term recall, recognition, sensitivity to interference and forgetting<sup>14</sup>. Here recall and recognition are examined in the same test, but they are different memory functions and involve different brain areas. Active recall ability is said to be related to Hippocampus, while recognition is associated to sense of familiarity, and related to temporal lobe<sup>15</sup>. Keetley et al in 2006 supported the hypothesis that digital mobile phone (DMP) radiofrequency emission improves the speed of processing of information in working memory<sup>16</sup>. In our study score is improved after exposure to EMW emitted from MP. The result of this study again supports the findings of previous study i.e., facilitating effects of EMW emitted from MP<sup>8</sup>. Preece et al (1999) reported improved cognitive functions with exposure to 915MHz radiofrequency radiation (RFR). They mentioned that subjects specifically performed faster (means reaction time (RT) was decreased) on choice reaction time (CRT) task, when exposed to DMP RFR. They showed that this improvement was only significant for simulated analogue phone exposure (whose output power was 1 W, as opposed to 0.125W for simulated digit phone)<sup>17</sup>. Koivisto et al (2000) also demonstrated significant improvement in

RT during exposure to 902 MHz (pulse modulated at 217 Hz) RFR, but not on simple RT and vigilance tasks. They further mentioned that cognitive time is decreased in mental arithmetic task during field exposure. Moreover they reported that RT showed improvement when memory load was three times, but no effects with lower memory load<sup>2</sup>. In accordance with this, Eldelstyn and Oldershaw in 2002 showed improved performance on forward digit span, backward spatial span and serial subtraction tasks following 30 min. exposure to 900 MHz DMP RFR<sup>18</sup>. Lee et al (2001) reported facilitating effect on Trail Making Task (TMT) in DMP users than non DMP users<sup>19</sup>. Improvement in memory tasks by TMT was also reported by others<sup>8</sup>. On the other hand, Maier et al (2004) demonstrated impairment in cognitive performance on auditory discriminative task following exposure to 902 MHz RFR (pulse modulated at 217 Hz)<sup>20</sup>. While Haarala et al (2005) were unable to report any effect of RFR emitted by 902 MHz MP on RTs or accuracy, in adult as well as children<sup>21</sup>. No effect of MP on RT was supported by Besset et al in 2005, who reported that daily exposure of 2 hrs/day for 5 days for 4 weeks to 900 MHz RFR, pulse modulated at 217 Hz had no effect on cognitive functions i.e., information processing speed, attention capacity, memory function and executive function<sup>22</sup>. In our study although score in 1<sup>st</sup> trial was improved, but effect on other trials and recognition score were not observed in subjects.

On comparison of the effects of EMW emitted from MP between males and females, no demonstrable difference was observed. While Smyth and Costall in 2003, who found fewer errors in the recall of word placement in a spatial configuration with exposure to 1800 MHz DMP RFR, showing improvement in short

term memory, which was only evident for males<sup>23</sup>. They further added that errors generated by females were remained unaffected across exposure conditions.

Preece et al concluded that reduction in choice reaction time is related to mild localized heating of angular gyral region in left temporal region of brain. Further they mentioned that this angular gyres region in MP user lies under and on the same side of head as the antenna of mobile phone<sup>17</sup>. Lee et al (2003) demonstrated that facilitating effect of MP is dose dependent and related to duration of exposure to MP<sup>19</sup>. They further reported that increased duration of exposure may have differential impact on different human attention functions, as they found absence of significant difference on the

scores of TMT A and TMT B. Improved RT for TMT working memory suggests that DMP exposure has positive effect on different tasks need involvement of higher level of cortical function<sup>16</sup>. They said that latency of facilitating effect can be explained by the time required for physiological changes to take place, as related to heat shock protein production and vascular intimal hyperplasia. It is interesting to note that compression of pinna is also a mechanism to explain the effect, as it reduces the distance and increases approximately 2 dB in 10 g SAR, if maximum exposure is said to be at pinna<sup>24</sup>. So, it is concluded that EMW emitted from mobile phone affects higher mental functions.

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