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ORIGINAL RESEARCH

Cognitive Impact of Daily Mobile Phone Usage Duration: A Focus on Visuomotor Coordination and Processing Speed

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ABSTRACT

Background: The pervasive use of mobile phones has raised concerns about the cognitive effects of electromagnetic radiation (EMR) exposure, particularly on visuomotor coordination and processing speed. **Aim:** This study aimed to assess the impact of prolonged mobile phone use on visuomotor coordination and processing speed. **Methods and Material:** The study was conducted using a cross-sectional design.Twenty healthy right-handed males aged 18–40 years were divided into two groups based on daily mobile phone call duration: Group I (≥1 hour) and Group II (<1 hour). Participants completed the Single Letter Cancellation Task (SLCT), Six Letter Cancellation Task (SxLCT), and Perceptual Speed Test (PST) to assess cognitive performance. **Statistical Analysis and Results:** Scores were analyzed using paired t-tests, and $p < 0.05$ was considered statistically significant. Group II performed significantly better than Group I in the SxLCT ($p = 0.02$), with a higher mean number of correct responses. Although Group II outperformed Group I in the SLCT and PST, the differences were not statistically significant ($p > 0.05$). **Conclusions:** Prolonged mobile phone use is associated with reduced visuomotor coordination, as evidenced by diminished performance in tasks requiring visual and motor integration. These findings underscore the cognitive risks of excessive mobile phone exposure and highlight the need for further research on its long-term effects.

Key Words: Mobile phone, electromagnetic radiation, visuomotor coordination, cognitive function, processing speed, cancellation task

INTRODUCTION

In the past few decades, the pervasive integration of mobile phones into daily life has revolutionized communication, enabling unprecedented connectivity and accessibility worldwide. The usage of mobile phones has witnessed an exponential surge, with a significant portion of the global population spending increasingly longer hours engaged in phone calls, text messaging, and various multimedia interactions. This phenomenon has undoubtedly transformed societal dynamics, yet it also prompts critical inquiries into its potential impacts on human health and cognitive functions.

Mobile phones work on electromagnetic radiation and extensive research has been conducted to explore the ramifications of exposure to such radiation, particularly concerning its effects on the human brain as mobile phone antenna is close to human brain while making a call.[1] Studies have implicated electromagnetic radiation from mobile phones in various physiological alterations, including changes in brain activity patterns, disruptions in sleep patterns, and even potential implications for long-term neurological health.[2-4] While the precise mechanisms underlying these effects remain subject to ongoing investigation, the accumulating body of evidence underscores the importance of understanding the potential cognitive repercussions of extensive mobile phone usage.

This study aims to investigate the effects of prolonged mobile phone use on two critical cognitive domains: visuomotor coordination and processing speed. Visuomotor coordination refers to the ability to synchronize visual input with motor responses, essential for tasks involving hand-eye coordination.[5] Processing speed, defined as the efficiency and speed with which individuals respond to visual stimuli, is another critical domain, providing insight into how quickly one can process and react to information.Both of these cognitive skills are integral to performing

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routine activities and professional tasks that rely on quick visual recognition and motor precision.[6,7]

Although previous research has extensively focused on the neurological impacts of mobile phone radiation, such as sleep disruption and brainwave alterations, fewer studies have examined the potential effects on visuomotor coordination. Furthermore, the study's focus on processing speed adds a novel layer to the exploration of mobile phone use and cognitive function. This investigation will fill gaps in existing literature by assessing whether prolonged exposure to mobile devices can impair these critical abilities, contributing to a broader understanding of the cognitive consequences of modern technology.

Study Design and Methodology

The study involved 20 healthy male adults aged between 18 and 40 years. All participants were righthanded and used right ear for most calls. The subjects were recruited from the staff and students of college.

Ethical clearance was given by PG Board of Studies of the Institution.

Inclusion Criteria: Healthy male subjects in the age group of 18–40 years and minimum of tenth grade education and willing for the test.

Exclusion Criteria: The criteria for exclusion from the study were:

- History of head trauma, drug administration for the past 1 month, any neurological disorder, any psychiatric disorder

Participants were divided into two groups, each comprising 10 individuals, based on their daily mobile phone usage:

Group – I: 10 subjects who make MP calls of at least 1 h or more per day (≥1 h)

Group – II: 10 subjects who make MP calls of less than 1 h per day (<1h)

Cognitive Tasks: Two cognitive domains that is visuomotor coordination and perceptual speed were tested two cancellation tasks and a perceptual speed test. The cancellation tasks included are well-established paradigms for assessing visuomotor coordination including attention, visual scanning, and selective attention abilities. The perceptual speed test assess visual perception and speed of cognitive processing.[8]

1. **Single Letter Cancellation Task (SLCT):** In this task, participants were presented with a grid of randomly arranged alphabets and instructed to identify and mark a specific target letter within the grid as fast as possible. Total time taken in seconds and the number of target alphabet cancelled were noted.
2. **Six Letter Cancellation Task (SxCLT):** Similar to the Single Letter Cancellation Task, participants were presented with a grid of randomly arranged alphabets, but this time, they were required to identify and mark six different target letters within the grid within 90 seconds. The total number of target alphabet cancelled were noted for scoring.
3. **Perceptual Speed Test (PST):** Participants were given a sheet with a chart containing numbers between 0 and 9 arranged in 34 columns and 20 rows. In the beginning of each row a target number was give. Participants were required to circle the target number in each row. 60 seconds time was given to complete the test.

Data Analysis

Scores obtained from the cancellation tasks and the perceptual speed test were compared between the two groups using paired t-tests. P-value was calculated using MS Excel. $P < 0.05$ was considered significant.

RESULTS

20 male subjects were recruited for the study.The study was conducted on 20 males in the age group of 18–40 years which were divided into two groups (Group I and II) depending on per day mobile call duration.The average duration of call per day of Group I was 75.4 ± 12.90 min and that of Group II was 43.6 ± 8.90 min. (Fig 1)

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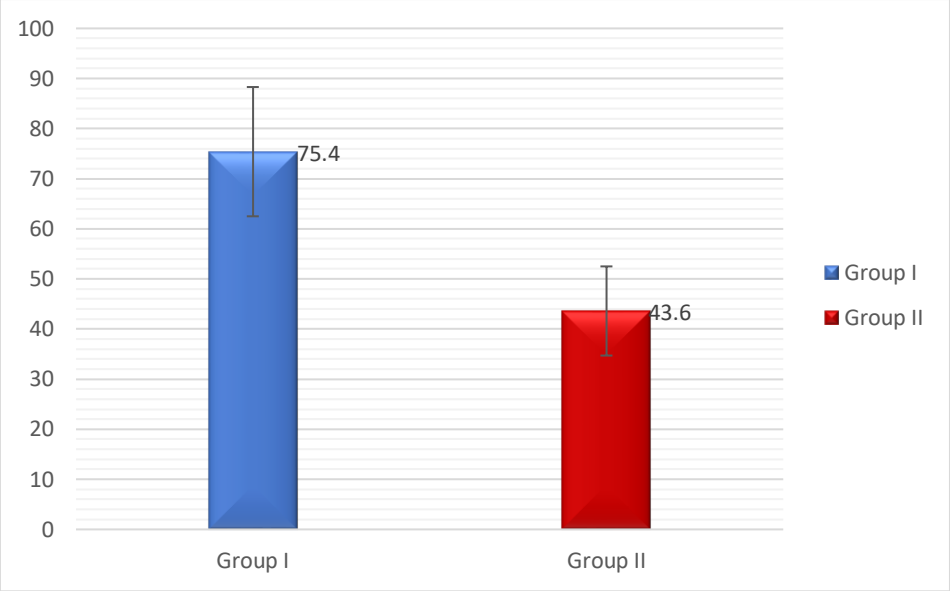

Figure 1: Average Call Duration in Group I and Group II

The cognitive performance of Group 1 (subjects making calls for >1 hour per day) and Group 2 (subjects making calls for <1 hour per day) was compared across three tests: the Single Letter Cancellation Task (SLCT), the Six Letter Cancellation Task (SXCT), and the Perceptual Speed Test (PST).

Group 2 demonstrated superior performance compared to Group 1 in the Single Letter Cancellation Task. Participants in Group 2 exhibited a higher accuracy rate and completed the task more efficiently. However, these differences did not reach statistical significance ($p > 0.05$). Significant differences in cognitive performance were observed between the two groups in the Six Letter Cancellation Task. Group 2 outperformed Group 1, demonstrating greater accuracy and efficiency in identifying and marking the target letters within the grid ($p < 0.05$). Although Group 2 generally performed better than Group 1 in the Perceptual Speed Test, the difference in cognitive performance between the two groups did not reach statistical significance ($p > 0.05$). Both groups exhibited similar reaction times and accuracy rates in processing visual stimuli during the test. (Table 1)

Table 1: Comparison of SLCT, SxLCT and PST scores in Group I and Group II

	SLCT[a] Time Taken (secs)	SLCT Total Score (out of 10)	SxLCT[b] (Net attempts)	PST[c] (Net attempts)
Group I (Mean±SD)	23.89 ±7.88	9.89±0.31	22.97±6.93	36.93±8.71
Group II (Mean±SD)	17.4± 5.23	8.48±1.82	33.34±10.50	42.41±9.20
p Value	0.04*	0.07	0.02*	0.23

[a]Single Letter Cancellation Test, [b] Six Letter Cancellation Test, [c] Perceptual Speed Test, *p value <0.05 significant

DISCUSSION

The present study aimed to investigate the cognitive effects of electromagnetic radiation (EMR) exposure from mobile phones, specifically focusing on tasks involving visuomotor coordination and processing speed. We examined the six-letter cancellation task, single-letter cancellation task, and perceptual speed test. The findings of this study shed light on the intricate relationship between mobile phone call duration and cognitive performance, particularly in tasks involving visuomotor coordination. Group 2, characterized by individuals with less than one hour of daily mobile phone call duration, displayed notably superior performance in both the Single Letter Cancellation Task (SLCT) and the Six Letter Cancellation Task (SXCT) compared to Group 1, comprising individuals with more than one hour of daily mobile phone call duration. While the difference in performance between the two groups was statistically significant only in the SXCT, the consistent trend across both cancellation tasks suggests a compelling association between prolonged mobile phone call duration and diminished cognitive function. These findings are consistent with previous studies where longer exposure to mobile phone radiation was associated with a decreased performance in memory task.[9] Hamblin et al studied the effect of 60 min exposure to mobile phone

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radiation on psychomotor performance. They found a decreased speed of psychomotor performance in participants exposed to mobile phone radiation as compared to sham conditions.[10] Similarly, Keetley et al reported an impaired performance in reaction time and sustained attention tasks following 90 min mobile phone exposure.[11]

The six-letter and single-letter cancellation tasks are measures of visuomotor coordination, involving the integration of visual information with motor responses. These tasks primarily engage the prefrontal cortex and parietal lobes. The prefrontal cortex is essential for executive functions, including attention and decision-making, while the parietal lobes play a crucial role in spatial processing and coordination.[12,13] Previous studies have shown that EMR exposure can affect the prefrontal cortex and parietal lobes. For instance, Volkow et al. demonstrated that mobile phone use increases glucose metabolism in the brain region closest to the antenna, suggesting heightened neural activity.[14] Prolonged exposure to EMR has been associated with alterations in neurotransmitter levels and ion channel function, potentially leading to impaired visuomotor coordination. Pallreported that EMR could affect calcium ion flux and neurotransmitter release, which are critical for synaptic transmission and motor control.[15] Various VGCC types occur in high density throughout the nervous system and play a crucial and widespread role in the release of neurotransmitters in brain and hormones from neuroendocrine cells.[16] Studies have shown EMF can alter VGCC activity.[17] Increased expression of L-type VGCC is associated with defects in alertness, orientation and executive control of attention in animals.[18] Neurotransmitters like NE and E which are involved in concentration were found to be decreased in rats following EMF exposure.[19]

The cerebellum plays a crucial role in visuomotor coordination by integrating sensory input with motor commands to ensure smooth, precise movements. It helps in timing, adjusting motor actions, and correcting errors in response to visual stimuli. 5HT and 5HT receptors, particularly 5-HT1A and 5-HT2A, are involved in fine-tuning motor control by regulating Purkinje cell output.[20,21]Altered levels of 5HT and alteration in its metabolism was found in cerebellum and hippocampus following EMF exposure. An increased density of 5HT receptors with decreased affinity for 5HT was found in the prefrontal cortex of rats following continuous exposure to electromagnetic radiation.[22] EMF can also modulate brain connectivity and cause imbalance of amino acid neurotransmitters.[23] Histological changes in neuronal and neuroendocrine tissues observed following EMF exposure are generally reversible once the exposure stops but can become permanent if the exposure is prolonged.[15]

Our findings, along with previous research, suggest that prolonged exposure to mobile phone radiation can negatively affect visuomotor coordination and processing speed, potentially compromising cognitive performance in tasks that rely on motor and visual integration.

CONCLUSION

The study highlights the potential cognitive risks associated with prolonged mobile phone use, particularly concerning visuomotor coordination and processing speed. Individuals with longer daily exposure to mobile phone radiation demonstrate diminished performance in tasks requiring precise motor and visual integration, possibly due to disruptions in neurotransmitter function and brain connectivity. These findings underscore the need for further research on the long-term effects of electromagnetic radiation exposure and its implications for cognitive health.

The study's strengths include its focused design, use of established cognitive tests, and controlled participant selection, ensuring reliable results. However, its limitations are a small sample size, gender restriction to males, reliance on self-reported mobile phone usage, and lack of long-term data.

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