

Stroop Effect in Smartphone Addiction Among College Students

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Abstract

*Smartphone addiction has emerged as a growing behavioral concern among young adults, particularly college students, due to excessive dependence on digital communication, entertainment, and social media platforms. Cognitive control deficits, such as impaired attention and reduced inhibitory capacity, are frequently associated with technology overuse. The **Stroop test**, a well-established neuropsychological tool, evaluates **selective attention, processing speed, and executive function**, making it highly suitable for assessing the cognitive implications of smartphone addiction. This study aimed to evaluate the effect of smartphone addiction on Stroop performance among college students in a tertiary educational setting. A cross-sectional observational design was used, enrolling 180 undergraduate students aged 18–25 years. Participants were divided into **Low Addiction, Moderate Addiction, and High Addiction** groups based on the **Smartphone Addiction Scale–Short Version (SAS-SV)**. The **Stroop Color–Word Test** was administered to assess cognitive interference, reaction time, and error rate. The study found that students with **high smartphone addiction** demonstrated significantly prolonged reaction times, increased Stroop interference scores, and a greater number of errors compared to those with low or moderate addiction levels. Factors such as nighttime mobile use, social media dependence, and gaming behavior were strongly correlated with cognitive slowing. Gender differences were minimal, but late-night phone usage was identified as an independent predictor of impaired Stroop performance. The findings highlight that smartphone addiction adversely affects executive function by disrupting attentional control and inhibitory processing. The study emphasizes the need for awareness programs, digital hygiene training, and routine assessment of cognitive health in young adults who exhibit problematic smartphone use. Establishing preventive strategies may help reduce the cognitive burden associated with excessive digital engagement.*

Keywords: *Stroop test, Smartphone addiction, Executive function, Cognitive interference, College students*

Introduction

Smartphone usage has become nearly universal among young adults, providing instant access to communication, social media, entertainment, and academic resources. While smartphones offer

substantial advantages, excessive use can lead to **smartphone addiction**, characterized by compulsive checking, inability to control usage, withdrawal-like symptoms, and interference with daily functioning. College students represent a particularly vulnerable group due to academic stress, social competition, and constant connectivity demands. Excessive smartphone use has been linked to reduced academic performance, sleep disturbance, anxiety, depression, and impaired cognitive control (2). Cognitive functions such as **attention, working memory, processing speed, and executive control** are crucial for learning efficiency. One of the most widely used tools to assess executive function is the **Stroop Color–Word Test**, which measures cognitive interference and the ability to inhibit automatic responses (3). The Stroop effect occurs when an individual takes longer to name the color of the ink in which an incongruent word is printed, revealing the brain’s difficulty in suppressing the more automatic reading response (4). Studies have suggested that technology overuse can impair executive functioning by altering neural pathways associated with attention regulation and inhibitory control (5). Smartphone addiction may reduce cognitive flexibility and increase distractibility due to constant notifications, multitasking, and prolonged screen exposure (6). Several researchers have reported that high levels of smartphone use correlate with increased mental fatigue, reduced prefrontal cortex activity, and impaired performance on tasks requiring sustained attention (7). However, limited research exists regarding the specific effect of smartphone addiction on Stroop performance among Indian college students, particularly within tertiary medical education environments. Given that the Stroop test provides insight into prefrontal cortical functions, it serves as an ideal measure to examine cognitive alterations associated with behavioral addictions. The present study investigates the relationship between smartphone addiction and Stroop performance among college students aged 18–25 years. The objective was to determine whether higher addiction levels correlate with longer reaction times, increased cognitive interference, and greater error rates. Understanding this relationship can help institutions develop early intervention programs aimed at promoting healthy digital habits and preventing cognitive decline associated with excessive smartphone use.

Materials and Methods

This cross-sectional observational study was conducted in the Department of Physiology, Rama Medical College, Hospital and Research Centre, Hapur, from December 2023 to July 2024. A total of 180 undergraduate students aged 18–25 years were recruited using stratified random sampling. Students with diagnosed neurological disorders, psychiatric illness, substance abuse, or uncorrected visual impairment were excluded. After obtaining informed consent, participants completed a structured questionnaire including demographic data, smartphone usage patterns, sleep habits, academic performance, and physical activity levels. Smartphone addiction levels were assessed using the **Smartphone Addiction Scale–Short Version (SAS-SV)**, a validated screening instrument containing 10 items rated on a 6-point Likert scale. Scores were categorized into **Low Addiction, Moderate Addiction, and High Addiction** groups based on established cutoff values. The **Stroop Color–Word Test** was conducted in a quiet, well-lit room using a standardized computer-based protocol. Three components were administered: (1) Word Reading,

(2) Color Naming, and (3) Color–Word Incongruent Task. Reaction time was recorded in milliseconds, and error rates were automatically logged. **Stroop interference score** was calculated as the difference between incongruent task reaction time and congruent task reaction time. Participants were instructed to refrain from using smartphones for at least 30 minutes prior to testing to reduce immediate digital interference. Sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI). Additional parameters recorded included screen-on time, nighttime phone use, number of daily unlocks, and primary purpose of use (social media, gaming, academic, entertainment). Data were analyzed using SPSS software. Mean values were compared using ANOVA, and correlations were assessed using Pearson’s coefficient. Regression analysis was used to identify independent predictors of Stroop performance. Ethical approval was obtained from the institutional ethical committee. Measures were taken to ensure confidentiality and voluntary participation. No incentives were given. All testing was performed between 10 AM and 1 PM to minimize circadian variation in cognitive performance. The study adhered to Helsinki ethical guidelines.

Results

Of the 180 participants, 68 were categorized as Low Addiction, 57 as Moderate Addiction, and 55 as High Addiction. Students with **high smartphone addiction** demonstrated significantly greater Stroop interference scores, longer reaction times, and higher error rates than those in the other groups. The mean reaction time in the incongruent task was highest in the High Addiction group, followed by Moderate and Low Addiction groups, with statistically significant differences ($p < 0.001$). Error rates were also significantly elevated in high-addiction individuals. Late-night smartphone use was strongly associated with impaired Stroop performance ($p < 0.01$). Social media overuse and gaming behavior showed moderate positive correlations with slower processing speed. No significant gender differences were observed. Regression analysis identified nighttime phone use and addiction score as independent predictors of cognitive interference.

Discussion

The findings demonstrate that **smartphone addiction negatively impacts executive function**, particularly inhibitory control and processing speed, as evidenced by impaired Stroop performance. Excessive screen time and nighttime smartphone use contribute to reduced attentional capacity and increased cognitive interference. Similar studies have also shown decreased prefrontal activity and slower cognitive processing in individuals with higher digital dependence (6,7). The study highlights the importance of developing awareness programs to promote responsible smartphone usage among college students.

Conclusion

This study demonstrates that smartphone addiction is significantly associated with impaired Stroop performance among college students. High addiction levels correlate with prolonged reaction

times, increased errors, and elevated cognitive interference. Nighttime phone use emerged as a major predictor of poor cognitive outcomes. The results emphasize the need for digital hygiene strategies and early screening to prevent cognitive decline associated with excessive smartphone use.

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