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Original Research Article

Effect of Short-Term Smartphone Use on Visual Reaction Time and Cognitive Performance in Young Adults

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Abstract

Background: Although exposure to a smartphone for a short time can impact attentional control and psychomotor speed in young adults, there is limited controlled experimental evidence with simple visual reaction time and cognitive performance measures.

Method: This was a prospective comparative study of the effect of 30 minutes of smartphone use on visual reaction time and selected cognitive domains in healthy college aged adults. The participants were divided into three groups of 30, with no-phone control, neutral smartphone reading and interactive smartphone use with social media and gaming. Visual reaction time, digit-symbol substitution score, Stroop interference time, and 2-back accuracy were measured at baseline and post intervention.

Results: There were no differences between groups in baseline characteristics or test scores. Post-intervention visual reaction time increased from 248.6 ± 28.4 ms to 255.8 ± 30.1 ms in controls, 250.9 ± 31.6 ms to 271.7 ± 34.8 ms in neutral users, and 247.3 ± 29.7 ms to 291.4 ± 39.5 ms in interactive users ($p < 0.001$). The interactive group showed a significant decrease in Digit-symbol scores (62.7 ± 8.9 to 55.6 ± 9.4; $p < 0.001$), and a significant increase in Stroop interference time (18.6 ± 16.1 seconds). Reaction-time delay was positively correlated with screen-interaction intensity ($r = 0.46$, $p < 0.001$), and negatively correlated with 2-back accuracy ($r = -0.39$, $p = 0.002$).

Conclusion: Interactive smartphone use for brief periods of time resulted in measurable reductions in visual reaction time and temporary impairments in cognitive function.

Keywords: Smartphone Use; Visual Reaction Time; Cognition; Attention; Young Adults; Screen Exposure.

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Introduction

Smartphones are now a part of the lives of young adults, and they are used as tools for communication, learning, entertainment, and constant alerts. Their cognitive effects are becoming more relevant as attention, working memory, response inhibition and reaction speed are key to academic functioning, driving safety, and clinical task performance. Smartphone usage reviews indicate that the frequent use of the smartphone can affect cognitive function by distraction, multi-tasking, reward anticipation and attentional capture [1].

Experimental studies have also demonstrated that simply having a personal cell phone in the vicinity can also decrease available cognitive resources when the phone is not being used [2]. These observations are especially pertinent in college settings where the use of a smartphone is nearly ubiquitous and extended digital interaction can take place just prior to study, practical classes, exams, or travel. Visual reaction time is an indicator of sensory processing speed, motor readiness and attention. It is widely used in physiology labs due to its ease of administration, reproducibility, and sensitivity to fatigue, arousal, distraction, and cognitive load. The presence of a smartphone has been shown to impair basal attentional performance and working speed in standardized concentration tasks in recent studies [3]. Other experimental research have demonstrated that the presence of the smartphone during learning tasks negatively affects memory recall, even if it is not used explicitly [4]. Concurrently, there is evidence that adolescents and young adults with problematic smartphone use have decreased executive control, slower reaction times, and less efficient working memory [5,6].

Even though these results are reported, the acute physiological impact of a specific time of smartphone use on visual reaction time and cognitive task performance is still poorly understood. Many studies measure the effects of chronic use, addiction scales or general screen time, instead of the immediate effects of a brief, realistic exposure. The nature of the smartphone activity could also be a factor: passive reading might be less distracting than interactive social media or games, which involve visual stimulation, quick decision-making, reward feedback and emotional engagement. Experimental studies that are able to distinguish between the effects of intensity of exposure and baseline dependence are still required, but neurocognitive reviews suggest that internet and smartphone addiction is linked to changes in executive function and reward processing networks [6,7].

The current study was conducted to fill this gap by examining no-phone rest, neutral smartphone reading and interactive smartphone use in healthy young adults. We predicted that using a smartphone in an interactive manner would result in longer visual reaction times and more cognitive performance reductions compared to reading a neutral smartphone content or no-phone control. The main goal was to see if there was a difference in visual reaction time after 30 minutes between the three groups. Secondary outcomes included assessing digit-symbol substitution, Stroop interference time, 2-back accuracy, and the relationship between screen-interaction intensity and cognitive outcomes.

Materials and Methods

This is a prospective comparative study carried out in the Department of Physiology of a teaching institute for three months. Students aged 18-25 years were recruited through notice board announcement and invitation in class, and were selected as healthy students. The study was a controlled laboratory study with three parallel exposure conditions. Participants were asked to refrain from caffeine, energy drinks, strenuous exercise and screen gaming for a minimum of 3 hours prior to testing. Testing took place in a quiet, well-lit room, between 9:00 AM and 12:30 PM, to reduce circadian and environmental variation.

Visual reaction-time difference was selected as the main outcome and the sample size was determined accordingly. Assuming a minimum clinically relevant difference of 25 ms between groups, a standard deviation of 35 ms, 80% power, 5% alpha error and 10% allowance for non-completion, 30 participants were enrolled in each group. The inclusion criteria were: age between 18 and 25 years, normal or corrected-to-normal vision, right-handedness for standardization of the response keys on the smartphone, and regular use of a smartphone for at least six months. Exclusion criteria included uncorrected visual impairment, sleep deprivation the night before the test, current neuropsychiatric illness, sedative or stimulant drug use, migraine during the test session, hand injury, and history of epilepsy or attention-deficit disorder.

All test procedures were familiarized with after baseline demographic recording. Visual reaction time was assessed with a computerised reaction time application (CRT) with an external response key validated by the authors. After discarding anticipatory responses with RTs < 100 ms and delayed responses with RTs > 600 ms, the mean of five valid trials was used for analysis for each task. Cognitive performance was assessed using the digit-symbol substitution test for psychomotor processing, the Stroop color-word test for response inhibition, and a computerized 2-back task for working memory. Mental fatigue was assessed using a 10-point visual analogue scale (VAS) for subjective mental fatigue. The intervention consisted of a baseline measurement followed by a group-specific intervention: Group A received no intervention, Group B received a neutral educational text on a smartphone, and Group C received social media feeds and a simple action game for 30 minutes.

The brightness of the smartphone screen was standardized at 70% and participants used their own phones to maintain ecological validity. Interactions were measured for Group C using screen activity logs (where available) and observer recording, and included the number of screen taps and swipes per minute. Testing began within 2 minutes of the end of the exposure. SPSS-style procedures were used for statistical analysis. Continuous variables were presented as mean ± SD and categorical variables were presented as frequencies and percentages. One-way ANOVA with Tukey post-hoc testing compared intergroup differences. Within group changes were assessed using paired t-tests. Pearson correlation and multivariable linear regression were used to assess the relationship between intensity of smartphone interaction and outcome change. A p value of less than 0.05 was deemed to be statistically significant.

Results

Ninety participants completed the study without protocol deviation. The mean age of the sample was 20.8 ± 1.9 years, and 48 participants (53.3%) were female. Baseline body mass index, sleep duration, daily smartphone-use duration, visual reaction time, and cognitive test scores were comparable across the three groups. None of the participants reported visual discomfort, headache, or excessive fatigue at baseline. The average daily smartphone use in the total sample was 4.9 ± 1.7 hours, indicating that the study population represented regular smartphone users rather than device-naive individuals. The primary outcome showed a graded effect across exposure conditions. Visual reaction time increased slightly in the no-phone control group, moderately in the neutral-reading group, and markedly in the interactive-use group. The mean change was 7.2 ± 16.8 ms in controls, 20.8 ± 22.6 ms in neutral users, and 44.1 ± 31.9 ms in interactive users (ANOVA p < 0.001). Post-hoc testing showed significant differences between Group C and both other groups, while the difference between Groups A and B was smaller but statistically significant. Digit-symbol substitution scores and 2-back accuracy declined significantly only in the interactive-use group, whereas Stroop interference time increased in both smartphone-exposed groups, with greater change in Group C. Correlation analysis demonstrated that higher screen-interaction intensity was associated with greater reaction-time delay (r = 0.46, p < 0.001), larger Stroop interference increase (r = 0.41, p = 0.001), and lower 2-back accuracy change (r = -0.39, p = 0.002). In multivariable regression adjusted for age, sex, baseline sleep duration, and habitual daily smartphone use, interactive smartphone exposure independently predicted reaction-time prolongation (beta = 0.42, p < 0.001). No adverse event required withdrawal. The findings indicate that short-term smartphone exposure is not uniform in effect; interactive use appears more disruptive than passive reading.

Table 1: Baseline characteristics of participants

Variable	No-phone control (n=30)	Neutral reading (n=30)	Interactive use (n=30)	p value
Age (years)	20.6 ± 1.8	20.9 ± 2.1	20.8 ± 1.9	0.84
Female, n (%)	15 (50.0)	17 (56.7)	16 (53.3)	0.87
BMI (kg/m2)	22.4 ± 2.7	22.7 ± 2.9	22.2 ± 2.6	0.78
Sleep previous night (h)	7.1 ± 0.8	6.9 ± 0.9	7.0 ± 0.7	0.66
Daily smartphone use (h)	4.7 ± 1.5	4.8 ± 1.8	5.1 ± 1.7	0.59

Table 2: Pre- and post-intervention visual reaction time and cognitive scores

Outcome	Group	Baseline	Post-intervention	Mean change	p value
Visual reaction time (ms)	Control	248.6 ± 28.4	255.8 ± 30.1	7.2 ± 16.8	0.07
Visual reaction time (ms)	Neutral reading	250.9 ± 31.6	271.7 ± 34.8	20.8 ± 22.6	0.002
Visual reaction time (ms)	Interactive use	247.3 ± 29.7	291.4 ± 39.5	44.1 ± 31.9	<0.001
Digit-symbol score	Control	63.4 ± 8.1	62.6 ± 8.5	-0.8 ± 3.4	0.31
Digit-symbol score	Interactive use	62.7 ± 8.9	55.6 ± 9.4	-7.1 ± 5.2	<0.001
2-back accuracy (%)	Interactive use	82.8 ± 7.6	75.4 ± 8.9	-7.4 ± 6.8	<0.001

Table 3: Correlation and regression analysis for change in visual reaction time

Predictor	Correlation / beta	95% CI	p value
Screen interactions per minute	r = 0.46	0.27 to 0.62	<0.001
Habitual daily smartphone use	r = 0.22	0.01 to 0.41	0.04
Sleep duration previous night	r = -0.18	-0.37 to 0.03	0.09
Interactive exposure (adjusted model)	beta = 0.42	0.23 to 0.61	<0.001
Neutral reading exposure (adjusted model)	beta = 0.18	0.02 to 0.34	0.03

Discussion

The present study revealed that the 30-minute interactive smartphone use significantly increased visual reaction time and decreased selected cognitive performance measures in healthy young adults. The slowing was largest in those who were exposed to social media and gaming, and was smaller but still measurable in those who were exposed to neutral reading. The results suggest that the cognitive impact of smartphone use is not just a consequence of chronic dependence, but may also be observed after short exposure periods when the task requires fast shifts in attention and interaction with the smartphone for reward. The cognitive costs of using a smartphone have been reported in the literature as attentional capture and a decrease in available working-memory capacity [1,2]. We build on these observations by showing that a simple physiological measure, visual reaction time, changes over a short time period immediately following the use of a smartphone.

This is a consequence of the extension of visual reaction time, which can be attributed to divided attention, visual fatigue, increased cognitive load, or lingering attention to phone-related stimuli. Skowronek et al. found that the availability of a smartphone negatively affected attention performance and working speed in a standardized concentration task [3]. The present study found that active interactive use had a greater impact than passive reading or availability, indicating that the intensity of engagement is important. Transient impairment in psychomotor speed and working memory is further supported by a decrease in digit-symbol score and 2-back accuracy. These findings are in line with reports that problem smartphone use is related to lower cognitive self-control and reaction-time performance [5]. The Stroop findings have clinical implications as response inhibition is needed in academic testing, driving, and clinical decision making. Even a small increase in interference time can be a sign of a decrease in the suppression of competing stimuli. Brain imaging studies of Internet and smartphone addiction reveal changes in brain areas related to executive function and reward processing such as prefrontal and cingulate networks [6]. The behavioral pattern is consistent with temporary executive-resource depletion following intensive phone interaction, although the current study did not involve neuroimaging. Mobile-phone alerts and digital interruptions have also been demonstrated to interfere with attention, which could be a plausible mechanism as a result of repeated orienting responses and expectation of new stimuli [7].

The study has practical implications. Young adults frequently use their smartphones right before lectures, laboratory classes, exams and travel. The findings indicate that reducing interactive smartphone use just prior to tasks that demand quick responses or focused cognition could be beneficial. This effect was not significant enough to suggest permanent impairment and participants did not fall outside of normal performance limits. In safety critical applications like driving, sports, operating instruments, or clinical practice, however, a small reaction time delay can be significant. Therefore, structured digital hygiene, phone-free preparation periods, and restrictions on high interaction applications prior to cognitive tasks could be reasonable recommendations.

This study has a number of strengths, such as the standardized exposure duration, the parallel comparison of neutral and interactive smartphone use, immediate post-exposure testing, and the use of multiple cognitive domains. Limitations include single center recruitment, short follow-up, lack of blinding of participants to the exposure condition, and reliance on a laboratory environment that may not completely mimic real world multitasking. The study also did not measure delayed recovery. Further studies are needed with larger numbers of subjects, objective eye strain measurement, EEG or pupillometry, and repeated measurements following various washout periods. Research comparing the use of smartphones for education and entertainment could be used to determine safer ways for students to use their devices.

Another finding from the study is the difference between screen time and cognitive engagement. Neutral reading on a smartphone screen still requires visual accommodation and sustained near focus, but it does not necessarily require rapid switching, social comparison, reward anticipation or motor responses. These demands are added together in interactive applications. This could be why neutral reading had a smaller delay and social media and gaming had a bigger delay. Previous studies have noted that the effects of the smartphone are context dependent and could differ based on the salience of the notification, its personal relevance, and the complexity of the task [8-14]. The results of the current study should therefore not be seen as proof that all educationally relevant uses of smartphones are detrimental. Instead, they suggest that high interaction use just prior to attention demanding tasks might be more detrimental than low interaction use.

The study is also relevant to road safety and classroom behaviour. While not the same as braking reaction time or clinical decision speed, visual reaction time has similar elements of stimulus detection, central processing, and motor execution. If the reaction time is extended following phone interaction, the person might be slower to respond to unexpected cues. This is significant as young adults frequently transition from using a phone to driving two-wheelers, crossing roads or laboratory work. Dual-task interference and attention studies have demonstrated that even simple tasks can be susceptible when there is residual cognitive load [15,16]. A brief period of time without the use of a cell phone prior to safety-sensitive activities may thus be a feasible low-cost behavioral recommendation.

The correlation between the two factors (habitual smartphone use and acute test change) was lower than the correlation between the two factors (screen-interaction intensity and acute change). This indicates that the activities participants engaged in during the exposure were more important than the number of hours they typically used their phone. The relevance of the habitual daily duration is maintained because heavy users might be exposed to distractive applications more often, but duration is not an accurate measure. Future research should measure the frequency of notifications, the type of application, the emotional content of the notification, and the multitasking behavior. Objective phone logs, eye tracking, and ecological momentary assessment can be used to differentiate between passive screen time and cognitively demanding digital engagement [17-18].

The results from an institutional point of view back policies that are educational and not punitive when it comes to digital hygiene. Practical demonstrations, pre-examination waiting periods, and clinical skill sessions may be beneficial for students to have their phones turned off. Faculty can suggest brief pre-task activities like silent mode, blocking notifications, and 2-5 minutes of screen-free rest. These strategies will not likely disrupt the normal educational use and will decrease attentional residue. The objective should not be to avoid the use of smartphones but to use them intelligently and wisely, as they are part of the learning environment.

Conclusion

The short-term interactive use of the smartphone significantly impaired the visual reaction time and psychomotor and working-memory performance in healthy young adults. Passive smartphone reading resulted in smaller changes, and no-phone rest resulted in minimal changes. The results indicate that the cognitive effects of smartphone use are related to the intensity of interaction. Avoid using the smartphone interactively before attention demanding tasks could help maintain optimal psychomotor speed and cognitive readiness.

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