Indian Journal of Psychological Medicine
Official publication of the South zone branch of the Indian psychiatric society
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Indian J Psychol Med. 2018 Sep-Oct; 40(5): 468–475.
doi: [10.4103/IJPSYM.IJPSYM_133_18]
PMCID: PMC6149309
PMID: 30275623

A Study of Magnitude and Psychological Correlates of Smartphone Use in Medical Students: A Pilot Study with A Novel Telemetric Approach

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Abstract

Context:

Smartphone use is being investigated as a potential behavioral addiction. Most of the studies opt for a subjective questionnaire-based method. This study evaluates the psychological correlates of excessive smartphone use. It uses a telemetric approach to quantitatively and objectively measure participants' smartphone use.

Methodology:

One hundred forty consenting undergraduate and postgraduate students using an Android smartphone at a tertiary care teaching hospital were recruited by serial sampling. They were pre-tested with the Smartphone Addiction Scale-Short Version, Big five inventory, Levenson's Locus of Control Scale, Ego Resiliency Scale, Perceived Stress Scale, and Materialism Values Scale. Participants' smartphones were installed with tracker apps, which kept track of total smartphone usage and time spent on individual apps, number of lock–unlock cycles, and total screen time. Data from tracker apps were recorded after 7 days.

Results:

About 36 % of participants fulfilled smartphone addiction criteria. Smartphone Addiction Scale score significantly predicted time spent on a smartphone in the 7-day period ($\beta = 0.234$, $t = 2.086$, $P = 0.039$). Predictors for time spent on social networking sites were ego resiliency ($\beta = 0.256$, $t = 2.278$, $P = 0.008$), conscientiousness ($\beta = -0.220$, $t = -2.307$, $P = 0.023$), neuroticism ($\beta = -0.196$, $t = -2.037$, $P = 0.044$), and openness ($\beta = -0.225$, $t = -2.349$, $P = 0.020$). Time spent gaming was predicted by success domain of materialism ($\beta = 0.265$, $t = 2.723$, $P = 0.007$) and shopping by ego resiliency and happiness domain of materialism.

Conclusions:

Telemetric approach is a sound, objective method for evaluating smartphone use. Psychological factors predict overall smartphone usage as well as usage of individual apps. Smartphone Addiction Scale scores correlate with and predict overall smartphone usage.

Key words: *Excessive use*, *predictors*, *psychological*, *smartphone*, *telemetry*

INTRODUCTION

Smartphones are part-and-parcel of our life. They are handy tools for communication, offer easy access to the Internet and media, and are highly personalizable with different wallpapers, fonts, themes, languages, and even operating systems.[1]

There are >950 million smartphone users in India alone. The number of smartphone users is growing with geometric progression and have left landline users far behind in the last 5 years.[2,3]

Why smartphones have become so popular?

The Technology Acceptance Model (TAM) is the theoretical construct which explains why and how humans accept a new technology in their life.[4] This model has explained the adaptation of personal computers and Internet-based phones in the past.[5,6,7] The TAM states that 1) how useful do we perceive a technology (perceived usefulness; PU), 2) how easy do we perceive using that technology (perceived ease of use; PEOU), and 3) the reasons behind selecting that technology for use predict an easy adaptation of a technology. Smartphones, being lightweight, trendy, multi-functional, portable, customizable, and user-friendly, are obvious contenders for a higher PU and PEOU compared to other gadgets.[8]

Excessive smartphone use and addiction

There are multiple reports of smartphone overuse in the scientific literature. For instance, in the USA alone, ownership of smartphones has risen by 76% in undergraduate students.[9] Another USA-based study estimated that a student spends 3.5 or more hours on his or her smartphone every day for entertainment and chatting.[10] An Africa-based study showed that excessive use of the smartphone in graduate students was associated with excessive procrastination, distraction, poor academic scores, and worsened grammatical and linguistic accuracy.[11] Smartphone users also report feelings of extreme anxiety and cognitive delays on separation from their smartphones.[12] This compulsive nature of checking smartphones frequently caused researchers to wonder whether smartphone use is a behavioral addiction!

Researchers have evaluated individuals' subjective smartphone usage and reported prevalence of smartphone addiction ranging from 8.7% in Korea to 32% in India.[13,14]

An Indian study adapted the criteria for substance dependence to smartphone use and showed that 40% of postgraduate residents using a smartphone fulfilled the criteria for smartphone dependence.[15] Similar to other addictions (substance and behavioral), excessive and addictive smartphone use has been linked to life stress, lower self-efficacy, higher perceived stress, high internal locus of control, materialism, and Internet addiction. Big five personality traits have been linked to usage of various apps on the smartphone.[16,17,18,19,20,21,22]

The need for this study was the fact that most of the evidence on this topic is based on self-reported, subjective questionnaires.[16,17,18,19,20,21] It is noteworthy that most of the studies are from Korea, China, and the west with scarce Indian literature.[14,15,23] Psychological factors, in addition to

biological and environmental factors, have predictive value in behavioral addictions.[24,25] This study was therefore designed to evaluate psychological correlates and predictors of excessive smartphone use with a telemetric approach, which is a more objective method for measuring one's smartphone use.

METHODOLOGY

Site

The study was conducted in the Psychiatry Department of a tertiary care teaching hospital in western India in an urban setting. The Institutional Ethics Committee approval was obtained. Written informed consent was taken from all participants.

Sample

All consenting undergraduate and postgraduate students using an Android operating system-based smartphone were recruited for the study. Students (1) with a history of any neuropsychiatric disorder, (2) having two or more smartphones, (3) owning a tablet device, and/or (4) having failed to complete both the phases of the study were excluded.

Procedure

Phase I – Participants were evaluated using the following materials.

Clinical datasheet

This was a self-designed, semi-structured proforma, which was used to gather sociodemographic data. The questionnaire also asked participants to provide information regarding their smartphone usage such as the number of hours spent every day on a smartphone, amount spent on monthly Internet pack, and so on.

Big five inventory

This is a 44-item inventory that measures an individual on five factors (dimensions) of personality; namely extraversion, agreeableness, conscientiousness, neuroticism, and openness.[26,27] Participants rated to what extent does each question apply to them, on a 5-level Likert scale. The scoring system includes reverse scoring questions. The big five inventory (BFI) has been used extensively with good psychometric properties across cultures.[28]

Materialism Value Scale

The Materialism Value Scale (MVS) explores materialism as a value that influences people to interpret their lives.[29] It measures the importance attributed to possession and/or acquisition of material goods in achieving major life goals or desired states. The MVS evaluates three domains of materialism: (1) Success – how much an individual uses material objects to judge success of others or oneself, (2) Centrality – the centrality of material values in an individual's life, and (3) Happiness – the extent of the belief that possession and acquisition of material goods leads to happiness and life satisfaction. We used the revised, 15-item short version of the MVS, as it has demonstrated better psychometric properties.[30]

Perceived Stress Scale

The Perceived Stress Scale (PSS) is perhaps the most widely used instrument for measuring the perception of stress.[31] It is a 10-item, 5-level Likert scale. It measures to what extent does an individual feel stressed. There are five negatively worded questions with reverse scoring instructions.

The score can range from 0 to 40, and a higher score indicates higher perceived stress. Although PSS is available with lesser items, psychometric properties were found superior with the 10-item version, which was used in this study.[32]

Ego Resilience Scale

"Resilience" is the ability to bounce back/recover from or adapt to stress. We used Ego Resilience Scale (ERS) to measure this trait.[33] It is a 14-item, 4-level Likert scale, where subjects indicate how much each item applies to them. Scores range from 14 to 56 and subjects can be grouped into very high resiliency trait (score 47–56), high resiliency trait (score 35–46) undetermined trait (score 23–34), low resiliency trait (11–22), and very low resiliency trait (score 0–10). ERS has shown good psychometric properties and temporal stability.[34,35]

Levenson's Locus of Control Scale

Locus of control refers to an individual's perceptions about the cause of events and his/her control on those events in his/her life. The Levenson's Locus of Control (LLOC) scale is a 6-level Likert scale and includes 24 items.[36] It evaluates an individual's locus of control across three domains, whether the individual believes the events in his/her life to be controlled by him/herself (internal locus of control), powerful others/external agencies (external locus of control), and chance/luck (chance locus of control). The scale is a modified version of the Rotter's I–E scale (which had only the internal and external subscales) and has a Cronbach's alpha value 0.68. The instrument has been utilized in multiple projects with good consistency and validity.

Smartphone Addiction Scale

The Smartphone Addiction Scale (SAS) is a 33-item questionnaire for assessment of an individual's subjectively perceived smartphone usage patterns.[37] It evaluates the addictiveness of one's smartphone usage across six dimensions, namely (1) daily life disturbance, (2) positive anticipation, (3) withdrawal, (4) cyber-space orientated relationship, (5) overuse, and (6) tolerance – inability to control one's smartphone usage despite efforts. The SAS showed high psychometric properties (Cronbach's alpha 0.96) and has been used extensively.[38,39] Kwon *et al*. also developed a shorter version of SAS (SAS-SV), which includes 10 items from the 33 included in the original SAS.[40] This instrument has cut-off scores (31 for males and 33 for females) for diagnosing smartphone addiction. We used in this study, (1) cumulative SAS score (from 33-item version), since it offered a more comprehensive picture of an individual's smartphone use and (2) SAS-SV score (from 10-item version) as it offered a cut-off value with which we could conduct a sub-group analysis of smartphone use pattern between those who scored above and below the cut-off scores.

On completion of this assessment, participants entered the Phase II. This consisted of making the following changes in the participants' Android smartphones.

Phase II: The study was conducted at a time when no important events (examinations, cultural/sports festival) were scheduled.

Installing the Google play store-based free app "Callistics©"

Callistics is an Android-based app available for free download from the Google play store. It is developed by the Mobilesoft r.s.o. Once downloaded, it keeps track of the number and duration of calls made and received from the Android device. It, however, does not keep track of any content from the calls.

Installing the Google play store-based free app "App Usage Tracker©"

App Usage Tracker (AUT) is a free app available on the Google play store for Android smartphones. It can be downloaded and used without any fees or permission. This app keeps track of the duration in minutes spent on all the apps by the smartphone user. The duration is recorded in minutes and seconds and is accurate to a 5-second margin. AUT does not keep track of any personal communication or media exchange, nor does it share the tracked data without the user's permission. We used AUT data on all individual apps, system apps, and a combined total smartphone usage in minutes over 7 days.

Installing the Google play store-based free app "Instant©"

Instant is a free app available on the Google play store for Android smartphones. It can be downloaded and used without any fees or permission. It keeps track of the duration in minutes spent on all the apps by the smartphone user. The duration is recorded in minutes and seconds and is accurate to a 5-second margin. It also provides the number of lock–unlock cycle an individual has performed on his smartphone over a stipulated time-frame. Instant does not keep track of any personal communication or media exchange, nor does it share the tracked data without the user's permission.

Participants were shown the workings of the three apps and were assured that their data would not be deleted or shared. Participants were advised to continue using their smartphone in a regular manner and were advised to follow-up after 7 days. During follow-up, readings from the "*Callistics*©", "*Instant*©", and "*App Usage Tracker*©" were recorded. Participants were then advised to uninstall the tracker apps if they wished.

Data analysis

Data were analyzed using descriptive statistics, *t*-test, and Mann–Whitney U test to evaluate and compare demographic variables and quantitative data. We used Pearson's correlation to assess the relationship between smartphone usage patterns and scores on scales for measurement of psychological variables. Backward stepwise multivariate regression was used to evaluate predictors of problematic smartphone use. Statistical significance was assumed at $P < 0.05$.

RESULTS

Sample

Initially, 163 participants were recruited, of which 23 dropped out after Phase I. The remaining sample of 140 (70 males and 70 females) consisted of interns (34, 24.3%), postgraduate residents (34, 24.3%), and undergraduate medical students in second year of MBBS (40, 28.5%) and third year of MBBS (32, 23%). Mean age of the sample was 22.89 ± 2.79 years.

Smartphone usage practices

Data from the App Usage Tracker [Table 1] showed that females were using the camera ($Z = -3.110$, $P = 0.002$) and the photo gallery ($Z = -2.251$, $P = 0.024$) for a significantly longer duration than males. Females also spent significantly longer duration on incoming ($Z = -2.920$, $P = 0.004$) as well as outgoing calls ($Z = -2.019$, $P = 0.043$) than males. Males were using the online video streaming apps ($Z = -2.289$, $P = 0.05$) and smartphone-based academic apps ($Z = -2.065$, $P = 0.039$) for a significantly longer duration than females. Males also consumed significantly more data on their smartphones than women (2130 vs 939 Mb, $Z = -4.101$, $P < 0.001$).

Table 1

Smartphone usage preferences and practices

Type of app	Usage time in minutes, median (IQR)	Statistical significance across designations χ^2, *P*
Utility	39 (76.75)	0.760, 0.684
Phone	141.5 (235.75)	0.245, 0.885
Messaging	4.5 (10.75)	1.132, 0.568
Social networking	146 (338.50)	16.634, <0.001 (UG > PG >intern)
Chatting	240 (333.75)	6.149, 0.046 (UG > intern > PG)
Browsers	64 (137)	1.854, 0.396
Camera	3 (15)	9.247, 0.010 (UG > PG > intern)
Photo gallery	30.5 (59)	2.511, 0.113
Video	46 (176.50)	7.136, 0.028 (UG > PG > intern)
Gaming	21 (118.50)	5.875, 0.053
Music	12 (43)	0.108, 0.742
Shopping	10 (51.50)	1.074, 0.585
Academic	0 (4.50)	12.197, 0.002 (intern > PG > UG)
Total app usage	1347 (873)	4.813, 0.090
Time spent on outgoing calls	81.50 (146.50)	0.976, 0.323
Time spent on incoming calls	123.0 (134.50)	2.061, 0.151
Number of lock-unlock cycles	375.50 (252.25)	0.074, 0.964
Total data consumption	1410 (2402.75)	10.028, 0.007 (UG > PG > intern)

IQR – Inter-quartile range

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Smartphone Addiction Scale scores

The SAS scores did not differ significantly between genders. About 36.4% (51/140) students fulfilled the SAS-SV cut-off for smartphone addiction. Prevalence of smartphone addiction did not differ significantly between genders ($\chi^2 = 0.278$, $P = 0.363$) or designations ($\chi^2 = 0.327$, $P = 0.849$). Participants with smartphone addiction spent significantly more time on their smartphone ($Z = -2.022$, $P = 0.043$) and performed significantly more number of lock–unlock cycles ($Z = -2.215$, $P = 0.027$) in the 7-day period.

Psychological variables and SAS scores

The multiple regression model [$R^2 = 0.446$, $F(13,125) = 9.557$, $P < 0.001$] showed the scores on PSS [$\beta = 0.282$, $t = 3.618$, $P < 0.001$, 95% confidence interval (CI): (0.669, 2.285)], BFI-agreeableness [$\beta = 0.152$, $t = 2.011$, $P = 0.046$, 95% CI: (0.012, 1.462)], BFI-conscientiousness [$\beta = -0.295$, $t = -3.931$, $P < 0.001$, 95% CI: (−1.850, −0.611)], BFI-neuroticism [$\beta = -0.165$, $t = -2.099$, $P = 0.038$, 95% CI:

(−1.385, −0.041)], LOC-internal [β = −0.328, t = −4.009, P < 0.001, 95% CI: (−1.219, −0.413)], and LOC-external [β =0.514, t = 5.497, P < 0.001, 95% CI: (0.770, 1.637)] as significant predictors for SAS scores.

Psychological variables and objectively measured smartphone use

Time spent on smartphone in 7-days correlated significantly with scores on SAS (r = 0.369, P < 0.001), PSS (r = 0.178, P = 0.035), BFI-conscience (r = −0.259, P = 0.002), and LOC-external (r = 0.256, P = 0.002). Total screen time (r = 0.231, P = 0.006) and lock–unlock cycles (r = 0.254, P = 0.002) correlated significantly with SAS scores. Time spent using shopping apps correlated with ERS (r = −0.214, P = 0.011) and BFI-extra (r = −0.214, P = 0.013). Time spent gaming correlated with score on MVS-success (r = 0.235, P = 0.005). Time spent on camera apps correlated negatively with BFI-agreeableness (r = −0.219, P = 0.019). Social networking apps correlated positively with score on PSS (r = 0.201, P = 0.018) and negatively with score on BFI-agreeableness (r = −0.228, P = 0.007), BFI-conscientiousness (r = −0.259, P = 0.002), and BFI-openness (r = −0.174, P = −0.040).

Multivariate regression analyses were performed using time spent on smartphone in 7-days as a dependent variable and scores on various psychometric tools as independent variables [Table 2].

Table 2

Multivariate regression analysis showing time spent on various smartphone apps and their significant predictors

Variable	R	Adjusted R^2	F	Significant	Significant predictors	95% CI (lower bound, upper bound)
TSU	0.468	0.131	2.480	0.004	SAS (β = 0.234, t=2.086, P=0.039)	0.346-13.217
SN	0.532	0.202	3.497	P<0.001	ERS (β = 0.256, t=2.278, P=0.023)	3.261-18.271
					BFI-Cons (β = −0.220, t = −2.307, P=0.023)	−15.987 to−0.659
					BFI-Neuro (β = −0.196, t = −2.037, P=0.044)	−13.420-2.541
					BFI-Open (β = −0.225, t = −0.2349, P=0.020)	−16.184-0.811
Chat	0.420	0.083	1.894	P=0.033	SAS (β = 0.237, t=2.056, P=0.042)	0.841-5.323
Game	0.436	0.099	2.079	P=0.017	MVS-Suc (β = 0.265, t=2.723, P=0.007)	2.954-18.668
Shop	0.407	0.072	1.764	P=0.049	ERS (β = −0.223, t = −2.163, P=0.032)	−6.157 to−0.273
					MVS-Happy (β = −0.184, t = −2.022, P=0.045)	−8.633 to−0.093
Acad	0.440	0.102	2.123	P=0.015	BFI-Agr (β = 0.198, t=2.022, P=0.045)	0.04-3.776

TSU – Total smartphone usage in minutes; SN – Time spent on social networking apps in minutes; Chat – Time spent on chatting apps in minutes; Game – Time spent on video gaming apps in minutes; Shop – Time spent on online shopping apps in minutes; Acad – Time spent on academic and knowledge-based apps in minutes; SA – Smartphone addiction; SAS – Smartphone Addiction Scale score; BFI-Agr – Big five inventory agreeableness subscale score; BFI-Cons – Big five inventory conscientiousness subscale score; BFI-Neuro – Big five inventory neuroticism subscale score; ERS – Ego Resiliency Scale score; MVS-Suc – Materialism values scale-success subscale score; MVS-Hap – Materialism Values Scale – happiness subscale score

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DISCUSSION

This study explores the possible role of psychological variables in predicting excessive smartphone use among medical students. Self-rated questionnaire-based studies on smartphone usage have implied that smartphone usage can be excessive and even addictive. Smartphones are constantly present around us, and it is very difficult to accurately and objectively recall one's own smartphone usage in a retrospective manner.[41] We attempted to eliminate subjectivity and recall errors in assessing smartphone usage by employing an objective, telemetric method.

The first important finding in this study was the prevalence of “smartphone addiction” and the predictive value of SAS. SAS scores also emerged as the sole predictor for the global smartphone usage in a 7-day period. Our sample showed 35% participants scoring above the cut-off score on SAS-SV for

smartphone addiction. This supports the existing Indian literature on the topic.[14,15] This, however, needs to be taken with a pinch of salt. Till date, studies evaluating smartphone addiction have explored problematic smartphone usage with self-report questionnaires,[42,44] adopted the substance dependence criteria for tolerance and withdrawal to smartphone usage,[45,46] and explored the impulse control dimension of excessive smartphone use.[47,48] These approaches, however, could not establish a robust neurobiological or psychopathological model for smartphone addiction as a separate diagnostic entity.[49] It is also worth noticing that, unlike substances such as alcohol or cannabis, many features in a smartphone (such as making and receiving calls) are a part-and-parcel of daily life, and not a luxury or a source of pleasure. These factors need to be considered and controlled for in future research for exploring this issue in detail. Summing up, SAS may be of value in determining the quantitative aspect of an individual's smartphone use. It needs to be explored whether that usage amounts to a behavioral addiction.

Coming to predictors of usage of individual apps, agreeableness was identified as a predictor for usage of academic apps. Agreeableness includes courteousness, trust, tolerance, and will to help others. Tolerance and forgiving characteristics make agreeable individuals more willing to accept new challenges and technologies as well as spend more time online.[50] Agreeable individuals have also been shown to be more persistent in investigating difficult content and user-unfriendly online data.[51] Academic apps contain scientific jargon, graphs, and statistics and are tedious to navigate through. They contain various tables, classifications and sub-classifications, and a lot of text, which may be difficult to read on a handheld small screen. Therefore, individuals with patience and tolerance, therefore agreeableness, are more likely to use such apps.

Predictors for high social networking apps usage were low ego resiliency, low conscientiousness, low neuroticism, and low openness. Conscientiousness, in earlier studies, has been negatively correlated with a higher preference toward apps involving leisure and creativity.[51,52,53] Studies have also shown a negative correlation between conscientiousness and adaptation of social apps Facebook and Twitter.[54,55] Reason for the negative impact of conscientiousness on social media could be the fact that, conscientious people are focused and organized and possess high self-control and therefore may show less inclination to engage in leisurely activities. Coming to the link between neuroticism and preference for social networking apps, the literature has mixed results. Early evidence showed a negative correlation between neuroticism and preference for social networking,[56] possibly due to high levels of neuroticism causing individuals to perceive new technology as threatening or stressful.[50] The recent trend, however, points toward a positive correlation between them.[55]

We also observed low scores on openness to new experiences as a predictor for longer time spent on social networking apps. It was expected that individuals with high openness would be more adaptive toward newer technologies and therefore would spend more time on smart phones.[57] A number of explanations have been offered by other investigators who too observed this discrepancy.[51,58,59] Individuals with high openness to experience, though are enthusiastic to try new things, may perceive social media and networks too restrictive a medium for their taste, or may not find them useful to their need.[58,60] It is hypothesized that, once a technology becomes mainstream, its popularity may compensate for the initial preference shown by individuals with high openness to experience.

Lower ego resiliency predicted more time spent on online shopping. Ego resiliency is a key construct for understanding motivation and behavior. Ego resiliency modifies one's level of control (ego control) in response to situations and stimuli.[61]

High ego resiliency and ego control have been identified as protective factors against impulsive behaviors and substance dependence, and therefore might be implicated in online shopping as well.[62]

Higher materialism, particularly the success subscale scores, correlated with and predicted longer duration spent gaming. Playing games involves chasing a target to achieve a reward, either monitory or emotional. Individuals with high materialism regard material possessions highly as a source of happiness and success. Materialism is also correlated strongly with motivation and therefore implicated in the excessive use of the Internet and cell phones, online gaming, and compulsive online buying. [20,63,64]

This article adds evidence to the existing literature by objectively evaluating smartphone usage practices. It addresses one important limitation in research concerning behavioral aspects of smartphones and social media use: It shows the ease of administration and plausibility of using telemetric services in objectively measuring smartphone usage. Future research with more focus on psychological predictors of problematic smartphone use will be beneficial. Screening in children and adolescents for some of these psychological variables may prove to be helpful in identifying the vulnerable population.

Limitations

The small sample size is an important limitation to the study. Reasons for a small sample were, (1) exclusion of students owning a smartphone based on Windows or iOS which eliminated a sizable sample, (2) unwillingness of many students to install apps to track one's smartphone use and to re-set the WhatsApp usage statistics. We also excluded students owning two smartphones and those using a tablet device. This limited the sample size and smartphone usage in those individuals could not be tested. A study involving a larger sample and multiple devices may yield different results. The sample being solely from a medical college may limit the generalizability of our findings.

CONCLUSIONS

Telemetric approach is a sound and practically viable method to objectively measure smartphone usage practices for research purposes. Psychological factors such as personality traits, materialism, and ego resiliency can be linked to the higher use of social networking apps, gaming apps, and online shopping apps, respectively. Further research in this domain is necessary.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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