12-1-2019

Should it Stay or Should it Go? Smartphone Dependency

Kira Foreman-Tran
Western University

Karina Schnurr
Western University

Ana C. Ruiz Pardo
Western University

John Paul Minda
The University of Western Ontario, jpminda@uwo.ca

Citation of this paper:
Foreman-TranKira, SchnurrKarina, PardoAna C. Ruiz, and MindaJohn Paul. Should it Stay or Should it Go? Smartphone Dependency. STEM Fellowship Journal. 5(1): 19-23. https://doi.org/10.17975/sfj-2019-008

Should it Stay or Should it Go? Smartphone Dependency

10.17975/sfj-2019-008

Kira Foreman-Tran, Karina Schnurr, Ana C. Ruiz Pardo, John Paul Minda

Department of Psychology, Western University, London, ON, Canada

ABSTRACT

As smartphones grow in use and popularity, it is important to understand the possible effects that varying levels of smartphone use may have on human cognition. Although smartphones provide many advantages for daily activities, one must also recognize the potential disadvantages. For example, smartphone use may lead to nomophobia, which is defined as the modern fear of not being able to access your smartphone or the internet (Yildirim & Correia, 2015). The present study used a pilot and main study to examine the effects smartphones have on human cognition. The pilot study was conducted to measure nomophobia, mobile phone involvement, smartphone attachment and dependency, and general smartphone use. This portion was also used to determine the paradigm for the main study. Participants in the main study completed the 12 Cambridge Brain Science tasks, which measured different aspects of cognition' while leaving their smartphones in one of two locations: on their desk, or outside of the testing room. Additionally, participants completed the same four questionnaires from the pilot study. Results from both studies reveal the majority of individuals show moderate levels of nomophobia, dependency and attachment, and involvement. Subsequent data analysis focused on the double-trouble task, which is an attention-based task. Results found that there was no significant difference in performance on the double-trouble task between the two locations. Contrary to common belief, it seems that the mere presence of one's smartphone does not affect performance on a cognitively demanding task.

KEYWORDS

Cognitive interference, Smartphone use, Smartphone dependency, Cognitive psychology, Cognitive science

INTRODUCTION

According to Statistics Canada, 76% of Canadians reported owning a smartphone in 2016 [1], suggesting widespread popularity of smartphones. Park and colleagues [2] proposed that smartphone popularity is due to the ease and flexibility with which they can be used to complete daily tasks. While there are many advantages of smartphone use, there are also negative effects, such as: nomophobia [3], smartphone involvement [4], dependency [5] and distraction [6]. Furthermore, notification settings and proximity to one's smartphone can evoke feelings of inattention, hyperactivity [7] and anxiety [8]. In a two-week study comparing notifications turned on versus off, university students reported experiencing higher levels of inattention and hyperactivity while their notifications were turned on [7]. Another study using physiological measures found that separation from one's smartphone while it is ringing leads to feelings of anxiety [8].

Seo and colleagues [9] discovered that mobile phone use negatively predicted attention which in turn affected mathematics and language arts achievement. Newer studies have found that receiving notifications or a call during a task can affect task performance [6, 10]. Kim and colleagues [6] examined the effects of notifications on task performance with regards to smartphone overuse and found that participants in the high overuse (risk) group were more sensitive to notifications than the low overuse group. The risk group demonstrated the highest level of impaired concentration after hearing incoming notifications [6]. Chen and Yan [10] investigated the effects of learning while multitasking with a mobile phone. They concluded that multitasking impaired learning for three possible reasons: (1) the same cognitive modules are used for both tasks, but only one task can be processed; (2) cognitive interference, where only one task is completed at a time; and (3) learning processes take longer when the recovery and resume time of the initial task is interrupted by mobile phone use.

Individual Difference Measures

Nomophobia

Nomophobia is the modern fear of not being able to communicate through a mobile phone or the Internet [3]. It is a situational phobia, classified in the Diagnostic and Statistical Manual of Mental Disorders, that elicits symptoms or behaviours related to anxiety that are associated with mobile phone use. Increased smartphone prevalence leads to reliance on one's device and a study revealed participants had increased feelings of anxiety when this interaction was broken [2]. Yildirim and Correia [3] developed the Nomophobia Questionnaire (NMP-Q) to measure individual levels of nomophobia. This questionnaire includes four dimensions of nomophobia: (1) not being able to communicate, (2) losing connectedness, (3) not being able to access information, and (4) giving up convenience.

Involvement

Walsh and colleagues [4], conducted a study investigating the effects of self and others on young people's (15-24 years old) mobile phone involvement. Researchers developed the Mobile Phone Involvement Questionnaire (MPIQ) and provided a distinction between mobile phone involvement and frequency of use. The authors reported that only self-identity predicted frequency of use while validation from others and self-identity predicted mobile phone involvement [4]. This suggests the presence of a phone-user psychological relationship which affects mobile phone use.

Attachment and dependency

Smartphone attachment and dependency is defined as the extent to which individuals rely on their phone for daily life [5]. Ward and colleagues [5] created the Smartphone Attachment and Dependency Questionnaire (SAD) to measure individual levels of smartphone attachment and dependency. Using the SAD, those who reported increased dependency on their smartphones showed poorer performance when engaging in a cognitively demanding task [5].

The "Brain Drain" Effect

Current literature has found that smartphones affect cognition [5–7, 9, 10]. For example, Ward and colleagues [5] found that the mere presence of one's smartphone can affect cognitive performance. By using three location conditions (i.e. on desk, other room, or pocket/bag) and two power conditions (i.e., ON or OFF), the Operation Span (OSpan) task [11] and a Go/No-Go task [12], researchers found an effect of location on OSpan performance [5]. Participants performed best in the "other room", followed by the "pocket/bag", and then the "on desk" condition [5]. These results were moderated by SAD levels, where higher levels showed a greater "brain drain" effect.

Extended-Self Theory

One theoretical explanation for increased smartphone use is Belk's 1988 Extended Self Theory [13]. According to Belk, people's belongings, whether unintentionally or intentionally, unknowingly or knowingly, can become an extension of one's self. More recently, Belk presented an updated Extended-Self Theory which incorporates the digital world, wherein electronic devices become "extensions of self" as other objects do [14]. One aspect of the extension of self is that when one unintentionally misplaces a possession, it creates a sense of loss or lessening of self [13, 14]. This theory could explain people's varying levels of nomophobia and dependency, and how these differences can affect performance on tasks involving higher-order cognition.

Present Study

The current project aims to expand on the current research on smartphones and cognition (e.g. Ward and colleagues [5]) to gain a better understanding of the possible effects smartphones have on cognition. This was conducted in two parts: a pilot and main study. The pilot study was used to measure typical smartphone use, individual difference measures (i.e., NMP-Q, MPIQ, SAD), and to make a paradigm decision for the main study. Using the 12 Cambridge Brain Science (CBS) tasks [15], the main study investigated the effects of smartphone presence on cognition. Specifically, the double-trouble CBS task, which is an attention-based task similar to those used in previous studies [5, 6]; it is more complicated than some previous tasks such as the Go-NoGo in Ward et al. [5] as it involves double inhibition. Decreased performance on attentionally-demanding cognitive tasks for those who have their smartphones closest to their proximity (i.e. on the desk) was predicted.

METHODOLOGY

Participants

Undergraduate students at Western University participated for course credit. The pilot study had a sample size of 100 (51 males, 49 females), with an age range of 17-24 years ($M = 18.84$). The main study had a sample size of 109 (39 males, 70 females), ranging from 18-27 years ($M = 18.84$). Respondents reported getting their first smartphone between 9-17 years (pilot, M = 13.06), and 9-16 years (main, M = 13.19). For both studies, at least 73% of participants reported English as their first language and 84% reported high English proficiency.

Materials and Procedure

Both studies used four questionnaires to measure individual differences in an online survey: (1) the Smartphone Usage Questionnaire (SUQ), which was designed for this study to measure typical smartphone use and determine the paradigm for the main study; (2) the MPIQ, which measured level of connectedness with one's phone; (3) the SAD, which measured the level of attachment and dependency on one's smartphone; and (4) the NMP-Q, which measured the level of fear of separation from one's phone.

The pilot was approximately 15 minutes in length. All questionnaire items which used a Likert-scale with ranking options ranging from 1 ("strongly disagree") to 7 ("strongly agree"). The SUQ included 41 items (27 multiple-choice and 14 Likert-scale items) with four subscales: demographics, paradigm questions, comfort level, and exploratory questions. For exploratory purposes, five items related to the "Screen Time" feature on iPhones. Each subscale provided an overview of demographics and typical smartphone use. The MPIQ contained 14 Likert-scale items with three subscales: smartphone involvement (i.e. connectedness to one's smartphone), self-identity (i.e. one's phone as an extension of self), and validation from others (i.e. affirmation from receiving notifications). Only the smartphone involvement subscale was analyzed (i.e. 8 items). A total score was calculated (range: 8-56), where higher scores correspond to greater involvement: no involvement (8), low (9-24), moderate (25-40), and high (≥41) level. The SAD contained 13 Likert-scale items with a total score (range: 13-91), where higher scores correspond to higher attachment and dependency: no attachment and dependency (13), low (14-39), moderate (40-65), and high (≥66) level. The NMP-Q measured nomophobia with 20 Likert-scale items. A total score was calculated (range: 20-140), with higher scores corresponding to greater nomophobia: no nomophobia (20), low (21-59), moderate (60-99), and high (≥100) level.

The main study randomly assigned participants to leave their phones in one of two location conditions, either on their desk or in a different room. All participants placed their smartphones on "silent" (i.e. no vibration or other notifications) and faced down in their respective location. Participants completed the 12 CBS tasks followed by the questionnaires (1-hour total). The CBS tasks measured four fundamental cognitive areas, as defined by the makers of these tasks: memory (e.g. Monkey Ladder–visuospatial memory), reasoning (e.g. Rotations–mental rotation), verbal ability (e.g. Grammatical Reasoning–verbal reasoning), and concentration (e.g. double-trouble–response inhibition; Figure 1). The present study focused on the double-trouble task since attention is a prominent topic in current research [5–7] and it is considered the hardest CBS task. The double-trouble task was a computerized variant of the Stroop test [16]. It is a colour-word mapping task with three coloured words: one at the top and two at the bottom of the screen. During the task, one must select the bottom word that describes the ink colour of the top word. The colour-word mappings are either congruent, incongruent, or doubly incongruent (Figure 2). Participants have 90 seconds to solve as many problems as they can, and their final score is the difference between the number of correct and incorrect answers.

Pearson correlations were calculated to examine the relationship between the three individual difference measures: the MPIQ, SAD, and NMP-Q. Correlation analyses were conducted for the purpose of determining if these measures were related to each other, if participants' responses were consistent, and if there were sensitivity differences.

To test the main hypothesis of whether closer proximity to one's smartphone leads to lower performance, a t-test was used to compare performance on the double-trouble task between the two conditions. This analysis had three assumptions: (1) independent samples, (2) normality, and (3) equal variances. The first assumption was met during testing. A Shapiro-Wilk normality test evaluated normality and showed normality was not met, therefore, a Wilcoxon-Mann-Whitney Test was conducted, and the third assumption was no longer required.

RESULTS

In both studies, results from the MPIQ (pilot: $X^2(2) = 39.14$; main: $X^2(2) = 52.64$), SAD (pilot: $X^2(2) = 46.16$; main: $X^2(2) = 62.55$), and NMP-Q (pilot: $X^2(2) = 36.26$; main: $X^2(2) = 44.28$) revealed that most participants reported moderate levels, with fewer participants falling in the high and low levels on each questionnaire, $p < .001$ (Figure 3). A Pearson's Chi-squared test was used to compare the frequency of levels (i.e., low, moderate, and high) of the three individual difference measures (i.e., MPIQ, NMP-Q, and SAD). There was no significant relationship for the pilot, $X^2(4) = 0.80$, $p = .938$, and main, $X^2(4) = 6.44$, $p = .169$, studies.

Moreover, both sets of results showed most participants

CORE COGNITIVE AREA	MEMORY				REASONING				VERBAL ABILITY		CONCENTRATION	
OUTCOME MEASURE	Visuospatial Working Memory	Spatial Short-Term Memory	Working Memory	Episodic Memory	Mental Rotation	Visuospatial Processing	Deductive Reasoning	Planning	Verbal Reasoning	Verbal Short-Term Memory	Attention	Response Inhibition
TEST	Monkey Ladder	Spatial Span	Token Search	Paired Associates	Rotations	Polygons	Odd One Out	Spatial Planning	Grammatical Reasoning	Digit Span	Feature Match	Double Trouble

Figure 1. Cambridge Brain Sciences (CBS) task divided by cognitive area, outcome measure, and test.

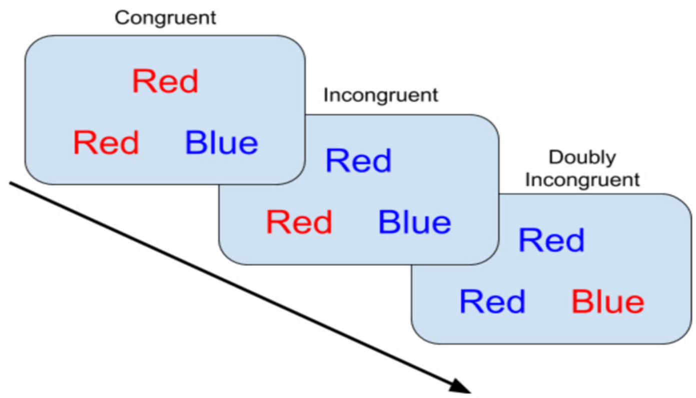

Figure 2. Sample of the Double Trouble attention-based CBS task showing a congruent, incongruent, and doubly incongruent example.

variety of situations. While studying, the majority of participants reported leaving their phone on their desk. The only situations where participants reported leaving their phone in another room was during an exam or while studying (Figure 4). The paradigm of the main study was chosen based on the results from the pilot study. Due to the majority of participants indicating leaving their phone on the desk while studying and since the physical distance would be the most separable, the main study included the “on desk” and the “outside” location conditions.

Most participants reported their smartphone as the most distracting electronic device (pilot=87%; main=92%), followed by their computer (pilot=9%; main=6%), iPad/tablet (pilot=3%; main–1%), smartwatch (main=1%), and “Other” (pilot=1%). The iPhone Screen Time feature was used to gain an objective measure for participants’ most used application, active screen time, and notifications received on a daily basis. The majority of participants reported a social networking platform as their most used application (e.g. Instagram; pilot=82%; main=86%), followed by entertainment (e.g. YouTube; pilot=16%; main=19%), games (e.g. Candy Crush Saga; main=3%) and other (main=1%) applications. Regarding total screen time (hours per day), the most reported was 11-20 for the pilot (20%) and 21-30 for the main (18%) studies. For number of notifications received per day, most reported values over 200 (pilot=28%; main=31%).

Correlation analyses in both studies revealed a significant strong positive correlation between all the questionnaires (Table 1A & 1B). In contrast, the double-trouble task score was not significantly correlated with any of the questionnaires (Table 1B). Overall, all three questionnaires were related in both studies; however, no relationship was observed between task performance and the individual difference measures.

A Shapiro-Wilk normality test showed that normality was not met, $W = 0.96$, $p = .002$. Thus, a nonparametric Wilcoxon-Mann-Whitney Test was conducted and showed no significant difference in task performance between placing one’s smartphone on the desk ($M = 26.89$, $SD = 14.37$) compared to outside the room ($M = 27.85$, $SD = 12.51$), $Z(107)$, -0.33, $p = 0.75$ (Figure 5). Therefore, the main prediction was not supported.

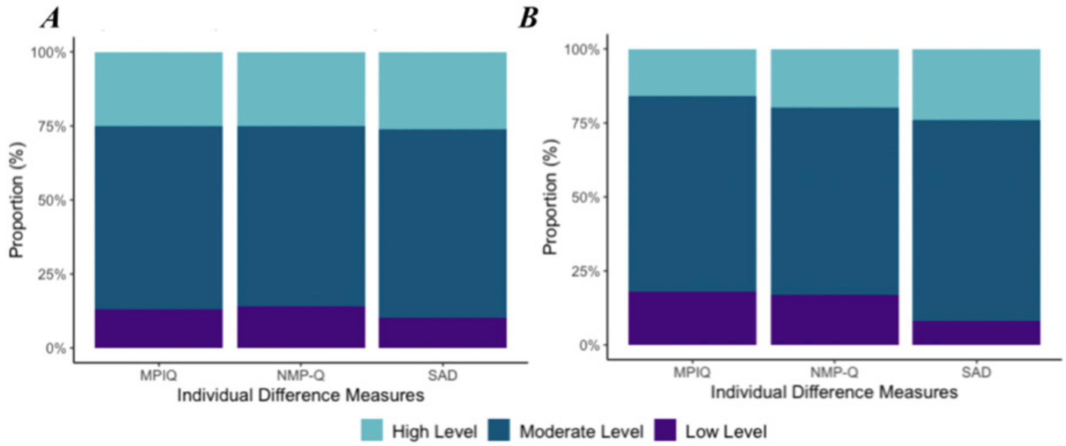

Figure 3. Results from the pilot (panel A) and main (panel B) study. The levels for each individual difference measure are shown: The Mobile Phone Involvement Questionnaire (MPIQ), The Nomophobia Questionnaire (NMP-Q), and The Smartphone Attachment and Dependency Questionnaire (SAD).

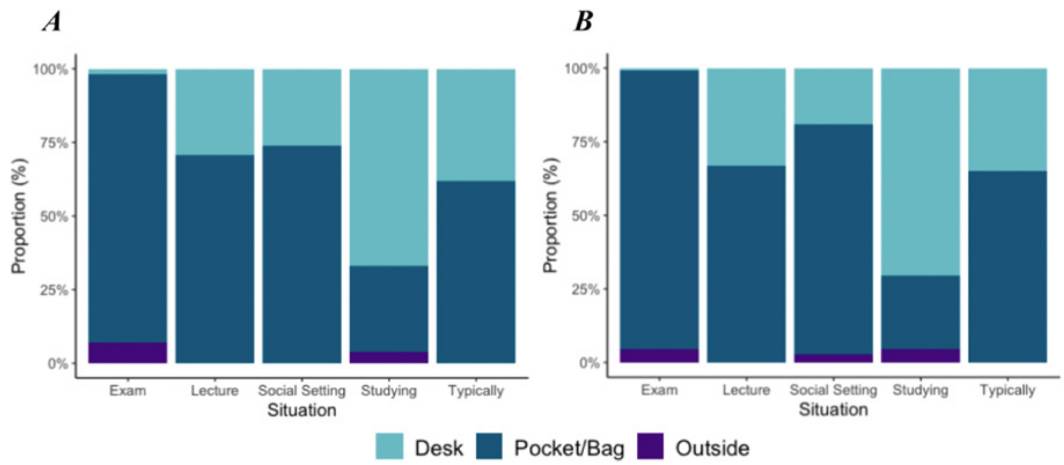

Figure 4. Results from the pilot (panel A) and main (panel B) study. The proportion of reported typical smartphone locations (i.e., either "on desk", "in pocket/bag" or "outside of the room") for different situations (i.e., during an exam, lecture, social setting, or typically).

Table 1. Pearson correlations between individual differences questionnaires (MPIQ, SAD, NMP-Q) and double-trouble score

A: Pilot Study – Questionaires Only				
		NMP-Q	MPIQ	SAD
NMP-Q	—	—	.81*	.80*
MPIQ	—	—	—	.81*
B: Main Study – Questionaires and Double-Trouble Score				
	Double-Trouble	NMP-Q	MPIQ	SAD
Double-Trouble	—	.04	-.01	.05
NMP-Q	—	—	.74*	.79*
MPIQ	—	—	—	.80*

Note: The questionnaires are shown above as follows: Nomophobia Quest. (NMP-Q), Mobile Phone Involvement Quest. (MPIQ), Smartphone Attachment and Dependency Quest. (SAD). Double-trouble is one of twelve computerized Cambridge Brain Science Tasks. *p <.001 (two-tailed)

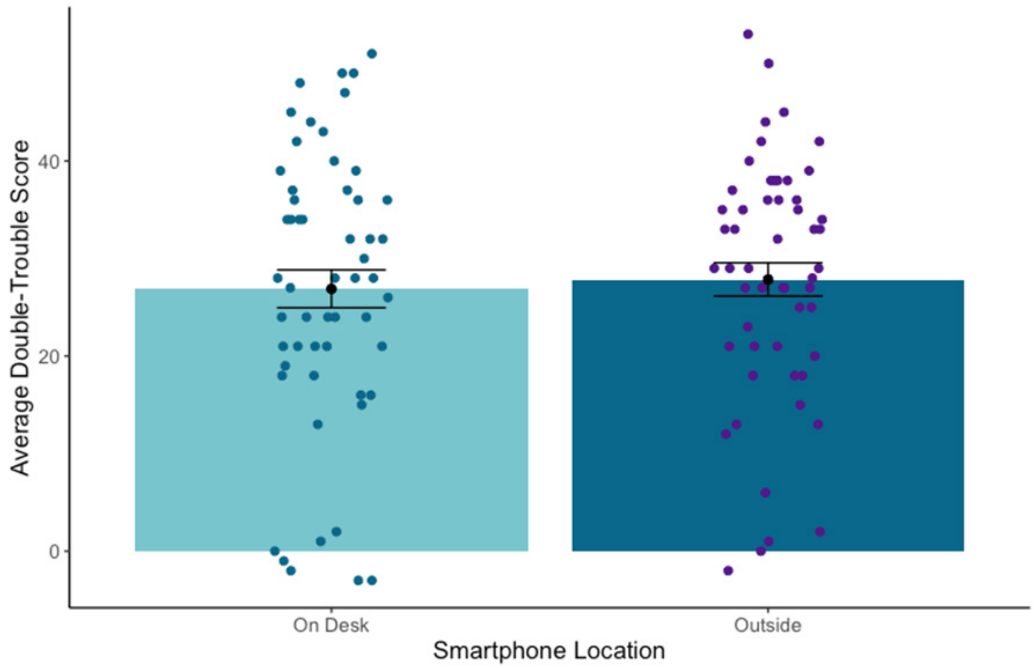

Figure 5. Results from the main study. There was no effect on performance on the double-trouble task between the smartphone location conditions (i.e., on desk and outside of the testing room). The blue and purple dots represent individual scores for the on desk and outside conditions, respectively. The bars represent average score on the double trouble for both smartphone location conditions: light blue for on desk (M = 26.89, SD = 14.37) and dark blue for outside (M = 27.85, SD = 12.51). The depicted error bars show standard error (on desk = 1.94; outside = 1.70). The 95% CI was as follows: on desk (upper = 30.78; lower = 23.01) and outside (upper = 31.27; lower = 24.44).

DISCUSSION

The pilot study was exploratory in nature (i.e. individual difference measures) and determined the smartphone paradigm for the main study. The main study was conducted to further understand individual difference measures and to investigate whether smartphone presence affects cognition, with respect to attention.

In both studies, the majority of participants reported moderate levels on the individual difference measures: involvement, attachment and dependency, and nomophobia. Additionally, most individuals reported keeping their smartphone near them in a variety of situations (e.g. studying). Given the growing use of smartphones in everyday life, results from these questionnaires show how individuals use and connect with their smartphone. For both studies, there were strong positive relationships between the NMP-Q, MPIQ, and SAD. Understanding the relationship between these questionnaires may help develop future interventions for current social concerns about the increased prevalence of nomophobia. There was no relationship found between participant performance and the individual difference measures. This suggests that individual differences in smartphone use had no significant relationship with cognitive performance.

For the main study, it was hypothesized that closer proximity to one's smartphone would result in lower performance. This hypothesis was not supported, which was not in line with previous research [5, 6, 8]. It is important to note that researchers chose to examine the double-trouble task, not only because it is the most difficult CBS task, but because it explicitly measures attention, a parameter often explored in previous literature surrounding smartphones and is a key component of executive functioning (e.g., self-control, inhibition) [5, 6].

Limitations

Given that the SUQ was developed for the current project, some items regarding the Screen Time feature were not applicable to all participants. Additionally, it is difficult to determine what smartphone application to measure and develop appropriate response options for the multiple-choice style questions in the SUQ. This Screen Time feature can also track multiple devices at once (e.g. iPhone, iPad), which may influence results. Further, the current study did not include the "in pocket/bag" location condition. This limited the range of individual differences that could be measured; however, it did depict the most physically separable location conditions. Moreover, in order to focus on the attention measure, only the sustained attention measure (i.e. double-trouble) was analyzed. Although there are several limitations, this data provides valuable insights into how smartphone location can impact users.

Implications

Results from the current study suggest that mobile phone dependency does not have an effect on attention. Although this conclusion is reflected in some literature [9], it is contrary to most previous studies [6, 7], including Ward and colleagues [5], which reported that the closer proximity of one's smartphone significantly decreased task performance. This suggests that further investigation is necessary in this area. Future research should emphasize other aspects of smartphone use (e.g. incoming notifications, popular apps, etc.), which are more representative of realistic smartphone use. The findings from the present study are important in an academic environment given the complex cognition needed for the CBS tasks. In September 2019, all public high schools in Ontario, Canada banned the use of cellphones during classroom instruction [17]. The goal of this ban is to prevent distractions in the classroom and allow students to focus on acquiring proper academic skills [17]. However, the current study indicates that the mere presence of one's smartphone does not significantly impact cognition, meaning that the ban on cellphones may not be as prudent as was once thought. Thus, it is important that cellphone use policies in educational settings are continually evaluated and updated as further research is published in this field.

Future Research

Further research must be completed using larger, more representative sample sizes and focus on other CBS tasks to explore the impact of smartphone location on numerous aspects of cognition. In addition, there is some evidence that smartphone notifications can lead to impairment in concentration, especially for individuals with high dependency on their phones [6], therefore, research should investigate the effects of receiving notifications rather than merely smartphone presence during complex cognitive tasks.

Final Conclusions

Although the current study found no effect between smartphone location and performance on an attention-based cognitive task, these results provide a basis for future research in the field. The majority of participants fell within the moderate level of involvement, attachment and dependency, and nomophobia. However, these levels did not correlate with task performance. Given the growing use of smartphones and increasing demand to constantly have access to technology and the internet, it is important to continue investigating the potential effects smartphones may have on cognition.

AKNOWLEDGEMENTS

This project was funded with a Research Western Strategic Support Grant (RES001823). I would like to thank Karina Schnurr (undergraduate student, Western University, Department of Psychology) for completing this project and manuscript with me; Dr. John Paul Minda (Professor, Western University, Department of Psychology), for his supervision and expertise; and Ana C. Ruiz Pardo for her supervision and guidance (Ph.D. candidate, Western University, Department of Psychology).

REFERENCES

1. Statistics Canada. Life in the fast lane: How are Canadians managing? Statistics Canada: The Daily [Internet]. 2017 Nov 14. Available from: https://www150.statcan.gc.ca/n1/daily-quotidien/171114/dq171114a-eng.htm?HPA=1
2. Park N, Kim Y-C, Shon HY, Shim H. Factors influencing smartphone use and dependency in South Korea. Comput Human Behav. 2013;29(4):1763–1770. doi:10.1016/j.chb.2013.02.008
3. Yildirim C, Correia A-P. Exploring the dimensions of nomophobia: Development and validation of a self-reported questionnaire. Comput Human Behav. 2015;49:130–137. doi:10.1016/j.chb.2015.02.059
4. Walsh S, White KM, McD Young R. Needing to connect: The effect of self and others on young people's involvement with their mobile phones. Aust J Psychol. 2010;62(4):194–203. doi:10.1080/00049530903567229
5. Ward AF, Duke K, Gneezy A, Bos MW. Brain Drain: The mere presence of one's own smartphone reduces available cognitive capacity. J Assoc Consum Res. 2017;2(2):140-154. doi:10.1086/691462
6. Kim S-K, Kim S-Y, Kang H-B. An analysis of the effects of smartphone push notifications on task performance with

regard to smartphone overuse using ERP. Comput Intell Neurosci. 2016(3):1-8. doi:10.1155/2016/5718580

7. Kushlev K, Proulx J, Dunn E. "Silence your phones": Smartphone notifications increase inattention and hyperactivity symptoms. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16); 2016: 1011-1020. New York, NY. doi: 10.1145/2858036.2858359
8. Clayton RB, Leshner G, Almond A. The Extended iSelf: The impact of iPhone separation on cognition, emotion, and physiology. J Comput-Mediat Comm. 2015;20(2):119–135. doi:10.1111/jcc4.12109
9. Seo DG, Park Y, Kim MK, Park J. Mobile phone dependency and its impacts on adolescents' social and academic behaviors. Comput Human Behav. 2016;63:282–292. doi: 10.1016/j.chb.2016.05.026
10. Chen Q, Yan Z. Does multitasking with mobile phones affect learning? A review. Comput Human Behav. 2016;54:34–42. doi:10.1016/j.chb.2015.07.047
11. Unsworth N, Heitz RP, Schrock JC, Engle RW. An automated version of the operation span task. Behav Res Methods. 2005;37(3): 498–505. doi:10.3758/bf03192720
12. Bezdjian S, Baker LA, Lozano DI, Raine A. Assessing inattention and impulsivity in children during the Go/NoGo task. Br J Dev Psychol. 2009;27(2):365–383. doi:10.1348/026151008X314919
13. Belk RW. Possessions and the extended self. J Consum Res. 1988;15(2):139–168. doi:10.1086/209154
14. Belk RW. Extended self in a digital world. J Consum Res. 2013;40(3):477–500. doi:10.1086/671052
15. Hampshire A, Highfield RR, Parkin BL, Owen AM. Fractionating human intelligence. Neuron. 2012;76(6):1225–1237. doi:10.1016/j.neuron.2012.06.022
16. Stroop JR. Studies of interference in serial verbal reactions. J Exp Psychol. 1935;18(6):643–662. doi:10.1037/h0054651
17. Jones A. Ontario to ban cellphones in classrooms next school year. CBC News [Internet]. 2019 Mar 12. Available from: https://www.cbc.ca/news/canada/toronto/ontario-school-classroom-cellphone-ban-1.5052564