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The Effect Of Smartphones on Working Memory

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Abstract

In 2017, Ward, Duke, Gneezy, and Bos reported that a phone's mere presence, even without using it, reduced cognitive capacity because subjects were devoting some amount of attentional processing to the phone. Some studies have successfully reproduced the finding, but others have found inconsistent or opposing results, suggesting that one's relationship to one's phone, or how one uses it, may affect whether its presence is distracting or not. The present study primarily attempted to replicate Ward et al's original finding by having half the subjects keep their phones next to them while they performed a cognitive measure of working memory (the OSpan task), while the other half were asked to leave their phones in an adjacent waiting room. After finishing the OSpan task, participants completed five questionnaires assessing smartphone related habits and opinions: the Fear of Missing Out Scale (FoMo), the Nomophobia Scale, the Mobile Phone Problem Use Scale (MPPUS-10), the Young Adult Attachment to Phone Scale (YAPS), and three phone-related reflection questions. No significant difference on OSpan performance was found between phone-present and phone-absent conditions. Furthermore, previous studies have reported that those with higher levels of phone attachment or dependency perform worse in the phone present group. The questionnaires listed earlier were used to investigate the relationship between the OSpan results and phone use and attachment. The phone present group on average scored lower than the phone absent group, but not to statistical significance. Although numbers trended in the hypothesized direction, the present results fail to replicate Ward et al.'s finding that the simple presence of one's phone has a "brain drain" effect.

Keywords: working memory, attention, smartphones, OSpan

Introduction

In 2016, 49.40% of the global population owned a smartphone.[1] Since 2016, the worldwide percentage of smartphone owners has increased to 86.29%.[1] According to the Pew Research Center, around 97% of Americans own a smartphone today.[2] Alongside the proliferation of smartphones integrating into our everyday lives, so have questions about how these devices may be affecting our cognition (such as working memory, attention, and other executive functioning processes).

In 2014, Thornton, Faires, Robbins, and Rollins first investigated whether the mere presence of a cell phone was distracting.[3] In this study, the researcher's phone was covertly placed on one participant's desk, and a phone-sized

notepad was placed on another participant's desk.[3] Thornton et al. found no significant difference between performance on simpler versions of cognitive tasks, such as the digit cancellation task and the Trail Making Test (TMT), that measured attention, cognitive capacity, executive functioning, and mental flexibility.[3] However, they did find a significant performance difference on the complex versions of the same cognitive tasks with the subjects in the phone-on-desk condition performing worse than those in the notepad condition.[3] One weakness in this study was that participants' personal smartphones were not used and may have been less distracting than if it had been their personal devices.

In 2017 Ward, Duke, Gneezy, and Bos investigated whether the mere presence of one's personal smartphone reduced performance on cognitive processes such as working memory. Subjects were randomly assigned to a phone location condition in which they either left their phones in a separate room with their other belongings or left most of their belongings behind but brought their devices into the lab with them.[4] A significant difference was found between group performance in phone present and phone absent conditions, with phone present participants performing worse on the Automated Operation Span task (OSpan task) and the Raven's Standard Progressive Matrices (RSPM).[4] The OSpan task measures working memory, or how many stimuli one can keep readily retrievable at once, and the RSPM measures an individual's fluid intelligence via how many unique spatial arrangement problems they can solve.[4] Ward et al.'s results led them to coin the term the "brain drain" effect in relation to the study.[4] The researchers also found that those with more attachment to their smartphones would suffer greater cognitive costs when their phone was near them.[4] Another study in 2020 by Tanil and Yong also found that participants performed better on working memory tasks when their phones were absent.[5] In addition, they found a significant negative effect of conscious phone thought on recall.[5] Other studies such as one by Niu, Shi, Yang, Jin, and Sun in 2022 have also successfully reproduced Ward et al.'s finding of impaired performance in the presence of smartphones.[6]

Nevertheless, the finding that smartphone presence has negative effects on cognition has not been consistently replicated. For example, Ruiz Pardo and Minda replicated Ward et al.'s study with 383 participants and failed to find a significant difference on OSpan performance between phone present and absent conditions on working memory.[7] Similarly, Koessmeier and Büttner had a sample size of 103 participants and did not find significant differences on performance between phone absent and present conditions.[8] For reference, Ward et al.'s study had a sample of 520 participants.[4] Furthermore, Haranto and Yang found that separation from smartphones impaired cognition because it induced substantial anxiety instead of enhancing focus due to its absence, leading to the opposite conclusion from Ward et al. that in some cases, phone separation could be detrimental rather than beneficial to cognitive performance.[7]

The purpose of this study was to attempt to replicate Ward et al.'s finding that the presence of a smartphone during a cognitive task had negative effects on performance. Ward et al. and others also questioned whether phone attachment or dependency might have further impacted any effects of phone presence on cognitive performance. Hence, the present study also investigates how individual attachment styles to smartphones may interact with phone location conditions. For example, those with higher degrees of phone attachment may benefit from having their phone away from them to minimize any distraction caused by the phone's presence. The idea that individuals vary between each other regarding degrees of phone attachment and/or dependency may help clarify why some studies have found detrimental effects of phone presence on executive functioning.

Various scales and surveys have been developed and used to try to measure phone attachment such as the Smartphone Addiction Scale (SAS) used in Tanil and Yong's study, the Fear of Missing Out scale used in Niu et al.'s study, and the smartphone attachment and dependency inventory used in both Ward et al. and Ruiz Pardo et al.'s study.[4,6] The present study uses the OSpan task to measure working memory as in previous studies, and adds various questionnaires assessing phone-related thoughts and habits, including the Fear of Missing Out Scale (FoMO), the Nomophobia Scale, the Mobile Phone Problem Use Survey (MPPUS-10), the Young Adult Attachment to Phone Survey (YAPS), and three reflection questions taken directly from Ward et al's original questionnaire.

Methodology

Participants

50 participants were recruited from UNCA's undergraduate population. Four participants were later removed: two for failure to follow instructions, and two for abnormally low OSpan scores that fell two standard deviations below the mean (a score of 6.32 or less out of a maximum of 60). There were a total of 25 participants in the phone absent condition and 21 participants in the phone present condition. The final sample was made up of 35 female-identifying participants, 8 male-identifying participants, and 3 non-binary identifying participants. The average age of the subjects was 23.12 years.

Measures

In this study, working memory was measured through the OSpan task run using the cognitive psychology lab software CogLab 2.0 by Cengage. The OSpan Task includes a series of math problems, each problem followed by a different word. The goal of the task is to answer the math problems correctly while also being able to recall the sequence of the words in the presented order. The number of words to be remembered varied from two to six across trials. A score of zero indicates no words were recalled in correct order across any of the trials, while a score of 60 indicates all words were recalled correctly in order on each trial. All words were short and monosyllabic ("bar," "world," "pipe," "cot," "man").

Subjects then completed the following other measures:

The Fear of Missing Out Scale is a 10 question survey that measures one's fear of missing out on social events with friends.[8] Example items include statements like, "I get worried when I find out my friends are having fun without me." Responses were scored using a 1-5 Likert scale for a score between 10 and 50.

The Nomophobia Scale has 20 questions and measures one's fear of being without access to a mobile phone.[9] Examples of items on this assessment include statements such as, "Running out of battery in my smartphone would scare me."[9] Responses were based on a 1-7 Likert scale for a score of 20 to 140.

A shortened 10-item version of the Mobile Phone Problem Use Survey was utilized and measures problematic phone use.[10] Example items include statements such as, "I find it difficult to switch off my mobile phone."[10] A Likert scale of one to 10 was used for a minimum score of 10 and a maximum score of 100.

The Young Adult Attachment to Phone Scale is a six question survey that measures one's relationship with and levels of dependency on their smartphone.[11] Example items on this assessment include, "Having my phone makes me feel safer."[11] Responses were based on a Likert scale of one to five with a minimum score of six and a maximum score of 30.

The reflection questions used in this study were also used in Ward et al.'s experiment and evaluate whether subjects thought about their phones during the OSpan task. These questions were, "While completing today's tasks, I often thought about my cellphone," "I think the smartphone affected my performance in the task," and "I think the smartphone affected my concentration in the task."[4] The reflection questions were evaluated on a Likert scale of 1-7 for a minimum score of three and a maximum score of 21.

Procedure

Up to four participants were invited to an adjacent waiting room wherein they had unknowingly been assigned to either the phone present or absent condition. All participants were first instructed to set their phones to Do Not Disturb. If participants were assigned to the phone-absent condition, they were instructed to leave their phone and other belongings in the waiting room. If participants were assigned to the phone-present condition they were instructed to bring their phones with them into the testing room "for later use in the study" following Ward et al.'s original procedure.[4]

In the testing room a brief demonstration of the OSpan task was conducted by the experimenter and OSpan instructions were also read aloud. Participants were instructed to wait until all other participants were finished with the OSpan task. When subjects were finished, the researcher collected the computers and handed out the collective survey packets. Once finished, surveys were collected by the researcher and participants were debriefed back in the waiting room from which they were subsequently dismissed.

Data

The phone absent condition had a mean OSpan performance of 42.75 while the phone present condition had a mean score of 36.0909 out of a possible 60. Although the data trends in the direction reported by Ward et al, an independent sample t-test revealed only a marginally significant difference between conditions on OSpan performance t(44) = 1.666, p = .051(one-tail), d = 0.492. Mean OSpan performance across the two conditions are shown in *Table 1* and *Figure 1* below.

Condition	N	Mean OSpan Score	Std. Deviation	Std. Error Mean
Phone absent	24	42.7500	13.87600	2.83243
Phone present	22	36.0909	13.15805	2.80531

Table 1. Group Statistics

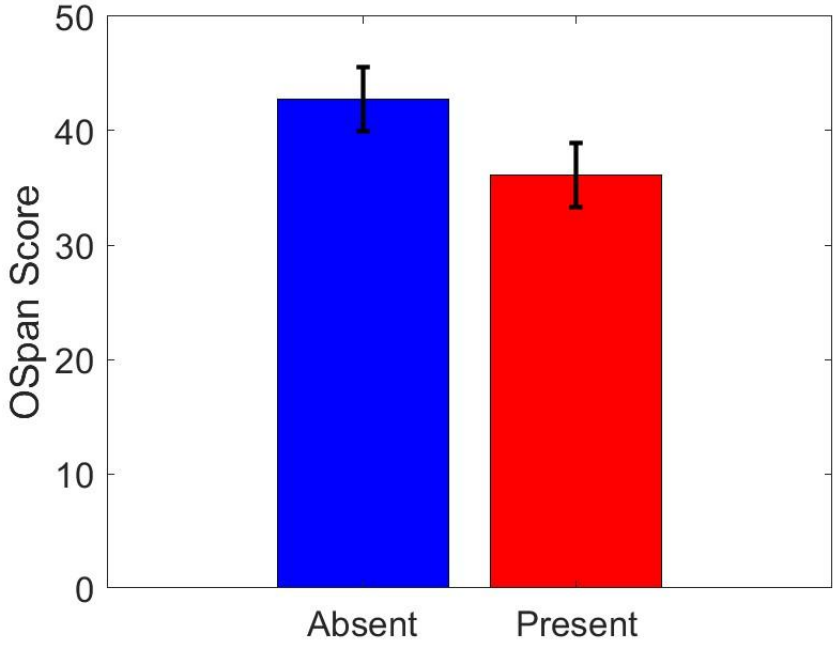

Figure 1. Average OSpan Scores by Phone Condition

Table 2 presents the correlation matrix between all phone-related surveys (Nomophobia, MPPUS, YAPS, Reflection Questions). All surveys are significantly positively correlated with each other, which is expected as they all similarly assess phone thoughts and attachment. More importantly, however, there was no significant relationship found between OSpan scores and any of the phone-related surveys except for the final three reflection questions. A scatterplot of OSpan by Reflection Questions can be seen in *Figure 2*.

	FoMO	Nomophobia	MPPUS	YAPS	Reflection Qs
OSpan	.033	-.013	.089	0.035	-.447**
FoMO		.454**	.496**	.396**	.363*
Nomophobia			.762**	.410**	.537**
MPPUS				.432**	.431**
YAPS					.356*

Table 2. Correlation Matrix

****. Correlation is significant at the 0.01 level (2-tailed). *. Correlation is significant at the 0.05 level (2-tailed).**

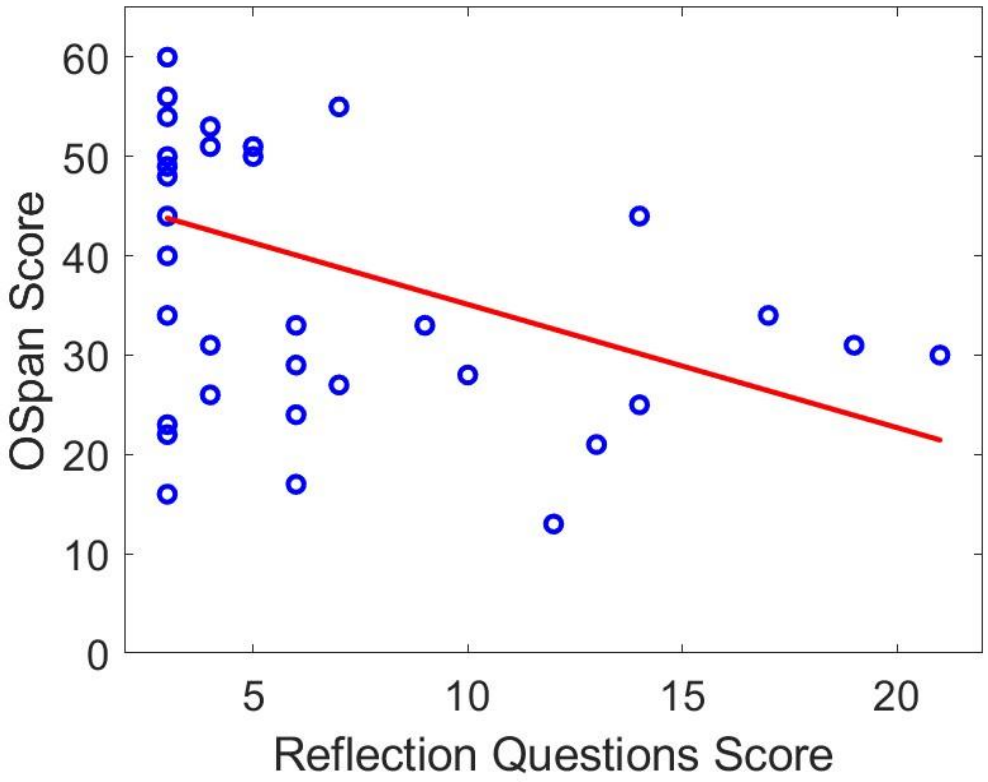

Figure 2. OSpan by Reflection Questions

Finally, to further investigate any relationship between phone attachment and OSpan performance, an independent-samples t-test was conducted on subjects who scored one standard deviation above the mean in the surveys (or above a score of 100 for the Nomophobia scale). This follows a similar analysis by Ward et al., who reported the largest negative effect of phone presence on subjects with the highest levels of phone dependency. However, in the present study, a sub-analysis of only those subjects scoring one standard deviation above the mean did not yield any significant difference in OSpan scores between phone present and absent conditions, though the

numbers trended in the predicted direction. It is important to note, however, that very few subjects qualified for these sub-analyses (five in FoMO, 10 in Nomophobia, seven in MPPUS, and eight in YAPS). Consequently, it is extremely likely that these analyses did not have enough power to see any possible effects.

Conclusions

The main purpose of the present study was to replicate Ward et al.'s finding that phone presence negatively impacted cognitive performance and that those with higher levels of phone attachment would exhibit more cognitive costs.[4] Although numbers trended in the direction suggesting that phone presence has a negative effect on cognition, no statistically significant difference was found between phone location conditions and OSpan performance. Therefore, the present study failed to replicate Ward et al.'s findings.[4] However, a significant negative correlation was found between reflection question responses and OSpan scores. This finding may suggest that unconscious or conscious thoughts on phones may affect cognition, which would support Ward et al., Niu et al., and Thornton et al.'s theory that some cognitive resources are used up by thinking about one's phone. However, this finding could also be a result of participants having seen their OSPan scores (a feature of the CogLab software) while waiting for other subjects to finish. Consequently, this knowledge may have impacted how subjects answered the reflection questions as a means of explaining their perceived poor performance. Additionally, questionnaires measuring phone attachment were incorporated into the study to try to clarify when or for whom the presence of a phone is detrimental; however, the present study failed to find any statistical effects for groups with higher degrees of phone dependency.

With the ubiquitous nature of smartphones in the modern world, it is natural to be curious about how it might be affecting our daily lives. Headlines like, "Have Smartphones Destroyed a Generation?" are common and have popularized the idea that phones are negatively affecting cognition every day.[13] It is easy to fall prey to confirmation bias and disregard conflicting findings to what one already suspects. That being said, it is still important to view findings in this research area through a critical lens in that an effect may be present, but is not as impactful as we may be led to believe. A meta-analysis of 19 studies on the effect of phone presence on working memory reported an average sample size of 134 participants and a pooled effect size of d = -0.01999, which is in the direction of Ward et al.'s study, but not as big as it may appear.[14]

It is important to note that the present study is underpowered and it is possible that any finding of any significant effect of phone presence on cognition may require a large sample of participants.[14] The principle that a large sample of subjects may be needed to effectively measure an effect of phone location suggests that the impact smartphones have is relatively small in general. It is also possible that individuals differ with respect to phone attachment and dependency and thus when randomly assigned to conditions cancel each other out in terms of effect.

Future studies should also incorporate the State-Trait Anxiety Inventory (STAI) to account for any testing anxiety in case that also impacts OSpan performance or questionnaire responses. To prevent subjects from seeing their final OSpan scores, it would also be beneficial to collect their computers as soon as they finish the task. Further, a more gender-balanced sample would aid in seeing if there are any gender-specific differences.

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