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'It's More Fun With My Phone': A Replication Study of Cell Phone Presence and Task Performance

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Abstract

From distracted driving, to work focus on a computer, increasing amounts of research is investigating how digital technology influences users' attention. A couple of widely cited studies have found that the mere presence of cell phones interferes with social interactions and cognitive performance, even when not actively in use. These studies have important implications but they have not yet been replicated, and also suffer from methodological shortcomings and lack of established theoretical frameworks to explain the observed effects. We improved the methodology used in a previous study of phone presence and task performance (Thornton, Faires, Robbins, & Rollins, 2014), while testing an 'opportunity cost' model of mental effort and attention (Kurzban, Duckworth, Kable, & Myers, 2013). We were unable to replicate Thornton et al.'s finding that presence of cell phones reduces performance in a specific cognitive task (additive digit cancellation). Moreover, contrary to our expectations, we found that participants who used their phones more, and who were more attached to them, found the tasks more fun/exciting and effortless, if they completed them with their phone present.

Keywords: attention; distraction; cell phones; smartphones; effort; task performance

Introduction

A growing amount of research in the cognitive science of attention studies how workers and students navigate a workspace with ample opportunities for distraction and/or multitasking (Cain & Mitroff, 2011; Mark, Voida, & Cardello, 2012; Ophir, Nass, & Wagner, 2009; Pea et al., 2012; Ralph, Thomson, Cheyne, & Smilek, 2014). Recently, this strand of research has moved on to how smartphones influence their users' attention. This is an important topic, since more than 72% of the US population own smartphones (Pew Research Center, 2016), and because it has very real consequences: the US Department of Transportation recently urged mobile companies to develop a simplified 'Driver Mode' for smartphones, due to an alarming rise in traffic accidents related to distracted driving (NTHSA, 2016).

A couple of widely cited studies have reported negative effects of the mere presence of cell phones on social interactions. Przybylski & Weinstein (2012) varied whether or not a mobile phone was placed next to strangers engaged in a conversation task and found that participants reported lower relationship quality and partner closeness when a cell phone was present. A follow-up observational study found a similar effect in a coffee-shop setting (Misra, Cheng, Genevie, & Yuan, 2014). However, the results from these studies are open to a multitude of interpretations (e.g. various meanings of phone presence in a social context).

Our point of departure was a controlled study by Thornton et al. (2014) who in a non-social context investigated effects of cell phone presence on performance in simple cognitive tasks. They varied whether or not a cell phone was present on a participant's table while he/she completed a series of tasks (*digit cancellation:* searching for and crossing out target numbers among other numbers, or *trail making:* connecting consecutively numbered or lettered circles displayed in random order). They found that people performed worse in more challenging versions of these tasks (crossing out pairs of target numbers that add up to a specific number; connecting circles so that consecutive numbers and consecutive letters alternate, e.g. 1-A-2-B-3-C-…), when a cell phone was present. The authors concluded that the mere presence of a cell phone, even when not in use, can be distracting and cause performance deficits on tasks that require full attention for optimal performance.

The experiments by Thornton et al. have potentially wide-reaching implications, from distracted driving to performance in schools and workplaces (Thornton et al., 2014). However, no replication studies have been conducted to establish the reliability of their findings. Moreover, their study had limitations: In their first experiment, they manipulated the presence of an experimenter's cell phone rather than the participant's own. In their second experiment, they varied the presence of participants' own phone but did not check whether their procedure for doing so made participants suspicious about the purpose of the experiment. They also did not test any theoretical frameworks that would explain their observed effects.

The present research

We followed up on Thornton et al.'s study, addressing these limitations: We i) conducted a replication study using their original stimuli for the digit cancellation task[1] (responding also to general calls for replication studies, cf. Francis, 2012; Nosek, Spies, & Motyl, 2012); ii) improved the original procedure to study effects of presence of participants' own smartphones while ruling out suspicion; and iii) tested a new theoretical framework for understanding the effects. In relation to the latter, we applied Kurzban et al.'s 'opportunity cost' model of attention and mental effort (Kurzban et al., 2013). According to this cognitive model, the human mind continuously computes the opportunity costs of our available tasks, i.e. the value of options that one is missing out on by persisting on the current task. The higher the perceived opportunity costs, the more the current task will feel mentally effortful and/or boring, with decreased quality of performance to follow. This model is well suited to predict effects of smartphones: Smartphones give immediate access to a virtual infinity of stimulating and relevant content, from global news to social gossip and video games. Insofar as they therefore afford opportunities for highly rewarding activities other than the task at hand, smartphone presence should increase the current task's opportunity costs. In turn, this might make one's current task feel more boring or effortful, and cause decreased quality of performance. Hence, our predictions were:

Prediction 1 (replication): Average scores in the additive digit cancellation task will be lower when a smartphone is present than when it is absent.

Prediction 2: The digit cancellation tasks will feel more effortful to complete when a smartphone is present than when it is absent.

Methods

Participants

53 participants (50 female) were recruited at the University of London, Royal Holloway[2]. Mean age was 18.8 years (SD = 1.4, range 17-27).

Materials

Digit Cancellation Task Participants completed two versions of a digit cancellation task, using Thornton et al.'s original stimuli. In both tasks, participants were given a piece of paper containing 20 rows of 50-digit strings. In the 'simple' version, participants cross out every instance of the number specified at the beginning of each row (e.g. 3: 7301638…). In the 'additive' version, participants cross out every instance of two consecutive numbers that, when added, equal the digit specified at the beginning of each row (e.g. 5: 1237814…). In the 'simple' version participants cross out as many numbers as possible in 90 seconds; in the 'additive' version they cross out as many pairs of numbers as possible in 180 seconds.

Effort Measure The participants filled in a brief questionnaire about how effortful they thought each task was to do. Participants indicated a) how boring or exciting the task was (1 = Very boring, 7 = Very exciting), b) how effortless the task was (1 = Intensely effortful, 2 = Completely effortless), c) how fun the task was (1 = Not fun at all, 7 = Intensely fun), and d) how difficult the task was (1 = Not difficult at all, 7 = Intensely difficult). We constructed the questionnaire to probe the experiences mentioned by Kurzban et al. (2013) as dimensions of effort that correspond to perceived opportunity costs.

Individual Difference Questionnaires Following Thornton et al., participants completed a) the Attentional Behaviour Rating Scale (Ponsford & Kinsella, 1991), a measure of general attentional difficulties, b) a Cell Phone Usage survey (Thornton et al., 2014), a measure of overall cell phone use, c) the Possession Attachment survey (Weller, Shackleford, Dieckmann, & Slovic, 2013), a measure of how attached participants feel to their phone, and d) general demographics.

Procedure

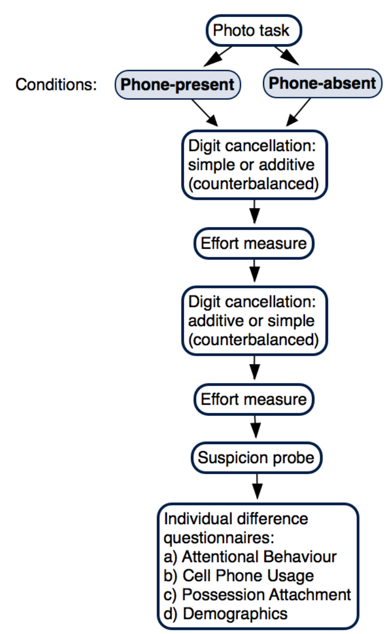

Figure 1: Experimental procedure

After signing a consent form, participants were asked to use their phone to photograph one of four objects placed on a desk. After the participant took the photo, an RA asked to

[1] Thornton et al. had observed the largest effect size in the digit cancellation task, so we chose to include only this task to make room for additional measures testing the opportunity cost framework.

[2] Thornton et al. found no effects of gender in the original study, so we did not attempt to balance the gender representation in our sample of participants.

look at it and made a note of the object photographed and the photo's orientation. (What the participant photographed was irrelevant – the purpose of this initial task was to check if the participant had a smartphone, and to give the RA control of the phone's placement without making the purpose of the experiment obvious.) Next, participants were seated. In the phone-present condition, the RA placed the phone face-up near the edge of the table and said "I'll just leave this here, if that's okay". In the phone-absent condition, the RA placed a stack of post-it notes near the edge of the participant's table, and asked the participant to turn off their phone and put it away in their bag. Participants were then given one of the digit cancellation tasks to complete (order was counterbalanced). After completing the task, they filled in an effort measure. Then they completed the second digit cancellation task, and filled in another effort measure. Finally, the participants filled in an open-ended question about what they thought the purpose of the experiment was, followed by the questionnaires. The procedure is summarized in figure 1.

Results

No participants reported suspicion that the purpose of the experiment was to study effects of phone presence.

Prediction 1: Phone presence and cancellation score

In the simple digit cancellation task, there was no significant difference between cancellation scores in the phone-present (Mdn = 65.0, IQR = 11) and phone-absent (Mdn = 69.5, IQR = 14.2) conditions, W = 348.5, p = 0.30[3]. Similarly, in the additive cancellation task there was no significant difference between scores in the phone-present (Mdn = 20.0, IQR = 4.5) and phone-absent (Mdn = 18.0, IQR = 6) conditions, W = 259.5, p = 0.62.

As will be discussed, scores in the additive cancellation task were highly left-skewed, with very few participants obtaining a score higher than 23 (see Fig. 2).

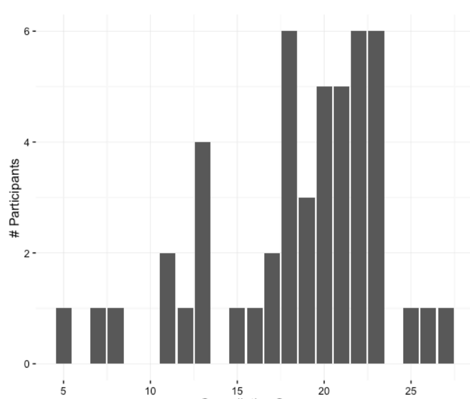

Figure 2: Distribution of scores in the additive cancellation task.

Table 1: Scores in the individual difference measures

	Phone present		Phone absent	
	Mean	SD	Mean	SD
Attentional behaviour	43.3	1.2	41.9	1.2
Cell phone use	57.0	2.3	58.3	1.6
Possession attachment	17.4	0.9	17.3	1.0

Prediction 2: Phone presence and subjective effort

To test effects on subjective effort, we first did a principal component analysis of responses on the effort measure. Scores for the simple cancellation task clustered on a 'fun/excitement' and a 'difficult/effortful' factor, whereas scores for the additive cancellation task clustered on a single factor of 'effortlessness'. We computed a score for each participant on these three factors and used them as our measures of 'effort'.

There was no main effect of phone presence on how effortful participants found the tasks, neither in the simple cancellation task (*'fun/excitement'*: phone-present, Mdn = 4.75, phone-absent: Mdn = 4.50, W = 285, p = 0.65; *'difficult/effortful'*: phone-present: Mdn = 3.0, phone-absent: Mdn = 3.5, W = 358.5, p = 0.32) nor the additive cancellation task (*'effortlessness':* phone-present: Mean = 3.81, SE = 0.17, phone-absent: Mean = 3.48, SE = 0.21, $t(43.58) = -1.25$, p = 0.22).[4]

Interactions: Effects of personality variables

To explore whether the personality variables interacted with effects of phone presence, we split participants into 'high' and 'low' scoring groups on the questionnaires (Attentional Behaviour, Cell Phone Usage, and Possession Attachment), separating the groups at the median. We conducted factorial ANOVAs for each effort dimension, using 'high'/'low' questionnaire category as predictors. In the simple cancellation task, there was a significant interaction between smartphone presence and Cell Phone Usage, $F(1, 41) = 5.00$, $p = 0.03$: When a phone was present, participants high on Cell Phone Usage rated the task as more fun/exciting (Mean = 5.17, SD = 1.05), than did those low on Cell Phone Usage (Mean = 4.47, SD = 0.72), $p = 0.039$. In other words, participants who generally use their phones more found the task less boring when they completed it with their phone next to them. See Figure 3.

[3] The distributions of cancellation scores were not normal, so we applied Wilcoxon's rank-sum test. (*t*-test gave similar results)

[4] The distribution of effort ratings was not normal for the simple cancellation task, but conformed to normality for the additive task.

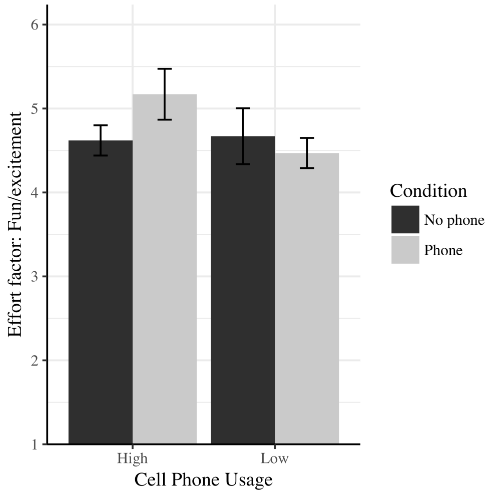

Figure 1: Interaction between phone use and phone presence on 'fun/exciting' ratings for the simple cancellation task. Error bars show standard errors.

Similarly, in the additive cancellation task, there was a significant interaction between smartphone presence and Possession Attachment, $F(1, 41) = 4.40$, $p = 0.04$. When a phone was present, participants high on Possession Attachment found the task more effortless (Mean = 4.04, SD = 0.90), than those less attached to their phones (Mean = 2.94, SD = 1.02), $p = 0.10$. In other words, participants more addicted to their phones felt that the task required less effort if they had their phone next to them. See Fig. 4.

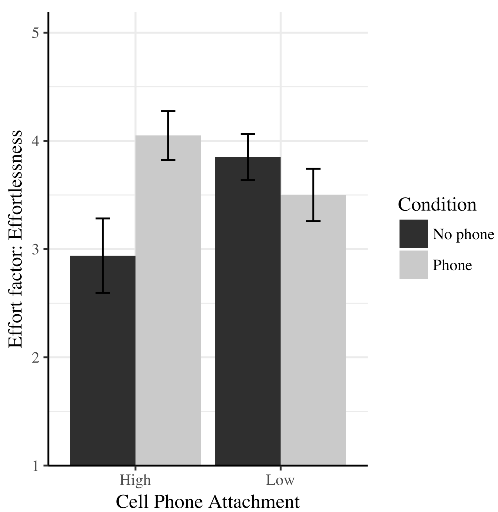

Figure 2: Interaction between phone attachment and overall scores on 'effortlessness' in the additive cancellation task.

Discussion

In terms of task performance, we, similarly to Thornton et al., did not observe any statistically significant effect of phone presence on performance in the simple digit cancellation task. More importantly, however, we did *not* replicate Thornton et al.'s central finding that phone presence causes diminished performance on the additive version of the task. Two things should be noted: Even though our sample size was similar to the original study, it may have been too small to reliably detect this effect. We ran a post-hoc power analysis of Thornton et al. and found that their experiments (n = 54 and n = 47) only had a power of .65 to detect an effect in a two-tailed *t*-test. Sample size should have been n = 66 just to obtain a power of .8. Note, however, that we did not even observe a trend towards replication – in fact, in our study, additive cancellation scores were marginally *larger* in the phone-present than the phone-absent condition. Moreover, recall that scores in the additive task were left-skewed with very few participants obtaining a score higher than 23. When we went over Thornton et al.'s stimuli, we discovered that one row of numbers (row nine), located when most participants were running out of time, had no targets at all. Moreover, the two rows before this one contained only one target each, in contrast to the first six rows which contained from two to four targets each. This will have reduced variation in performance between participants in the higher end of the performance distribution. For example, if one participant just managed to cross out the single target in row eight before running out of time, whereas another were ahead and managed to search through also all of row nine, these two participants will still have been given the same score. Hence, the material design is likely to have reduced our power to detect an effect, because it will have masked some of the variation in performance between participants.

Another issue is that in our setup, each participant only completed two versions of the cancellation task, whereas in Thornton et al.'s original study each participant completed two versions of the cancellation task and two versions of the trail making test. Whereas Thornton et al. did not discuss this, it is possible that effects of phone presence on task performance in this particular lab scenario is contingent on some degree of mental fatigue or shift in motivation from performing more tasks (Baumeister, Bratslavsky, Muraven, & Tice, 1998; Inzlicht, Schmeichel, & Macrae, 2014). However, we did add an effort measure for participants to complete after each task, which reduced the difference in participant investment between the original study and ours.

In terms of subjective effort, there was also no main effect of smartphone presence. However, we observed an unpredicted effect in which participants using their phones more often, and participants more attached to their phones, found the tasks more fun/exciting and effortless, respectively, if they completed them with their phones next to them. We cannot draw any strong conclusions due to our limited sample size and the post-hoc nature of this analysis, but future studies should test if the relationship replicates.

The interaction ran in the opposite direction from what we had initially predicted from Kurzban et al. (2013)'s 'opportunity cost' framework. Nevertheless, we still expect this framework to be useful to approach cognitive effects of information communication technologies. From 'fear of missing out' to popular anti-distraction apps like *Freedom* and *SelfControl* that people use to restrict the functionality of their own devices, many current phenomena suggest that opportunity cost models remain important to explore. However, if the interaction effect replicates, it might mean that factors like anxiety from separation from one's phone (Cheever, Rosen, Carrier, & Chavez, 2014) or positive feelings from having more stimulation available (Gazzaley & Rosen, 2016) provides better explanations than Kurzban et al. (2013)'s opportunity cost model.

Finally, Kurzban et al.'s paper offered a persuasive, but abstract model. The effort measure we developed here is the first attempt to operationalize their opportunity cost model for experimental studies. Despite the present paper's mixed findings, we encourage future studies to apply Kurzban et al.'s model to human-computer interaction research and to test the reliability and validity of our effort measure.

In sum, follow-up research should establish whether Thornton et al.'s finding of a detrimental effect of phone presence on performance in the additive cancellation task is valid, by using larger sample sizes and adjusting the experimental stimuli to better pick up variation between participants. Future studies should also test whether heavy phone users really do feel that tasks are less, rather than more, effortful to complete when they have their phones present. With smartphone use now ubiquitous, it should be a priority in cognitive science research on executive functioning to establish conclusive findings on how smartphones affect users' attention and performance, and why.

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