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

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Abstract
A couple of widely-cited studies have found that presence of cell phones interferes with social interactions and cognitive performance, even when not actively in use. These studies have important implications but have not been replicated, and also suffer from methodological shortcomings and lack of established theoretical frameworks to explain the findings. We improved the methodology used in a previous study of phone presence and task performance [8], while testing an 'opportunity cost' model of effort and attention [2]. We were unable to replicate Thornton et al.'s finding [8] that presence of cell phones reduces performance in a simple cognitive task (additive digit cancellation). Moreover, contrary to our expectations, we found that participants who were more attached to their phones found the tasks *more* fun/exciting and effortless, if they completed them with their phone present.

Author Keywords
Attention; distraction; smartphones; task performance.

Introduction
Much HCI research has studied how information workers and other users of digital technology navigate

a workspace filled with distractions [1,3,10]. Recently, this strand of research has moved on to how smartphones influences 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 [5].

A couple of widely-cited studies have reported negative effects of the mere presence of cell phones on social interactions [4,7]. Przybylski & Weinsten [7] varied whether 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 [4]. These studies, however, are open to a multitude of interpretations related to e.g. various meanings of phone presence in a social context.

Our point of departure was a controlled study by Thornton et al. [8] who in a non-social context investigated effects of cell phone presence on performance in simple cognitive tasks. They varied whether a cell phone was present on a participant's table while he/she completed a series of tasks (e.g. searching for and crossing out target numbers among other numbers, or connecting consecutively numbered circles displayed in random order). They found that people performed worse in more challenging task versions 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 when full attention is required for optimal task performance.

Thornton et al.'s findings have potentially wide-reaching implications, from distracted driving to performance in schools and workplaces [8]. However, no replication studies have been conducted to establish the reliability of the results. 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 presence of participants' own phone but did not check whether the procedure made participants suspicious about the purpose of the experiment. They also did not test any theoretical frameworks to 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 (responding also to general calls for more replication studies, cf. ReplichiCHI), ii) improved the original procedure to better study effects of presence of participants' own smartphones without arousing suspicion, 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 [2]. According to this cognitive model, the human mind continuously computes the opportunity costs of available tasks, i.e. the value of the 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 potentially well suited to predict effects of smartphones: Smartphones

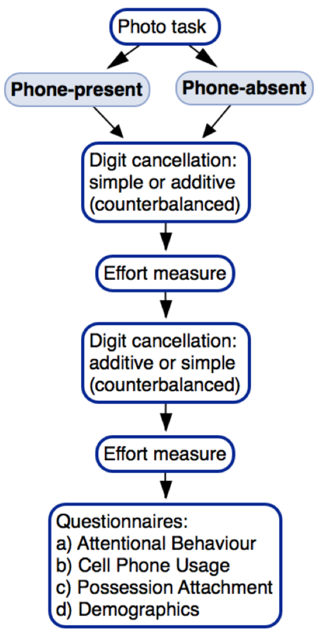

Figure 1: Experimental procedure

give immediate access to a virtual infinity of stimulating and relevant content, from global news to social gossip and video games. In so far that they therefore afford opportunities for other, highly rewarding, activities 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 an additive digit cancellation task will be lower when a smartphone is present than when it is absent.

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

Method

Participants

53 participants (50 female) were recruited at the University of London, Royal Holloway. Mean age was 18.8 years (SD = 1.4, range 17-27).[1]

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: 7~~3~~016~~3~~8…). In the 'additive' version, participants cross out every instance of two consecutive numbers that when added equals the digit specified at the beginning of each row (e.g. 5: 1~~23~~78~~14~~…). 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 the tasks were to complete. Participants indicated a) how boring or exciting the task was to do (1 = Very boring, 7 = Very exciting), b) how effortless the task was to do (1 = Intensely effortful, 2 = Completely effortless), c) how fun the task was to do (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. [2] as the dimensions of effort that correspond to perceived opportunity costs.

ADDITIONAL QUESTIONNAIRES

Following Thornton et al., participants completed a) the Attentional Behaviour Rating Scale [6], a measure of general attentional difficulties, b) a Cell Phone Usage survey [1], a measure of overall cell phone use, c) the Possession Attachment survey [9], a measure of how attached participants feel to their phone, d) general demographics.

Procedure

After signing a consent form, participants were asked to photograph one of four objects placed on a desk. After taking the photo, an RA asked for the phone to examine the photo and made a note of the object and

[1] Thornton et al. (2014) used sample sizes of n = 54 (exp. 1) and n = 47 (exp. 2), and found no effects of gender.

	Phone present	Phone absent
Simple cancellation	64.3 (1.8)	65.6 (2.3)
Additive cancellation	18.6 (1.0)	18.4 (1.0)
Attentional Behaviour	43.3 (1.2)	41.9 (1.2)
Cell Phone Use	57.0 (2.3)	58.2 (1.6)
Possession Attachment	17.4 (0.9)	17.3 (1.0)

Table 1: Mean scores and standard deviations in the digit cancellation tasks and the questionnaires

the photo's orientation. (What the participant photographed was in fact irrelevant – the purpose of this initial task was to check whether the participant had a smartphone, and 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 task 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 was of the experiment, followed by the questionnaires. The procedure is summarized in figure 1.

Results

No participants reported any 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 scores in the phone-present (Mdn = 65.0) and phone-absent (Mdn = 69.5) conditions, W = 348.5, p = 0.30[2]. Similarly, in the additive cancellation task there was no significant difference between scores in the phone-present (Mdn = 20.0) and phone-absent (Mdn = 18.0) 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 above 23.

[2] The distributions of cancellation scores were not normal, so we applied Wilcoxon's rank-sum test.

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 an 'ease/effortless-ness' 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 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: 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).

Interactions: Effects of personality variables
To see 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 factor, with questionnaire scores 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 ($M = 5.17$, $SD = 1.05$), than did those low on Cell Phone Usage ($M = 4.47$, $SD = 0.72$), $p = 0.039$. 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 2.

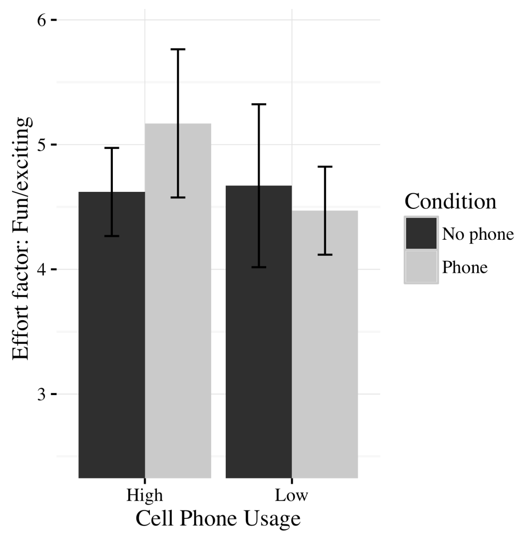

Figure 2: Interaction between phone use and phone presence on 'fun/exciting' scores in the simple cancellation task. Error bars show standard error * 1.96 (95% CI).

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 ($M = 4.04$, $SD = 0.90$), than those less attached to their phones ($M = 2.94$, $SD = 1.02$), $p = 0.10$. In other words, participants more addicted to their phones felt that the task required less effort when they had their phone next to them. See Figure 3.

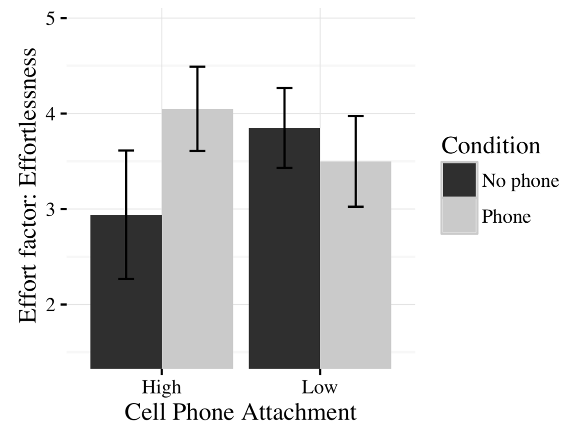

Figure 3: Interaction between phone attachment and overall scores on 'effortlessness' in the additive cancellation task.

Discussion

We did not replicate Thornton et al.'s findings [8]: we found no detrimental effects of phone presence on performance in the digit cancellation tasks. Two things to note: Our sample size was similar to the original study, but may not have been large enough to reliably detect the effect. We ran a 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 observed not even a trend towards replication – in our study, additive cancellation scores was marginally *larger* in the phone-present than the phone-absent condition. In addition, recall that scores in the additive task were left-skewed with very few participants obtaining a score above 23. When we went over Thornton et al.'s stimuli, we discovered that one row of numbers, located where most participants ran out of time, had no targets. This will have masked differences in performance where, for example, one participant reaches the empty line earlier than another, but both run out of time before the lines again contain targets.

Second, we did not find a main effect of smartphone presence on effort. 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, when 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 analysis, but future studies should test whether this relationship replicates. If reliable, it could have important implications for how to think about e.g. students working surrounded by technology.

In sum, follow-up research should adjust the experimental stimuli to better pick up variation between participants, and use larger sample sizes, to firmly establish whether Thornton et al.'s effect is reliable. 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 smartphones ubiquitous, it should be a priority for HCI research to establish conclusive findings on how they affect attention and performance.

References

1. Mary Czerwinski, Ran Gilad-Bachrach, Shamsi Iqbal, and Gloria Mark. 2016. Challenges for Designing Notifications for Affective Computing Systems. *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing: Adjunct*, ACM, 1554–1559.
2. Robert Kurzban, Angela Duckworth, Joseph W Kable, and Justus Myers. 2013. An opportunity cost model of subjective effort and task performance. *Behavioral and Brain Sciences* 36, 6: 661–79.
3. Gloria J Mark, Stephen Voida, and Armand Cardello. 2012. "A Pace Not Dictated by Electrons": An Empirical Study of Work Without Email. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, ACM, 555–564.
4. S. Misra, L. Cheng, J. Genevie, and M. Yuan. 2014. The iPhone Effect: The Quality of In-Person Social Interactions in the Presence of Mobile Devices. *Environment and Behavior*: 1–24.
5. NTHSA. 2016. *Visual-Manual NHTSA Driver Distraction Guidelines for Portable and Aftermarket Devices*. Washington, DC.
6. Jennie Ponsford and Glynda Kinsella. 1991. The use of a rating scale of attentional behaviour. *Neuropsychological Rehabilitation* 1, 4: 241–257.
7. Andrew K. Przybylski and Netta Weinstein. 2012. Can you connect with me now? How the presence of mobile communication technology influences face-to-face conversation quality. *Journal of Social and Personal Relationships* 30, 3: 237–246.
8. Bill Thornton, Alyson Faires, Maija Robbins, and Eric Rollins. 2014. The mere presence of a cell phone may be distracting implications for attention and task performance. *Social Psychology* 45, 6: 479–488.
9. Joshua A Weller, Crystal Shackleford, Nathan Dieckmann, and Paul Slovic. 2013. Possession Attachment Predicts Cell Phone Use While Driving. *Health Psychology* 32, 4: 379–387.
10. Steve Whittaker, Vaiva Kalnikaite, Victoria Hollis, and Andrew Guydish. 2016. "Don " t Waste My Time': Use of Time Information Improves Focus. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, ACM, 1729–1738.