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# Cell Phone Notifications Harm Attention: An Exploration of the Factors that Contribute to Distraction

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**Abstract:** Recent research has found that the presence of cell phones impairs attention during learning. The present experiment sought to better understand this phenomenon by measuring the effects of cell phone presence, cell phone notifications, and cell phone ownership (participant's or others) on attention. Attention was measured using a Stroop task in a within-subjects design, wherein participants (n = 105) were exposed to five experimental conditions. Cell phone notifications caused distractions, regardless of phone ownership and task difficulty, increasing the amount of time required to complete the task. However, unlike the noted literature above, the researchers did not find that the mere presence of a cell phone contributed to distraction. These results help us better understand which factors actually contribute to distraction and inattention.

**Keywords:** *Attention, cell phone, distraction, task switching.*

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## Introduction

Whether in the classroom or at home, distractions have a negative impact on learning. One distraction in particular, cell phones, has become a pervasive part of everyday life. While cell phones provide a lot of benefits, they also are designed to provide a lot of distractions. Recent research has found that cell phones harm attentional processes, even when we are not actively using them (Boila, et al., 2020; Chen & Yan, 2016; Craik, 2014; Lee et al., 2021; Smith et al., 2011; Tanil & Yong, 2020; Thornton, et al., 2014; Wilmer et al., 2017; Womack & McNamara, 2017).

Attention plays a crucial role in acquiring, accessing, and managing information. When attentional processes are disrupted, they impair memory and learning (Allport et al., 1972; Boila, et al., 2020; Chen & Yan, 2016; Craik, 2014; Gardiner & Parkin, 1990; Jacoby et al., 1989; Lee et al., 2021; Naveh-Benjamin & Brubaker, 2019; Smith et al., 2011; Wilmer et al., 2017; Womack & McNamara, 2017). For example, if we are asked to learn a list of words we are less likely to recognize those words later if we are distracted by a secondary task while learning the list of words (Chen & Yan, 2016; Gardiner & Parkin, 1990; Lee et al., 2021; Sumuer, 2021; Wilmer et al., 2017; Womack & McNamara, 2017). Not only does distraction hurt memory for things that were presented during learning, it causes confusion between relevant and irrelevant information (Boila et al., 2020; Chen & Yan, 2016; Jacoby et al., 1989; Lee et al., 2021; Smith et al., 2011). Full, undivided attention is arguably the necessary first step in the learning process.

Cell phone notifications are designed to draw attention to the incoming information and therefore, away from the current task. When we are focusing on one task, like reading a book, and a cell phone chirps, we switch our attention to a new task, checking the cell phone. We tend to call situations like these "multitasking" when we are, in fact, task switching. Rather than focusing on and selectively attending to multiple tasks at the same time, we are rapidly switching attention between multiple tasks. Each time our attention switches from one task to another we have to go through a multi-step process in order to engage in the new task (Boila et al., 2020; Craik, 2014; Glass & Kang, 2019; Loh et al., 2016; Wilmer et al., 2017; Womack & McNamara, 2017). First, we must stop the current task; then search for information about the new task; then find the new task parameters; and, finally, engage in the new task (Draheim et al., 2016; Glass & Kang, 2019; Sumuer, 2021; Wilmer et al., 2017; Womack & McNamara, 2017). As a result of this multi-step process, task switching comes at a cost. We are slower to respond to the new task and we tend to make more errors (Glass & Kang,

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2019; Kiesel et al., 2010; Lepine et al., 2005; Monsell, 2003; Rogers & Monsell, 1995; Sumuer, 2021). Furthermore, researchers have found that students remember less on-task information and more off-task information when task switching occurs (Glass & Kang, 2019; Richter & Yeung, 2014; Sumuer, 2021; Tanil & Yong, 2020). Cell phones have a negative impact on attention and learning because they often cause task switching (Boila et al., 2020; Glass & Kang, 2019; Ophir et al., 2009; Sumuer, 2021; Tanil & Yong, 2020).

The use of cell phones, and other media devices like laptops and tablets, during class or when studying is especially problematic because the resulting task switching can disrupt attention and, therefore, the learning process. Studies of media multitasking – task switching caused by using media devices while performing another task like listening to a lecture or studying – have found that student attention and learning is impaired when media multitasking occurs (Boila et al., 2020; Chen & Yan, 2016; End et al., 2010; Glass & Kang, 2019; Kuznekoff & Titsworth, 2013; Lee et al., 2021; Loh et al., 2016; Sumuer, 2021; Tanil & Yong, 2020; Wood et al., 2012; Wilmer et al., 2017; Womack & McNamara, 2017). Research reveals that not only do cell phones distract the students who are using them, but the sound of a cell phone captures the attention of others in a room, causing attention switching, which harms attention and learning (Boila, et al., 2020; Glass & Kang, 2019; Röer, et al., 2014; Sumuer, 2021; Tanil & Yong, 2020; Wilmer et al., 2017; Womack & McNamara, 2017). Furthermore, just having a cell phone present can disrupt attention for the user and others around them (Chen & Yan, 2016; Tanil & Yong, 2020; Thornton et al., 2014).

Counterintuitively, research has demonstrated that digital natives (i.e., those who grew up in the digital age) or those who have had practice with media multitasking, are no better than those with little or no practice (Chen & Yan, 2016; Dindar & Akbulut, 2016). In fact, those who practice media multitasking tend to spend less time on task and are more easily distracted (Chen & Yan, 2016; Glass & Kang, 2019; Rosen et al., 2013).

Highlighting the similarities among adolescents and young adults, Rosen et al. (2013) investigated middle school, high school, and college students on media, technology, and task switching. Results revealed that students of all ages tended to:

1. Consume media for approximately the same total number of hours per day.
2. Prefer the same level of task switching (high).
3. Display similar perceptions of the role of technology in life.
4. Stay on task for about the same percentage of time (average of < 6 minutes).

This research demonstrated that there were few developmental differences among these age groups in terms of technology use and task switching. There were no differences in the amount of media consumed, amount of task switching during task engagement, perceptions of how technology is to be used, and all age groups demonstrated short periods of time on task. A deeper understanding of how cell phones affect attention could therefore help inform instructional practices for these age groups.

The present experiment attempts to both replicate some of the previously mentioned results and to investigate possible differences in degree of distraction based on task difficulty. To investigate the effects of cell phones on attention we designed an experiment using the Stroop Task (MacLeod, 1991; Stroop, 1935). In the Stroop task, participants are shown color words (i.e. red, blue, green) in different colors and asked to identify the color of the word. On congruent trials the color word and the color of the word are the same (e.g., “RED” in red). These trials are much easier to respond to and participants are faster to react when asked to identify the color. On incongruent trials the color word and the color of the word are not the same (e.g., “RED” in blue). These trials are much more difficult to respond to and participants are slower to react. The Stroop task allows us to measure participants’ attention during both easy and difficult tasks.

We hypothesized the following:

1. Participants will be slower to respond to both congruent and incongruent trials when a cell phone is present than when a cell phone is absent. This hypothesis is based on previous research showing that the mere presence of a cell phone may be distracting (Thornton et al., 2014).

2. Participants will be slower to respond to both congruent and incongruent trials when receiving notifications on their phone compared to the other’s phone. In other words, the most distracting conditions should be receiving notifications from one’s own phone.

3. Participants will be slower to respond to both congruent and incongruent trials when notifications are received on the other’s phone compared to no notifications being received. In other words, the second most distracting condition should be the other’s phone receiving notifications.

4. Participants will be faster to respond to congruent trials than incongruent trials. In other words, participants' response time will be faster when the task is easier. This hypothesis simply seeks to confirm that we found the Stroop Effect (Stroop, 1935).

## Methodology

*Participants and Materials*

Participants were 105 undergraduate students from a small, private, liberal arts university in the north eastern United States. Participants may have received extra credit for their psychology or education courses by participating in this experiment. This experiment used an online Stroop task provided by PsyToolKit (Stoet, 2010), a stopwatch, the participant's cell phone, and the experimenter's cell phone.

*Study Design*

This experiment used a counterbalanced one-way within-subjects design with 5 different conditions: No Cell (no cellular phones were present), O- (other's phone: no notification), O+ (other's phone: with notifications), P- (participant phone: no notifications), or P+ (participant phone: with notifications). A partial Latin Square counterbalancing order was devised such that there were ten different counterbalancing orders (see Table 1).

*Table 1. Counter balancing orders*

| Order Number | Block 1 | Block 2 | Block 3 | Block 4 | Block 5 |
|---|---|---|---|---|---|
| 1 | No Cell | P+ | O- | P- | O+ |
| 2 | P+ | P- | No Cell | O+ | O- |
| 3 | P- | O+ | P+ | O- | No Cell |
| 4 | O+ | O- | P- | No Cell | P+ |
| 5 | O- | No Cell | O+ | P+ | P- |
| 6 | O+ | P- | O- | P+ | No Cell |
| 7 | O- | O+ | No Cell | P- | P+ |
| 8 | No Cell | O- | P+ | O+ | P- |
| 9 | P+ | No Cell | P- | O- | O+ |
| 10 | P- | P+ | O+ | No Cell | O- |

*Procedure*

Participants were brought into a computer lab individually and seated at a computer. On the computer a browser was open with 6 tabs, each tab for a separate Stroop task. The experimenter then sent a text message to the participant, which said, "Test" to ensure that the cell phone/number was working. The experimenter gave instructions for the Stroop task, and explained to use the left most tab for the first block, and to use the second to the left most tab for the second block and so on. The participant then completed a practice block of 40 trials of the Stroop task. After the practice block, the 2$^{nd}$-6$^{th}$ blocks were experimental blocks: No Cell (no cell phones present), O- (other's phone: no notifications), O+ (other's phone: with notifications), P- (participant phone: no notifications), or P+ (participant phone: with notifications). The presentation order of experimental blocks was counterbalanced to eliminate order effects and carryover effects.

In the No Cell condition, the participant was instructed to put their phone on silent, turn off vibration, and place their phone in their bag or pocket, while the experimenter also put their own phone on silent and in their pocket. In the O- condition, the participant put their phone away and on silent, and the experimenter had their phone on silent, face-down on the desk next to the participant. In the O+ condition, the experimenter had the sound on, and set a timer on their phone for every 30 seconds, with the sound of a ringtone that is typically used for cell phone notifications. The experimenter's phone was face-up on the desk next to the participant. In the P- condition, the experimenter's phone was put away and on silent, and the participant was instructed to keep their phone on silent, and place it face-down on the desk next to them. In the P+ condition, the participant was instructed to turn the sound on, and to place their phone face-up on the desk. The experimenter had their phone behind a clipboard, so that the participant could not see it, and sent a text to the participant every 30 seconds that said, "Notification 1," "Notification 2," etc. In every block, the experimenter kept track of time with a stopwatch that was started when the participant began the Stroop task. This precaution was instituted in order to track notifications (including when any extra notifications were received) and record all notifications on a notification log. Data from participants who received non-experimental notifications were excluded from analysis.

## Results

The average response times for congruent and incongruent trials, the difference between the mean congruent and incongruent response times, and the percent correct were recorded for each block (See Table 2). A one-way repeated measures ANOVA was run on percent correct and difference between congruent and incongruent response times. There was no significant difference between conditions in percent correct, $F(4, 416) = 1.829$, $p = .122$, $\eta^2 = .017$. This indicates that cell phone presence, notifications, and cell phone ownership did not make participants any less accurate at identifying the word color. There was also no significant difference between congruent and incongruent response times, $F(4, 416) = 1.021$, $p = .696$, $\eta^2 = .010$. This indicates that the differences between easy and difficult trials remained relatively consistent regardless of cell phone presence, notifications, or cell phone ownership.

*Table 2. Mean measurements for No Cell, O-, O+, P-, and P+ Conditions*

| | No Cell | | O- | | O+ | | P- | | P+ | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Measure** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** | ***M*** | ***SD*** |
| Percent Correct (%) | 95.38 | 4.9 | 95.74 | 4.5 | 94.67 | 5.7 | 95.67 | 5.1 | 94.95 | 5.7 |
| Congruent RT (ms) | 646.46 | 92 | 655.62 | 94 | 681.56 | 106 | 668.01 | 120 | 690.54 | 116 |
| Incongruent RT (ms) | 730.6 | 111 | 725.77 | 109 | 752.5 | 110 | 736.29 | 113 | 755.64 | 144 |

A 5 (condition: No Cell, O-, O+, P-, P+) x 2 (congruency: congruent, incongruent) repeated measures ANOVA was run on response times (See Figure 1). There was a significant main effect of condition, $F(4, 416) = 8.205$, $p < .001$, $\eta^2 = .073$), which revealed that while participants were accurate at identifying the color word they were significantly slower to do so in some conditions. The Bonferroni *post hoc* revealed that participants were significantly slower to respond in the P+ and O+ conditions than in the No Cell condition (both *p*s < .01). This indicates that participants were significantly slower to respond when they could hear cell phone notifications, regardless of whose phone it was, compared to when no cell phones were present at all. Additionally, participants were slower to respond in the P+ and O+ conditions than in the O- condition ($p < .01$). This indicates that participants were significantly slower to respond when they could hear cell phone notifications, regardless of whose phone it was, compared to when someone else's phone is present but silent.

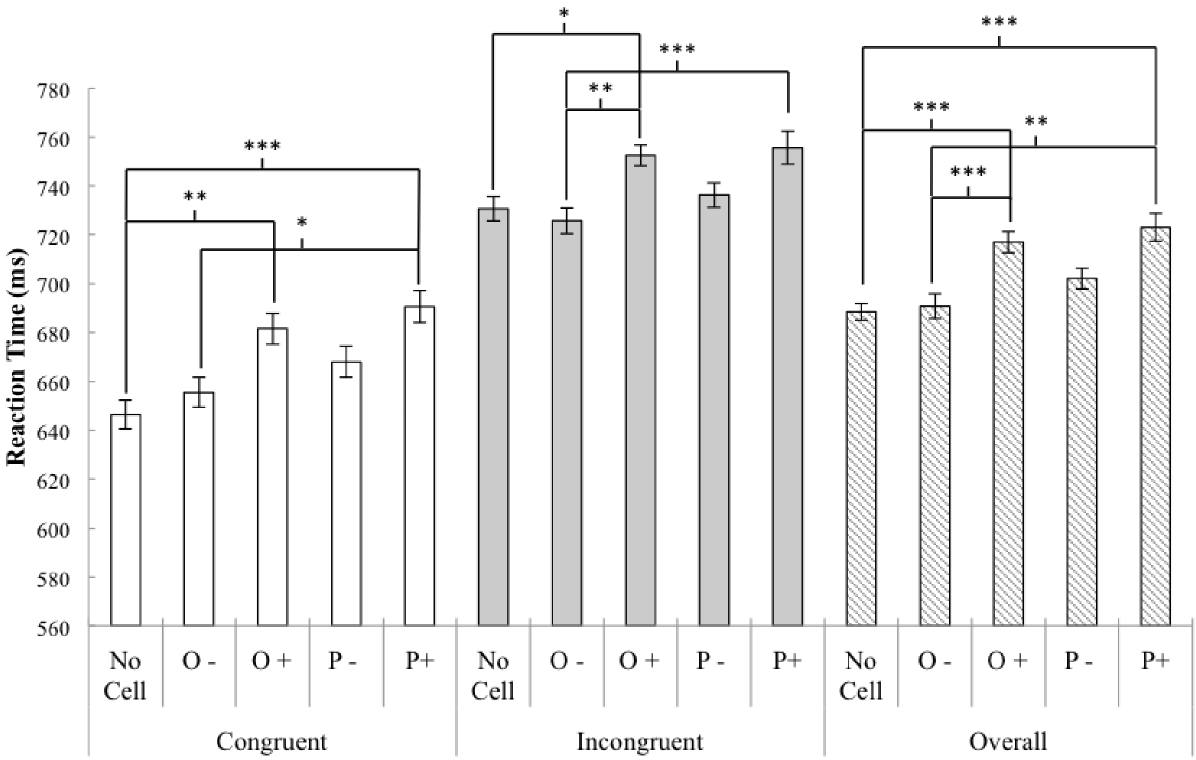


*Figure 1. Average reaction times by condition and trial type. Note. Error bars represent SEM; * p < .05, ** p < .01, ***p< .001.*

There was also a significant main effect of congruency, $F(1, 416) = 165.247$, $p < .001$, $\eta^2 = .614$). Participants were slower to respond to incongruent trials than congruent trials. There was no significant interaction between condition and congruency, $F(4, 416) = 1.021$, $p = .396$, $\eta^2 = .010$. This indicates that participants were on average slower to respond to incongruent versus congruent trials and that the difference between congruent and incongruent trials was consistent across conditions.

A simple effects test revealed that within congruent trials, participants were significantly slower to respond in the P+ and O+ conditions than in the No Cell condition ($p < .001$ and $p < .01$, respectively). This result indicates that even when the task is relatively easy, participants are still distracted by cell phones with notifications, regardless of ownership. Participants were also significantly slower to respond in the P+ than the O- condition ($p < .05$). This indicates that during a relatively easy task it was more distracting when a participant's phone was receiving a notification than when the other's phone was present and not receiving notifications.

A simple effects test revealed that within incongruent trials participants were significantly slower to respond in the O+ than in the No Cell condition ($p < .05$). This indicates that when the task is more difficult, the other's phone receiving notifications was more distracting than when no cell phone was present. Participants were also significantly slower to respond in the O+ and P+ condition than the O- condition ($p < .01$ and $p < .05$, respectively). During the more difficult task, participants were significantly slower to respond when a phone was receiving notifications, regardless of ownership, than when the other's phone was present but not receiving notifications.

A 2 (notification: absent (-), present (+)) X 2 (ownership: other, participant) X 2 (congruency: congruent, incongruent) was run on response times (see Figure 2). There was a significant effect of notification, $F(1, 104) = 17.564$, $p < .001$, $\eta^2 = .144$, indicating that participants were slower to respond when a cell phone received a notification. There was no significant effect of ownership, $F(1, 104) = 2.471$, $p = .119$, $\eta^2 = .023$, indicating that cell phones were equally distracting no matter whose phone it was. There was a significant effect of congruency, $F(1, 104) = 142.577$, $p < .001$, $\eta^2 = .578$. Participants were slower to respond on incongruent trials. There was no significant interaction between notification and ownership, $F(1, 104) = .254$, $p = .615$, $\eta^2 = .002$, indicating that a phone receiving a notification was just as distracting if it was the participant's phone or an other's phone. There was also no significant interaction between notification and congruency, $F(1, 104) = .022$, $p = .881$, $\eta^2 = .000$, indicating that the difference in response times between congruent and incongruent trials was the same regardless of whether there was notification. There was no significant interaction between ownership and congruency, $F(1, 104) = .365$, $p = .547$, $\eta^2 = .003$, indicating that the difference in response times between congruent and incongruent trials was the same regardless of whose phone it was. Furthermore, there was no significant three-way interaction between notification, ownership, and congruency, $F(1, 104) = .068$, $p = .795$, $\eta^2 = .001$. This final null result reveals that the effects of notification and congruency were completely independent of each other - that notifications were just as distracting regardless of the phone ownership and whether the trials were congruent or incongruent. Similarly, participants were always slower on incongruent versus congruent trials regardless of phone ownership or whether there were notifications.

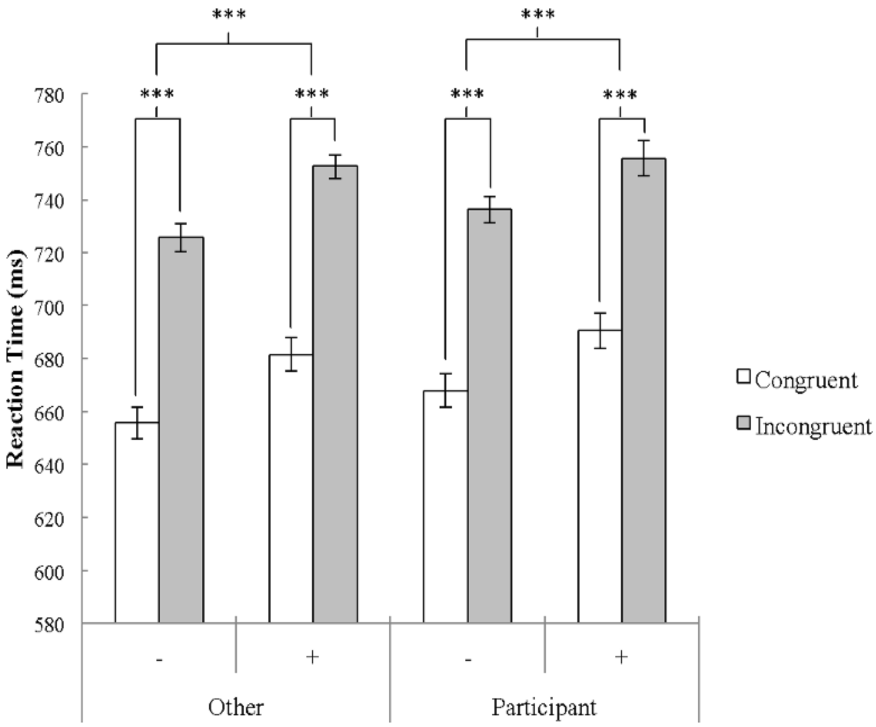


*Figure 2. Average reaction times by condition and trial type. Note. Error bars represent SEM; * p < .05, ** p < .01, ***p< .001.*

## Discussion

Results indicate that cell phone notifications and congruency affected response times while ownership of the phone did not. Put differently, participants were slower to respond when a phone was receiving notifications regardless of whether it was their phone or the other's phone. Similarly, participants were slower to respond on the incongruent trials, i.e., the more difficult trials, than on the congruent trials overall. This pattern of results contrasted with some of our hypotheses.

Our first hypothesis was that participants would be slower to respond to both congruent and incongruent trials when a cell phone was present than when a cell phone was absent, as suggested by the "mere presence of a cell phone". We did not find support for this hypothesis. While participants responded slower to incongruent trials than congruent trials, that difference in response times remained consistent regardless of cell phone presence or ownership (see Figure 1). It should be noted that Thornton et al. (2014) only found an effect of cell phone presence when the task was sufficiently difficult. In both tasks used to measure attention – the Digit Cancellation Task and the Trial Making Task – participant's performance was only harmed on the more complex trials that required more attentional resources (Thornton et al., 2014). In contrast, we did not find an effect of cell phone presence on more difficult trials – participants were similarly slow to respond to incongruent trials regardless of cell phone presence.

Our second hypothesis was that participants would be slower to respond to both congruent and incongruent trials when receiving notifications on their phone compared to the other's phone. We did not find support for this hypothesis. While participants were slower to respond to both congruent and incongruent trials when receiving notifications; phone ownership did not affect response times as predicted. These results are notable as most studies of cell phone use have focused on the effects of one's own cell phone on attention rather than the distraction of other's phones (see Boila et al., 2020; Glass & Kang, 2019; Sumuer, 2021; and Tanil & Yong, 2020). Thornton et al. (2014) did use an experimenter's phone in one of their experiments and the participant's phone in another. They did not directly compare them, however.

Our third hypothesis was that participants would be slower to respond to both congruent and incongruent trials when notifications are received on the other's phone compared to no notifications being received. This hypothesis was supported. Simply put, notifications are distracting regardless of phone ownership. Taken together, this set of findings supports previous research by Röer et al. (2014) who found that cell phone ringtones were distracting regardless of ownership. They also note that these results run counter to what we might expect from the self-reference effect wherein stimuli that are more relevant to ourselves are given higher attentional priority (see also Röer et al., 2013)

Our final hypothesis was that participants would be faster to respond to congruent trials than incongruent trials. In other words, participants' response time would be faster when the task is easier, as per Stroop (1935). This hypothesis was supported, confirming previous research on the Stroop Effect and serving as a manipulation check.

## Conclusion

This research has important implications for phone usage in any settings that require attention. Specifically, in education and work settings where other's cell phone notifications can cause distractions. These findings contribute to the literature on cell phones and attention in several ways. We experimentally manipulated four factors – cell phone presence, cell phone notifications, phone ownership, and task difficulty (congruency) – in a within-subjects design, allowing for a more nuanced understanding of how each factor affects attention. Namely, we found that cell phone presence affected attention only if notifications were received, in contrast to previous research that either only examined cell phone presence or ringtone presence (i.e., Röer et al., 2014; Thornton et al., 2014). Furthermore, this research contributes to the literature by replicating the Stroop Effect (Stroop, 1935) and replicating the finding that cell phone notifications harm attention (i.e., Stothart et al., 2015).

## Recommendations

Future research should study the effects of these conditions (phone ownership and notification) in a lecture/classroom setting, where the focus and attention required may be different than what is required for the Stroop task in the laboratory. Another potential variable to investigate would be the distraction caused by a confederate actually using their phone, or using a laptop, as both of these are very common in classrooms. It would also be interesting to see whether the distraction provided by the presence of cell phones and hearing notifications differs between those who do not use their phone as often versus those who use their phone frequently; and who have varying levels of self-control with using their phone.

## Limitations

One limitation of this study was that the participants were likely aware that the study was about cell phones, as the experimenter had to ask the participant to take out their cell phone or turn the sound off, so this may have played a role in the results. Participants may have been better able to control their attention and therefore performed better in this laboratory task than they would in a classroom setting where they would not be pre-warned that a cell phone would be receiving notifications. If this is the case, then the effects of cell phone notifications would be *underreported* in this experiment.

**Authorship Contribution Statement:**

Kaminske: Conceptualization, design, analysis, writing, supervision. Brown: Conceptualization, design, writing, editing/review. Aylward: Design, methodology, investigation. Haller: Editing/review, citations.

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