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Smartphone Display Size Influences Attitudes Toward Information Consumed on Small Devices

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Abstract
Previous research has suggested that differences in the size of extremely large displays can change how individuals perceive and react to the displayed content. However, are such effects also observed on small screen devices (i.e., smartphones)? Participants read a news article on either a small or a large smartphone display and rated their attitudes toward the material before and after reading. Results indicated that although participants remembered information equally well across the different smartphone displays, the larger smartphone display did produce a larger change in attitude toward the material. These results suggest that characteristics of smartphone design can impact perceptions of the content being viewed, fundamentally changing how one views some information that has been gathered on these mobile devices.

Keywords
mobile devices, attitudes, learning

With more prevalent and robust access to high-speed data connectivity, mobile devices represent a rapidly growing and relevant technology segment, especially for information gathering. Small devices like smartphones are beginning to make up a substantial portion of the average individuals' data gathering, with roughly 34% of users admitting they use their small device as their primary gateway to the Internet (Duggan & Smith, 2013). Further, in some countries, smartphone use for Internet access has surpassed that of desktops (Hern, 2015), and even in the United States, roughly 19% of Americans rely on smartphones as their sole means of access to the Internet (Smith, 2015). As these devices become more powerful and integrated into our daily lives, it is important to consider how consuming information via these small devices affects our reaction to this information.

There is some evidence suggesting that small screens can impact how well individuals utilize and reason with information collected from these mobile devices. For example, smaller screen devices have been shown to be less effective for simple exercises like vocabulary learning (Kim & Kim,

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2012) and can also have deleterious effects on more complex reasoning performance (Sanchez & Branaghan, 2011). This small screen disadvantage has also been observed in more formal academic settings, as most students seem to acknowledge that mobile devices are not ideal platforms for instructional purposes (Fouh, Breakiron, Hamouda, Farghally, & Shaffer, 2014; Tossell, Kortum, Shepard, Rahmati, & Zhong, 2015). Related to this point, in term of soliciting knowledge, studies that examine online surveying using mobile devices find that surveys administered on mobile devices often take longer to complete (Liebe, Glenk, Oehlmann, & Meyerhoff, 2015) and sometimes result in higher estimations of measurement error (Struminskaya, Weyandt, & Bosnjak, 2015) or other undesirable responses (Mavletova, 2013). While some argue that these differences do not promote large underlying differences in the quality of responses to these mobile surveys (e.g., de Bruijne & Wijnant, 2013; Liebe et al., 2015; Peytchev & Hill, 2010; Wells, Bailey, & Link, 2013), at the very least these results suggest some interaction between small screen devices and how users read and respond to questions presented on these small screens.

Screen Size and Attitudes

However, a largely unaddressed question is whether reading or viewing information on small screen devices also affects *attitudes* toward the material read on such devices? In other words, as research has suggested the reading on smaller screens can be more frustrating (i.e., Chen & Chien, 2005), does the difficulty associated with reading on small screens translate into different reactions toward the information presented on these devices? For example, if one reads a story about the latest political scandal on their smartphone instead of their laptop or desktop, is there a measurable difference in how an individual emotionally reacts to this story? Naturally, such questions are critical for those who disseminate information via mobile applications (e.g., news outlets and social media), in addition to mobile advertisers, and so on, who seek to influence attitudes and purchasing behavior via these small platforms.

While this question has not been investigated extensively within small screen mobile devices, research has suggested that differences in very large screens (i.e., televisions and projection screens) can produce changes in emotional responses toward content. For example, previous research has indicated that very large television screen sizes often produce more favorable attitudes and positive feelings toward television programming and advertisements (Lombard, Ditton, Grabe, & Reich, 1997) as well as increasing ratings of the overall interaction experience (Hou, Nam, Peng, & Lee, 2012; Ivory & Magee, 2009). Similarly, Reeves, Lang, Kim, and Tatar (1999) found that viewing emotionally charged videos on very large screens (i.e., 56 in.) instead of smaller screens (i.e., 12 in.) produced significantly larger emotional reactions and overall greater physiological arousal to the videos. These results support the suggestion that screen size is a relevant characteristic to consider when examining affective reaction, although with very large screens that are not realistic for use in mobile settings.

These large screen findings, however, are consistent with recent research which has shown that differences in mobile device screen size can influence affective change within a user. Kim and Sundar (2016) had participants rate how much they trusted an advertisement that was presented on either a large or a small smartphone screen. It was found that across multiple facets of trust, larger devices tended to produce more trustworthy reactions to the advertisement. While the results of Kim and Sundar (2016) demonstrate that larger mobile devices can produce larger affective reactions, it is important to note that they did not include a measure of cognitive performance or memory of the information being consumed on the mobile devices, nor any estimate of preexisting attitudes toward the presented advertisement, nor control for the type/make of the device used. As it is reasonable to expect that memory (new or old) can impact affective reaction (e.g., Blaney, 1986), it seems important to control for these cognitive aspects. Further, given the scope and variety of mobile devices, it seems also important to control for physical differences between the actual devices being compared, as these physical characteristics may impact affective reaction to the device itself.

For example, research on consumer behavior regarding the purchase of small devices also seems to support this assertion that larger display sizes may produce a magnification of the affective response in users, albeit toward the device itself. In a study examining consumer attitudes toward smartphones, Seva and Helander (2009) found that purchase behavior was significantly influenced by initial affective reactions to the device. Importantly, these affective reactions appeared to be strongly tied to aspects of the device's display size. Not only did consumers rate interactions with small- to medium-sized smartphone displays more positively than those with their larger mobile counterparts, but those devices that had overly large screens (and subsequently were more difficult to hold in hand) were also rated more negatively overall (Seva & Helander, 2009). Taken together with the very large screen results mentioned earlier, these results suggest that larger display sizes on mobile devices produce larger affective reactions from the user overall, both toward the material being presented and the device itself. Note that the valence of the affective reaction is not necessarily implied here and is obviously contingent on the nature of the material displayed on the device. In other words, while it is speculated that larger displays will produce larger affective reactions, whether this reaction is positive or negative in regard to emotional affect is entirely contingent on the directionality of the presented content.

Current Study and Predictions

As a whole, the abovementioned research seems to suggest that presentation of information on different screen sizes can impact how users reason with, and respond to, said information. Larger screens or physical devices do appear to promote a larger reactivity in individuals; however, why is this the case? A possible explanation for these findings is that users feel an initial emotional reaction related to the perception of the size of the display and that this reaction then permeates into how the content is viewed. For example, in Seva and Helander's (2009) study, consumers felt more negative affect toward phones with large displays *before* they had even actually used it. This is perhaps directly related to psychological theories of perceptual fluency, which posit that implicit perceptual cues (i.e., how easy or difficult it is to process) produce affective and metacognitive reactions that in turn subsequently affect how that information is encoded and retrieved (Schwarz, 2011; Song & Schwarz, 2008a; Yue, Castel, & Bjork, 2013). For example, printing information in difficult-to-read fonts has been found to produce more negative appraisals of the presented information when compared to more easy-to-read fonts (Sanchez & Jaeger, 2015; Song & Schwarz, 2008b). It may be that something similar is happening in previous screen size studies, such that the larger displays/devices somehow produce a larger initial perceptual reaction, which in turn biases subsequent attitudes related to the material.

To investigate whether differences in mobile display size do affect both learning and attitude change toward material consumed on a mobile device, a study was conducted where participants read a news story on two different versions of a small device. Consistent with previous research on display sizes, it was expected that larger mobile screens should produce stronger reactions to the news article, perhaps related to a perceptual reaction to the larger screen itself, and thus influence judgments related to the subject matter. Importantly, both preexisting participant attitudes toward the general content of the news story and general cognitive ability or participants were also measured. As such, this research seeks to build upon previous research that has investigated the interaction between attitudes and screen size but with only very large screens (e.g., Reeves, Lang, Kim, & Tatar, 1999) or in less constrained mobile presentations (e.g., Kim & Sundar, 2016).

Method

Participants

Forty-three ($N = 43$) undergraduates from a large public university in the United States participated in this experiment. Twenty-one participants (71% female; average age = 19.62 years) read in the smaller screen condition and 22 participants (77% female; average age = 19.18 years) read in the larger screen condition. These screen size groups were not significantly different in terms of age, $t(41) = .86$, $p > .05$, or gender makeup ($\chi^2 = .19$, $p > .05$). All participants were native English speakers and compensated with course credit. Further, all participants reported owning and using a smartphone device, with a vast majority of participants in both conditions reporting use of Apple's iOS® platform for their smartphone (small screen = 76%, large screen = 86%; $\chi^2 = .73$, $p > .05$).

Materials

Preexperiment questionnaire. This preexperiment questionnaire consisted of four questions that were designed to assess participants' existing attitudes toward job placement and the likelihood of finding a job upon graduating; *1 = How confident are you that your major is preparing you (and other students in your major) for a job after graduation?; 2 = How confident are you that students in your major will find a job within the field of their major after graduating (for example, biology degree students working in the biology field)?; 3 = How satisfied are you with your college education?; 4 = How optimistic are you about your future career?*. Participants were asked to respond on a scale from 1 to 10 (1 *being lowest*) relative to each question. Higher scores equated to more confidence or satisfaction regarding the subject of each question. As these questions are all related to future job prospects and career preparation, this questionnaire was meant to approximate participants' attitudes toward their own ability to find a job, which is the critical variable of interest below.

Text. All participants read a real news story entitled "In Weak Job Market, Many College Graduates Are Jobless or Underemployed," adapted from Yen (2012) with slight modifications for length and content. This text was 698 words long, briefly discussed the weak job prospects facing university graduates, and included anecdotes about several real college students and their struggles. There were no illustrations presented in the story.

Based on condition, participants read this text on a desktop computer using a virtual mobile device (described next) in a 16:9 portrait ratio with either a smaller mobile screen size (4 in. diagonally) or a larger mobile screen size (5.5 in. diagonally). These screen sizes and aspect ratios were chosen to be consistent with recent popular devices released from Apple™ (i.e., iPhone 5®/SE and iPhone 7 Plus®), and appearances were identical in size to these actual consumer devices (Figure 1). The choice of these specific screen sizes arguably increases the ecological validity of the current study, as they represent real-world devices that capture iterative design characteristics between sequential versions of a consumer product (i.e., the progression of screen size within Apple's iPhone™ line). The fact that both these devices are still currently commercially available at the time of writing also increases the relevance of the current work.

Virtualization of the small devices was used for several reasons. First, the virtual presentation of these devices allowed us to keep all other physical aspects constant, minimizing any confounding effect related to the physical hardware itself (e.g., size, weight, etc., which does differ substantially between the real consumer devices; see physical differences in Table 1). As mentioned earlier, such differences can affect base attitudes toward a mobile device (Seva & Helander, 2009), and by standardizing the interaction here, a more controlled examination of screen size is thus possible. Second, device virtualization is also common practice among designers/developers as a means of testing new interfaces without using an actual device, and thus this usage is consistent with industry

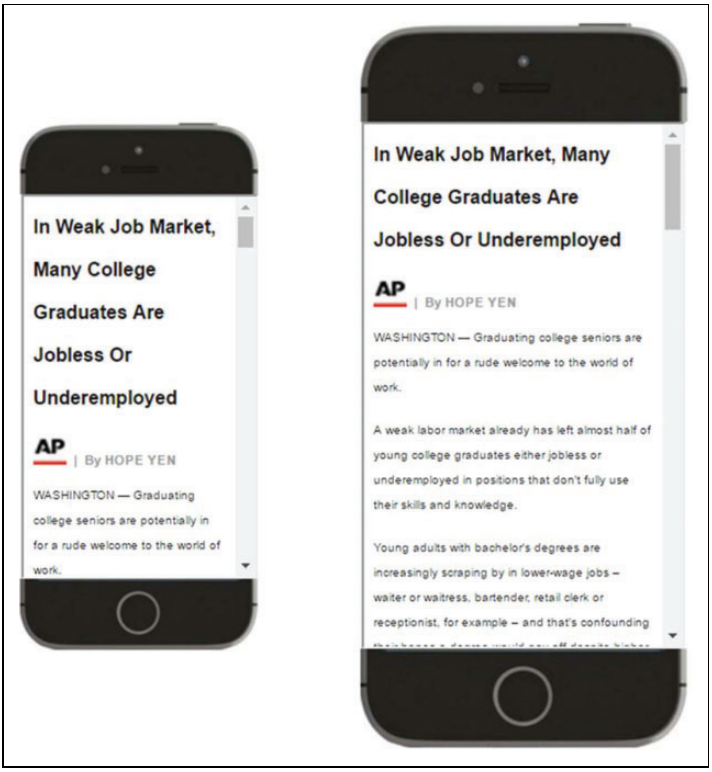

Figure 1. Screenshots of the different virtual mobile devices. For illustration purposes only: may not be presented in actual size due to resizing during production. However, size ratio between devices is accurate.

Table 1. Some Physical Differences in Actual Consumer Devices That Were Virtualized in This Study.

Physical Characteristics	iPhone 5/SE	iPhone 7 Plus
Height (mm)	123.8	158.2
Width (mm)	58.6	77.9
Depth (mm)	7.6	7.3
Weight (g)	113	188
Rounded corners on device?	No	Yes

Note. Drawn From http://www.apple.com/iphone/compare/

best practices. These virtual devices were opened full screen in web browsers, and participants interacted with these devices via normal mouse clicking and scrolling wheels, which was identical across conditions. Font type and size were identical across devices, also consistent with the defaults in the actual consumer devices.

Posttest. After reading, participants completed a posttest. In the first part of the posttest, participants were asked to answer five multiple-choice items (Appendix) about material in the article to evaluate how well they remembered the news story. This measure is critical, as it ensures any subsequent patterns of effects are not due to differences in learning or engagement with the material. In the second part of the posttest, they were then asked to respond to a postexperiment questionnaire, which

Table 2. Descriptive and Inferential Statistics for Each Group by Measure.

Measure	Smaller Screen, *M* (*SD*), $n = 21$	Larger Screen, *M* (*SD*), $n = 22$	*t* Value ($df = 41$)	Cohen's *d*
Confident major prepares you	6.81 (1.03)	6.72 (1.55)	0.20	.07
Confident job in major	6.43 (1.54)	6.23 (1.74)	0.40	.12
Education satisfaction	6.81 (1.47)	7.32 (1.32)	−1.19	.37
Future career optimism	7.19 (1.83)	7.82 (1.26)	−1.31	.40
Multiple choice memory	3.48 (1.12)	3.55 (1.01)	−0.21	.07
How hard find a job	6.52 (1.54)	7.41 (1.14)	−2.15*	.66
Difficult to read text	3.52 (1.93)	4.23 (2.47)	1.04	.32
How believable was article	7.24 (1.84)	7.95 (1.43)	1.43	.43
WMC	27.05 (7.21)	27.86 (8.08)	−0.35	.11

Note. WMC = working memory capacity.
*$p < .05$.

included three questions that were designed to evaluate their attitudes toward the content area and the reading experience. (*1 = How hard will it be to find a job after graduation and 2 = How difficult was it for you to read the text on the mobile device?; 3. How believable was the information in this article?*). Participants rated their attitude toward these three questions on a scale from 1 to 10 (1 *being lowest*). Higher scores were indicative of either higher difficulty finding a job or in reading or more believability. Participants were also asked to report whether they personally owned and used a smartphone and asked to identify the make of their smartphone (to the best of their ability).

Working memory capacity (WMC). To control for any differences in general cognitive ability, all participants were also evaluated for their WMC (Conway, Kane, & Engle, 2003). Participants completed the Symmetry Span task, which is a validated measure of attentional control and has been previously related to other measures of general cognitive ability/standardized testing (Unsworth, Heitz, Schrock, & Engle, 2005). In this task, for every trial, participants are asked to make a symmetry judgment for a figure along a vertical axis and then remember a spatial location in a 4×4 matrix for later test. Set sizes ranged from 3 to 5 trials, and participants completed three instances of each set size. The maximum score on this measure is 42.

Procedure

Participants were first given 3 min to complete the preexperiment questionnaire. Participants were then advised they would be reading a text on a virtual mobile device that would be presented on the screen in front of them, and they should read the entire text as they will be tested on the material at a later time. Participants were then given 5 min to read the text and warned when they had 2 min to complete reading. After reading, participants closed the virtual device and were given up to 8 min to complete the posttest. After successfully completing the posttest, participants then completed the WMC task. Upon completing the WMC task, participants were then debriefed and dismissed. The entire experiment took no longer than 1 hr.

Results

Descriptive statistics and inferential statistics are available in Table 2. As is visible in Table 2, prior to reading, there were no group differences regarding participant satisfaction in their education, nor their prospects toward finding a job in their field, all $ts(41) < 1.31$, $p > .05$. Further, there were also

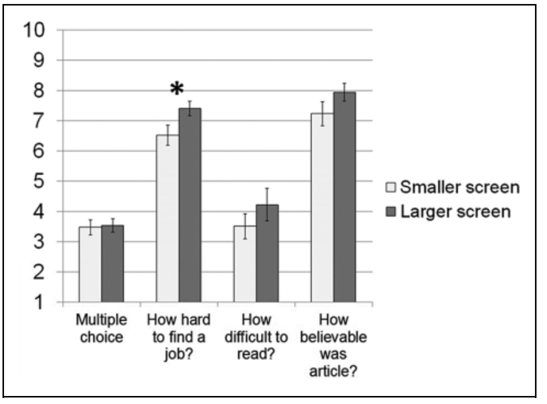

Figure 2. Posttest results by condition.

no differences in WMC, $t(41) = -.35$, $p > .05$. These findings are important, as they suggest that these groups were well matched on both relevant preexperimental attitudes and general cognitive ability. As such, it is not likely that these variables are the cause of any subsequent effects.

Posttest

In regard to the multiple-choice memory test, there were also no differences between groups, $t(41) = -.21$, $p > .05$. Participants were just as likely to remember information from the news story regardless of which device the text was presented on. Similarly, there were no significant differences in participants' ratings of reading difficulty, $t(41) = 1.04$, $p > .05$, or believability of the article, $t(41) = 1.43$, $p > .05$. These findings suggest that participants were able to understand the text equivalently and that neither group felt the text was either unbelievable or hard to read as a result of the screen size manipulation.

However, specific to the question of whether screen size can affect subsequent attitudes toward material consumed on a small device, there was a significant main effect of screen size on participants' ratings of how hard it would be to find a job after graduating (Figure 2). Participants who read on a larger mobile device were significantly more likely to think it would be difficult to find a job upon graduating, $t(41) = -2.15$, $p < .05$, $d = .66$.

Discussion

Considered as a whole, these results indicate that physical smartphone characteristics such as display size can impact some judgments of the content displayed. Consistent with prior research indicating that larger displays invoke greater reactivity to the media being consumed (Hou et al., 2012; Kim & Sundar, 2016; Reeves et al., 1999), participants who read on a larger mobile device produced a larger reaction to the presented material. In the context of this study, this translated into larger expressed difficulty of finding a job upon graduating. The magnitude of this attitude change also appears to be nontrivial as demonstrated by a medium to large effect size (Cohen, 1988). These results thus build on past findings by demonstrating that differential reactivity to display sizes can also be invoked in small consumer devices, by implementing a modest change in screen area (i.e., 4 in. vs. 5.5 in.; 38% change) that is consistent with actual changes found in design iterations of a given consumer device.

One explanation for these findings is that users become more engaged with content presented on larger screens as evidenced by greater feelings of presence (Hou et al., 2012) and stronger physiological reactions to large displays (Reeves et al., 1999). This is also potentially connected to notions of perceptual fluency, whereas initial perceptual reactions are potentially biasing the interaction with the device. As engagement or perceptual fluency was not explicitly measured here, future research is needed to explicitly establish whether physiological differences in arousal or perception can account for the observed differences in attitudes. However, it must be noted that the lack of memory differences does seem to somewhat contradict this suggestion. If individuals truly were more engaged, it would be reasonable to expect larger differences in how well they remembered the text, which was not observed. Similarly, one might expect that ratings of reading difficulty would likewise be sensitive to such differences in perception or arousal, but this was also not observed in the current study.

Finally, future research should also focus on the extent to which the characteristics of a device can influence real-world behavior. The results reported here did not examine whether the display size manipulation produced attitude change outside a lab setting or in any observable behaviors. For example, it would be interesting to see if reading on larger smartphone displays actually caused participants to be more likely to produce behaviors consistent with these affected attitudes (e.g., seek out university career services in an attempt to better their chances of finding a job). Further, such questions naturally resonate with studies of consumer behavior and thus present a unique opportunity to investigate uses of mobile devices like shopping and how display size might impact purchasing trends. Related to this point, it would also be of interest to explore how other realistic device characteristics might moderate this effect, for example, does the ability to zoom or scroll reduce or eliminate these observed differences?

In conclusion, this study reported that relatively small differences in smartphone characteristics, specifically display sizes, can influence some attitudes toward the content being viewed. This suggests that simple device characteristics can have a measurable impact on how we gather and use information in our daily lives. As smartphones and other mobile technologies pervade daily life, and more and more tasks are being completed using these small devices, it is important to consider how the characteristics of these mobile devices can impact user's judgments and attitudes, and thus consider these issues more closely when attempting to explain how individuals use and reason with information in the real world.

Appendix

*Multiple-Choice Questions (Correct Answers Indicated by *)*

1. According to the article, which region was most likely to have unemployed/underemployed college graduates?
   a. Pacific Northwest
   b. Mountain west*
   c. Northeast
   d. Southwest

2. The article claims that technological advances are eliminating mid-level jobs such as:
   a. Waiter/waitress
   b. IT representative
   c. Home health aides
   d. Bank tellers*

3. According to the article, approximately how many total young college graduates are unemployed or underemployed in the United States?
   a. 33%
   b. 41%
   c. 53%*
   d. 65%

4. The student Michael Bledsoe currently works as a:
   a. Barista*
   b. Bank teller
   c. Construction worker
   d. Bartender

5. According to the article, business major Cameron Bawden had approximately how much student debt?
   a. $15,000
   b. $22,000
   c. $25,000*
   d. $32,000

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