User Experience with Web Browsing on Small Screens: Experimental Investigations of Mobile-Page Interface Design and Homepage Design for News Websites

Nan Yu^a and Jun Kong^b
{nan.yu, jun.kong}@ndsu.edu

^a Department of Communication, North Dakota State University, Fargo, ND, 58108

^b Department of Computer Science, North Dakota State University, Fargo, ND 58108

Abstract

The efficiency of web surfing with a smartphone depends heavily on how well a website is structured. With the goal of understanding the effects of mobile-page and homepage designs on small-screen devices, we conducted two experimental studies to examine how users evaluated interface designs that are widely used on mobile news websites. We found that the designs for mobile news pages and the structures for website homepages can have a significant impact on perceived ease of use, reading time, and the overall reading experience. Based on the evaluation results and the analysis of the current interface design for popular mobile news websites, we developed two important guidelines for mobile news websites: 1) the single-page design is favored over the multi-page and zooming designs for displaying text-based information, and 2) a homepage with a thumbnail design facilitates information processing better than the progressive and list-view designs. Our research provides valuable empirical evaluations that help interface designers understand the potential impact of various interface designs on user experience. We also identified several directions related to interface design for future investigation.

Key words: mobile web browsing, homepage design, mobile-page interface design, HCI, human-web interaction, usability

1. Introduction

With the increasing popularity of smartphones, such as the iPhone, Android, and Windows Phone, mobile web browsing has been growing remarkably fast. According to the latest study from Pew Research (2014), 90% of American adults have cell phones or smartphones. The increasing number of cell-phone users makes media content that has traditionally been disseminated through newspapers, TV, or desktop computers more accessible to people. A national survey indicated that about 60% of cell-phone owners have browsed the Internet on a smartphone (Pew Research, 2014). Most prestigious news organizations, including CNN, FOX, ABC, NBC, *The New York Times*, *USA Today*, and *The Washington Post*, have all developed their own mobile applications and websites for tablets and smartphones. Smartphones and tablets are predicted to replace the functions provided by personal computers because they are able to handle almost all major tasks at home or work (Bonnington, 2015).

The widespread use of smartphones poses new challenges for designers who create mobile web content for users: how to make mobile web browsing easier, more efficient, and more interactive? To answer this question, we conducted two separate studies that examined various mobile-page interface designs (Study 1) and homepage designs (Study 2) for mobile news websites to understand how they influence users' browsing experience.

We based our research on prior scholarly investigations into the standards and principles of mobile web design (e.g., Moll, 2007; Fling, 2009). We found that most of the research either primarily used non-touch-screen mobile devices (e.g., Moll, 2007) or simulated the mobile web content on regular computers (Qiu, Zhang, & Huang, 2004). However, there is a critical need to understand the reading experience on the most current version of smartphones. This research is one of the first studies to compare the conventional designs for mobile news websites and investigate their potential impact on the users' experience. We also analyzed some of the most popular mobile e-commerce sites to gain an understanding of the adoption of the design features we evaluated. Through the empirical results we obtained, we hope we can offer useful suggestions for smartphone interface designers that will improve the users' experience with mobile news web browsing.

2. Literature Review

2.1. Mobile-Page Interface Design

Depending on the mobile-page interface design, people can use their fingers to slide, tap on certain hyperlinks, flip pages, or zoom the content in or out to view web-based content on a smartphone. In Study 1, we identified three basic types of interface designs for mobile news websites. The first one was the *single-page* design. In this design type, a full news story was presented vertically in a single column. For example, *mobile.nytimes.com* implements this type of design. Readers slide their fingers downward in order to read the story. The second type was the *zooming* design where readers could zoom in when they felt uncomfortable reading the content on a small screen. On real mobile sites (such as *www.usatoday.com*), a user can zoom in on the content while reading. The third type was the *multi-page* design where a long article is divided into a few pages. At the bottom of each page, users can tap on navigation links to complete the reading (e.g., *www.cnn.com*). In Study 1, we examined these three types of interface designs to determine whether the design differences can affect the usability of mobile news websites. Our primary purpose, however, was not to set one mobile-page interface design apart or disqualify others. We aimed at understanding the advantages of each design type and examining how the designs enhance people's web-browsing experience in general.

2.2. Homepage Design

The homepage of a news website is the gateway through which readers can locate a particular topic or article to read. The homepage design is crucial because it determines how quickly information can be located. A user-friendly homepage usually contains a vast amount of information with a clear organization for different news sections. For example, a reader who is interested in sports can get to the sports section by tapping on the appropriate link on the homepage and selecting an article to read.

In Study 2, we identified three types of homepage designs that have been used by news agencies for their mobile web displays. The first type was the *list-view* design in which the homepage contained news section names and article headlines. Sometimes, each story headline might be accompanied by a brief summary of that story. The list-view design presented a lot of information simultaneously on the homepage. Readers could make a decision about whether they wanted to read an article by looking at the section name, the story title, and a brief introduction about the news. Homepages utilizing this design type were usually very

long in length, so readers needed to navigate vertically to locate the information of interest. An example of the list-view design is *m.foxnews.com*.

The second type was the *progressive* design where a homepage on a smartphone contains only the news section names. After tapping on a section name, readers saw a dozen news headlines for that section. Another tap on one of the headlines led to a preview of the article's summary. Then, by tapping on the article summary, people could read the news story. We described this design as "progressive" because information is presented progressively through a few levels; users progressively obtained more information through several taps. However, we found that news organizations rarely used this type of design. Indeed, the only example we found was *abcnews.go.com/m*.

The third type of homepage design was the *thumbnail* design in which the homepage usually contained the news section names with relatively large thumbnails or images. By tapping on the image for a section, readers entered another page that listed article headlines for that news section. On this page, each headline might be accompanied by a small picture and a summary of each article. By tapping on the article title, people could read the full news article. Compared with the list-view and progressive designs, the major difference offered by the thumbnail design was that it provided visual presentations. When choosing news sections, users were offered both graphic and text-based information to choose an area of interest. An example of the thumbnail design is *m.huffpost.com*.

In Study 2, our major purpose was to test whether various routes of information seeking through different homepage designs for mobile news websites have an impact on the users' browsing experience. Again, our major goal was not to set any design style apart but to understand how users evaluate these designs based on their natural interactions with a smartphone.

2.3. Interface Assessment

Many scholars of human-computer interactions have emphasized the assessment of how interface design affects user experience. Qiu, Zhang, and Huang (2004) compared three types of display models including presentation optimization, semantic conversion, and zooming on small display devices. The authors found that the optimized presentation enhanced the layout by maximizing the screen utilization and minimizing the users' navigation complexity. In addition, the semantic conversion summarized and provided a

content overview to the users, and the zooming approach was implemented based on the semantic conversion with the zooming function. However, this study was conducted using a simulator – not on real touch-screen devices. Other researchers conducted usability evaluations of different interface designs for various applications, including social-networking sites (Chinthakayala, Zhao, Kong, & Zhang, 2014) and browsing tabular data on small-display devices (Potla, Annadi, Kong, Walia, & Nygard, 2012). Roudaki, Kong, and Yu (2015) comprehensively evaluated the users' preference for mobile browsing techniques such as platform-specific mobile design, web page restructuring, and zooming based interaction.

Previous literature on interface assessment has focused on a variety of variables that can lead to a more positive user experience (Palmer, 2002; Lee, Fiore, & Kim, 2006; Sundar, Bellur, Oh, Xu, & Jia, 2014). One variable is the perceived ease of use, which is defined as the degree to which users feel a technology or a system requires little physical or mental effort. When an interface design is easy to use, the design is often simple, straightforward, and user-friendly, requiring fewer actions before a goal is achieved (Sundar et al., 2014). Research has established that perceived ease of use is a strong predictor of positive attitudes toward and behavioral intentions to use a technology (Venkatesh, Morris, Davis, & Davis, 2003; Lee et al., 2006).

Perceived interactivity refers to the degree to which a design can provide interaction with the user (Palmer, 2002). Enhancing the perceived interactivity is positively associated with users' satisfaction (Gonzales, Finley, & Duncan, 2009). Moreover, Sundar et al. (2014) found that different levels of website interactivity may have an impact on the users' engagement with or recall of the web content. Greater interactivity may lead to more user engagement and more favorable attitudes toward the web content, but may also reduce the recall and memory of information. Scholars recommend that a medium level of interactivity for a website may be more beneficial.

Users' memory of the content they just read is considered an indicator of how deeply the information has been processed (Lang, Borse, Wise, & David, 2002). Some scholars argue that, when an interface design is simpler and requires less effort to operate, users may remember the content better in terms of how much information they can recall, compared to people who have interacted with a more complicated design (Sundar et al., 2014).

Therefore, based on previous work on the assessment of interface design, this study included variables

such as perceived ease of use, perceived interactivity, recall, users' satisfaction, and users' intention to continue their mobile web browsing as important indicators of a positive user experience. In Study 1 and Study 2, we focused on two major questions: (a) How does the mobile news webpage design affect users' web surfing? (b) Will users' evaluations of the design predict their satisfaction with and positive behavioral intentions about using mobile news web browsing?

Specifically, we proposed two research questions for Study 1.

RQ1: Does mobile-page interface design have an impact on (a) perceived ease of use and (b) perceived interactivity?

RQ2: Can the enhancement of perceived ease of use and perceived interactivity lead to positive behavioral intentions about using mobile web browsing?

We also proposed two research questions for Study 2.

RQ3: Does homepage design have an impact on (a) reading time, (b) recall, (c) attitude toward the content, (d) perceived ease of use, (e) perceived user-friendliness, or (f) perceived ease of learning?

RQ4: Do any of the factors mentioned in *RQ3* predict users' satisfaction with their mobile web browsing experience?

3. Study 1

We conducted a between-subjects experiment where participants interacted with one of the mobile-page interface designs (i.e., single-page, multi-page, and zooming) on a smartphone. These three web designs are commonly used for current mobile news websites. Therefore, we selected them for our usability studies for comparison purposes.

3.1. Method

3.1.1. Participants

A total of 79 people participated in this study. They were recruited from a mid-size, midwestern university in the United States. Participants came from different majors and academic standings. The majority (86.1%) of the participants considered English to be their first language. The participants' age range was from 18 to 30 ($M = 20.77$, $SD = 2.88$). About 68% of the participants were male. Over 79% described themselves as Caucasian, 12.7% as Asian Americans, 6.4% as African Americans, and 1.3% as Hispanic. About 50% of the

participants reported that their annual household income was above \$60,000. When participants were asked about their previous experience with using mobile devices for web browsing, over 59% reported that they had used an iPod Touch, 29% had used an iPhone, and 67% had used other types of mobile devices to access the Internet. When participants were asked how long they had been using cell phones to access the Internet, 20 participants (25.3%) reported having very little or no experience with mobile web browsing. The average length of time using cell phones to access the Internet was about 17 months ($SD = 19.01$). When comparing the three experimental conditions, we found there were no significant group differences regarding familiarity with mobile web browsing ($F[2, 75] = .94, p = .39$) or with the length of time using cell phones for web browsing ($F[2, 76] = .99, p = .38$).

3.1.2. Experimental Stimuli

A scholar from the computer science department set up the stimuli on an iPod Touch [3.5 inches, 960*640 pixels]. An index page was programmed with HTML; the page provided hyperlinks that directed users to different articles. We chose “Weight Loss” as a topic because it is relevant to college students but not intrusive. The index page looked like a regular news topic page from a news organization (i.e., CNN). The index page was the first page the participants read and contained four links to four different articles. This design type is commonly seen in users’ natural interaction with smartphones where they see news headlines first. If the users want to continue reading, they can tap on the article title on the index page and read the full-text article. To ensure that all of the participants read the same article, we made the first web link, “College’s too-fat-to-graduate rule under fire” the only active link, and this link led to the main article. The other three links on the index page were inactive. Vertical sliding was allowed on the index page, which remained the same in all three experimental conditions. The main article contained 560 words and a picture of a campus gym. All of the participants in the three experimental conditions read the same article. The only difference was the mobile-page interface design.

For the *single-page* design, the main article was displayed in a single column. Participants needed to use their fingers to slide and navigate vertically in order to complete the reading. Participants could not perform zooming or tapping with this design (Figure 1).

With the *zooming* design, the main article was displayed on the small mobile screen as an overview.

Due to a cell phone's limited screen size, the participants needed to zoom in if they wanted to read the article. When performing the zooming function, the participants had to use two fingers and slide them in opposite directions. When the fingers stopped moving, the zooming paused. Users could then locate the information by sliding the page (vertically or horizontally) with their fingers to complete the reading (Figure 2). This design was different from the real zooming function provided by *www.usatoday.com* in that zooming was required in this study because the font size in the overview was too small to read. In most real scenarios, zooming is only an optional action. We purposely made this action mandatory because we wanted people to use zooming with their reading in order to test the impact of this design on the users' experience.

In the *multi-page* design, the main article was displayed on four subpages. At the bottom of each subpage, there were two hyperlinks for navigation between subpages. The links directed the users to the previous or the next subpage. In this condition, people had to use their finger(s) to tap on the navigational arrow to read the entire article. Zooming was disabled for this design. Participants could still slide vertically but they needed to tap through a few pages to complete the reading. The hyperlinks were presented in a light-blue color, the traditional color for links on webpages (Figure 3). Table 1 summarizes the number of participants for each experimental condition.

Table 1: Number of participants by experimental condition (Study 1).

Single-page	$n = 26$
Zooming	$n = 27$
Multi-page	$n = 26$

Figure 1: Screen shots of the single-page design. (Left: index page; middle: the beginning-of-the-article page; and right: the end-of-the-article page.) Readers need to slide vertically to finish reading the article.

Figure 2: Zooming design. (Left: index page; middle: zoomed-out overview of the article page; and right: zoomed-in article page.) Readers need to zoom in on the overview page to complete the reading. Vertical and horizontal sliding are allowed when the page is zoomed in.

Figure 3: Multi-page design. (Upper row: left - index page; middle - the beginning of the first page; and right - the end of the first page. Lower row: left - 2nd page; middle - 3rd page; and right - 4th page.) Readers need to tap through four subpages to finish reading the article. Navigation links are placed at the bottom of each subpage. Vertically sliding is allowed on each subpage.

3.1.3. Procedure

Participants were invited to register for individual research sessions online. There was an experiment coordinator who guided each participant in starting the usability test. Upon their arrival at the research lab, the participants were greeted, and they were asked to read and sign an informed consent form. The experiment coordinator then *randomly* assigned each participant to one of the three experimental conditions (i.e., single-page, zooming, and multi-page). Participants were told they were going to read an article on a mobile device and complete a questionnaire.

Before the reading started, the experiment coordinator demonstrated how he/she could navigate from

an article's index page to the page with the actual article and how he/she could navigate the individual pages to finish reading the article. Participants were allowed to practice until they felt comfortable browsing the webpages on the iPod Touch. We found that about 95% of the participants required minimal instruction for using a smartphone to read the article and needed very little time (fewer than 10 seconds, on average) to practice. After reading the article, the participants were asked to evaluate their reading experience. When they completed the study, they were thanked and debriefed. The entire process took approximately 20 minutes.

3.1.4. Measures

The participants' responses were collected immediately after completion of the test. The questionnaire was administered on a computer in the lab. We measured several key variables such as perceived ease of use and perceived interactivity to understand the users' interactions with the device. We also included behavioral questions that assessed the users' future behavioral preferences. The demographic questions that measured age, gender, primary languages, income, familiarity with mobile web browsing, and prior experience with touch-screen mobile devices were placed at the end of the questionnaire.

3.1.4.1. Perceived Ease of Use

The perceived ease of use measure was adapted from the Mobile Phone Usability Questionnaire (MPUQ) (Ryu & Smith-Jackson, 2006). Minor modifications were made to fit this study's context. This measurement incorporated three types of user experience: perceived ease of operation, perceived ease of reading, and perceived ease of navigation. All questions were measured on a 5-point Likert scale that was anchored with *strongly disagree* and *strongly agree*.

Perceived ease of operation was measured by asking about participants' agreement with three items: "The operations of this device for web browsing are simple and uncomplicated," "It is easy to learn to operate the device for web browsing," and "I can operate the device for web browsing easily." Items were combined to form the perceived ease of operation index ($\alpha = .82$, $M = 4.32$, $SD = .73$).

Perceived ease of reading was measured with two items: "The layout of webpages makes the reading easy," and "The layout of webpages makes the reading difficult" (reverse-coded). The two items were combined to form the perceived ease of reading index ($r = .67$, $M = 4.05$, $SD = .80$).

Perceived ease of navigation was measured by asking participants to rate their navigation experience

on three items: “It is easy to navigate on an individual screen,” “It is easy to navigate between pages,” and “It is easy to navigate between different paragraphs of the article I just read.” The three items were combined to form the perceived ease of navigation index ($\alpha = .73$, $M = 4.14$, $SD = .61$).

3.1.4.2. Perceived Interactivity

Perceived interactivity was measured with two items: “The device provides user-friendly interaction,” and “The layout of the webpages provides significant user interaction.” Items were combined to form the perceived interactivity index ($r = .80$, $M = 4.06$, $SD = .74$).

3.1.4.3. Behavioral Intent

Behavioral intent was measured with three items. The first item measured the likelihood of revisiting the webpages ($M = 4.11$, $SD = .86$) in the future. The second item measured the likelihood of using the device again in the future for web browsing ($M = 3.97$, $SD = .83$). The third item examined the likelihood of buying a mobile device with similar web-browsing features in the future ($M = 4.24$, $SD = .85$).

3.2. Results

3.2.1. Effects on the Perceived Ease of Use (*RQ1a*)

One-way ANOVA tests were performed to investigate *RQ1a* and *RQ1b*. Our analysis did not discover any significant effect of the mobile-page interface design on perceived ease of operation, $F(2, 76) = .52$, $p = .60$, or on perceived ease of navigation, $F(2, 76) = .83$, $p = .44$. However, our analysis did reveal a significant effect of interface design on ease of reading, $F(2, 76) = 4.35$, $p = .016$, $\eta_p^2 = .10$. Specifically, the Bonferroni post-hoc analysis indicated that participants who used the zooming design ($M = 3.71$, $SD = .91$) reported a significantly lower level of perceived ease of reading than people who utilized the single-page design ($M = 4.29$, $SD = .79$) and individuals who had the multi-page design ($M = 4.17$, $SD = .55$). The difference between the single-page and multi-page designs on the perceived ease of reading was not significant ($p > .05$). Figure 4 illustrates the influence of the interface design on perceived ease of reading.

Figure 4: Means for the perceived ease of reading categorized by the mobile-page interface design (Study 1).

3.2.2. Effects on the Perceived Interactivity (*RQ1b*)

Our analysis did not find a significant impact of the interface design on perceived interactivity, $F(2, 76) = .95, p = .40$. Table 2 summarizes the means for all dependent variables.

Table 2: Means for all dependent variables across three experimental conditions (Study 1).

	Single-page	Multi-page	Zooming
Perceived ease of operation	4.23 (.97)	4.29 (.63)	4.43 (.54)
Perceived ease of reading	4.29 (.79)	4.17 (.55)	3.70 (.91)
Perceived ease of navigation	4.27 (.61)	4.08 (.61)	4.09 (.61)
Perceived interactivity	4.17 (.85)	3.90 (.69)	4.11 (.67)

Note: Numbers in parentheses are standard deviations. Dependent variables were measured on a 5-point Likert scale (1= *strongly disagree* and 5=*strongly agree*)

3.2.3. Predictors of Behavioral Intent (*RQ2*)

To answer *RQ2*, we performed three multiple regression analyses. Our goal was to identify the factors that can predict (a) the behavioral intention to continue using the same mobile device for web browsing, (b) the intention to revisit the website, or (c) the intention to purchase similar mobile devices.

When considering the intention to continue using the same mobile device for web browsing as the dependent variable, the regression analysis showed that, together, mobile-page interface design, perceived ease of operation, perceived ease of reading, perceived ease of navigation, and perceived interactivity accounted for a significant portion of the dependent variable's variance, $F(5, 73) = 6.53$, Adjusted $R^2 = .26, p$

$< .001$. Of the five factors, perceived interactivity was the only significant predictor ($\beta = .49, p = .001$) of the intention to continue using the same mobile device for future web browsing.

These five factors also accounted for a significant portion of the variance in the intention to revisit the website, $F(5, 73) = 7.22$, Adjusted $R^2 = .29, p < .001$. Perceived ease of operation ($\beta = .31, p = .028$) and perceived interactivity ($\beta = .42, p = .003$) significantly predicted the intention to revisit the webpages using the same device.

Finally, we found that none of the five variables could predict purchasing intentions, $F(5, 73) = 1.20, p = .32$. Table 3 reports the statistics associated with the regression analyses.

Table 3: Predictors of behaviors related to mobile web browsing (Study 1).

<i>Predictors</i>	Intention to use the same mobile device for future web browsing	Intention to revisit the website	Intention to buy a mobile device with similar web-browsing features
Mobile-page interface design	.05	-.05	-.01
Ease of operation	.23	.31*	.13
Ease of reading	.12	.02	.64
Ease of navigation	-.11	.02	-.01
Perceived interactivity	.49**	.42**	.20

* $p < .05$ and ** $p < .01$. Numbers in the table are standardized regression coefficients.

3.3. Summary and Discussion of Study 1

Our first study revealed several substantial results that may be valuable for mobile-interface designers. First, among the three types of interface designs we examined, the single-page and multi-page designs were rated as easier to read than the zooming design. We did not find any difference for the perceived ease of operation or perceived ease of navigation. It seemed that all three design types require little effort in terms of operation and navigation (i.e., $M_{\text{operation}} = 4.32, M_{\text{navigation}} = 4.14$). However, the subtle difference in the interface design had a significant impact on the perceived ease of reading. This result may suggest that users are very task-orientated when interacting with web content. They may have paid less attention to how they operated or navigated the webpages (which were intuitive actions), but had a clear feeling about how the design influenced them in terms of completing the reading task. Although allowing for a clearer view of the content,

the zooming design may not be the best design for mobile readers. The single-page and multi-page designs created a more positive reading experience for the users.

We also found that the web-interface design had little impact on perceived interactivity. However, based on the regression analysis discussed in the previous subsection, this variable was a positive predictor of the behavioral intention to continue using mobile browsing. In other words, enhanced interactivity can significantly increase users' intentions to browse a mobile website. Therefore, interactivity should be taken into consideration when designing mobile web interfaces in order to attract new users or retain existing ones.

4. Study 2

4.1. Method

In Study 1, we compared three types of interface designs and evaluated how they affect the users' reading experience on a smartphone. In Study 2, our focus was to assess homepage designs. We conducted a between-subjects experiment in which participants were exposed to three different types of homepage designs on a smartphone: progressive, list-view, and thumbnail.

4.1.1. Participants

A total of 55 people participated in Study 2. Participants were recruited from a mid-size, midwestern university in the United States. Participants came from different majors and academic standings. The participants' age range was from 18 to 26 ($M = 20.24$, $SD = 2.14$). About 64% of the participants were male. Over 76.4% described themselves as Caucasian, 18.2% as Asian Americans, 1.8% as African Americans, and 1.8% as Hispanic. When participants were asked about their previous experience with using mobile devices for web browsing, over 12% reported that they had never used mobile devices to browse the Internet. About 73% of the people reported that they browsed the Web on a mobile device every day or several times a week.

4.1.2. Experimental Stimuli

We set up the experimental stimuli on an iPod Touch that had a screen size of 3.5 inches (960 x 640 pixels). The mobile device had colorful graphics and imaging capability. The browser used to display the websites was Safari.

In this study, we went beyond the examination of mobile-page interface design to the investigation of homepage design. The first step to create the stimuli focused on categorizing the information presented on the

homepage. We identified four levels of news content: section names, news headlines, news summaries, and full articles.

On the first level (section names), users can get a general idea about each news section from their names--*Technology*, *World*, *Entertainment*, and *US*. On the second level, people can read the article headlines. The third content level is a short summary of each article and is usually presented under each news headline. The fourth content level is the full text of the news article. We chose to create a CNN mobile homepage by emulating its color schemes and font styles.

Of all of the links we created for the different content levels, we made *Technology* the active link for all of the news sections. We made the article entitled “Napkin PC enables high-tech doodling” the active link for the second level of information. For the third level, a brief summary of “The napkin PC is an idea for a next general personal computer...” was the active link. The fourth information level contained the full text of the article with an image of the napkin PC. Therefore, the participants in each of the experimental conditions read the same content and were exposed to the same amount of information. The article was fairly short, containing 196 words, and told the story of a new technology called the napkin PC. This topic should appeal to college-age participants who are often quick adopters of new technologies. We chose this article because technology is usually a value-neutral topic, and young readers are often attracted to new technologies.

In the *progressive* design, the first page contained several levels. The first level had only the news section names. By tapping on a section name (*Technology*), readers could see the next content level--news headlines. When readers tapped on a news headline, the article summary appeared. Then, readers could tap on the article summary to read the full story (Figure 5).

In the *list-view* design, the first page contained three information levels: the section names, the news headlines, and the article summaries. This information was presented simultaneously. The first page was structured as a single column and readers could slide to the bottom to find the *Technology* section. They could tap on either the headline or the article summary to enter the page for the full news article (Figure 6).

In the *thumbnail* design, the users first saw images for the various sections. The first page contained the section names with relatively large thumbnails or images. By tapping on the *Technology* section’s image, readers entered another page that listed the article headlines. On this page, each headline was accompanied by

a small picture and a summary of each article. By tapping on the article title, the participants could read the full-text article. Table 4 summarizes the number of participants in each experimental condition (Figure 7).

Table 4: Number of participants by experimental condition (Study 2).

Progressive	$n = 18$
List-view	$n = 19$
Thumbnail	$n = 18$

Figure 5: *Progressive* condition. (Upper row: readers see the section names, article titles, and news summaries after each tap that they make. Lower row: the webpages for the full article.)

Figure 6: *List-view* condition. (Upper row: Section names, article titles, and news summaries are presented simultaneously. Lower row: The webpages for the full article.) Readers need to slide down to the bottom of index page and tap on the first article under the *Technology* section to read the news story.

Figure 7: *Thumbnail* condition. (Upper row: left and middle - section names are presented visually in the first layer; and right - by tapping on the image, readers will see article titles and news summaries. Lower row: The webpages for the full article.)

4.1.3. Procedure

Participants were invited to register for a research session online. Each research session contained up to three participants. There were two experimental coordinators at each research session. Upon their arrival at the research lab, participants were greeted and asked to read and to sign an informed consent form. The experiment coordinator then *randomly* assigned each participant to one of the three experimental conditions (i.e., progressive, list-view, and thumbnail). Participants were told that they were going to read an article on a mobile device and then complete a questionnaire. We used two view blockers for each participant so he/she would not be affected by another participant while reading.

Before the reading started, the experiment coordinator demonstrated how he/she could use the mobile device and read the article. Participants were allowed to practice until they felt comfortable browsing the

webpages on the iPod Touch. The average practice time was fairly short. A timer was used to record the reading time. Each participant was asked to start the timer when the reading began and to stop the timer when the reading was completed. After reading the article, participants were asked to evaluate their reading experience. When they completed the study, they were thanked and debriefed. The entire process took approximately 25 minutes.

4.1.4. Measures

Participants' responses were collected immediately after they finished reading the article on the mobile device. The questionnaire was administered on a computer in the lab. Our items measured key variables such as perceived ease of use, perceived user-friendliness, and perceived ease of learning with the goal of understanding the users' interactions with the device (Lund, 2001). We also measured reading time, recall, attitude toward content, and users' satisfaction. All items, except for reading time and recall, were assessed using a 5-point Likert scale that was anchored with *strongly disagree* and *strongly agree*. The demographic questions that measured age, gender, and prior experience with touch-screen mobile devices were placed at the end of the questionnaire.

4.1.4.1. Reading Time

Participants' reading time was collected using a timer that was given to them before the reading started. They were allowed to practice with the timer until they were comfortable using it. Participants were instructed to start the timer when they began browsing the homepage to locate the article and to stop the timer when they finished reading the article. The reading time was recorded in seconds ($M = 76.65$, $SD = 24.60$).

4.1.4.2. Recall

We used four questions to measure the participants' recall of the content. Three options were given for each recall question, and participants indicated the answer based on the article they just read. For each recall question that the participants answered correctly, they received a score of 1. If all four questions were answered correctly, we gave that participant a score of 4 for the recall variable. If a participant scored 0, it meant that none of the recall questions was answered correctly ($M = 2.75$, $SD = 1.14$).

4.1.4.3. Perceived Ease of Use

Perceived ease of use was measured by asking participants to rate their browsing experience with five items: “The browsing style was easy to use,” “The browsing style was simple to use,” “The browsing style required the fewest steps possible to accomplish what I wanted to do with it,” “Using the browsing style is effortless,” and “I can use the browsing style without written instructions.” The five items were combined to form the index for the perceived ease of use ($\alpha = .80$, $M = 4.27$, $SD = .66$).

4.1.4.4. Perceived User-Friendliness

Perceived user-friendliness was measured by asking participants to rate their browsing experience with six items: “The browsing style was user-friendly,” “I didn’t notice any inconsistencies as I used the browsing style,” “The browsing style was flexible,” “I can use the browsing style successfully every time,” “I can recover from mistakes quickly and easily,” and “Both occasional and regular users would like this style.” The six items were combined to form the index for perceived user-friendliness ($\alpha = .78$, $M = 4.10$, $SD = .61$).

4.1.4.5. Perceived Ease of Learning

Perceived ease of learning was measured by asking participants to rate their browsing experience with four items: “I learned to use the browsing style quickly,” “I easily remember how to use the browsing style,” “It is easy to learn how to use the browsing style,” and “I quickly became skillful with the browsing style.” The four items were combined to form the index for perceived ease of learning ($\alpha = .81$, $M = 4.43$, $SD = .59$).

4.1.4.6. Attitude toward Content

Attitude toward content was measured by asking participants to rate how they perceived the content of the article they just read on four 5-point scales: “not at all interesting–interesting,” “useless–useful,” “worthless–valuable,” and “not at all beneficial–beneficial.” The four items were combined to form the index for the attitude toward content ($\alpha = .82$, $M = 3.85$, $SD = .72$).

4.1.4.7. Users’ Satisfaction

Users’ satisfaction was measured by asking participants to rate their browsing experience with three items: “I am satisfied with this browsing experience,” “My browsing experience was wonderful,” and “My browsing experience was pleasant.” The three items were combined to form the index for users’ satisfaction ($\alpha = .83$, $M = 4.01$, $SD = .74$).

4.2 Results

4.2.1. Reading Time, Recall, and Attitude toward Content (*RQ3a-c*)

Our ANOVA analysis discovered a marginally significant effect of the homepage design on reading time, $F(2, 52) = 2.76, p = .07, \eta_p^2 = .10$. Specifically, participants in the thumbnail condition ($M = 67.44, SD = 19.29$) took less time than people in the progressive condition ($M = 86.11, SD = 28.87$). The difference in reading time between the progressive and list-view conditions was not significant ($p > .05$), nor was the difference in reading time between the list-view and thumbnail conditions ($p > .05$). ANOVA tests showed that the effects of the homepage design on recall and attitude toward content were insignificant [$F_{recall}(2, 52) = 1.43, p = .25$; $F_{attitude}(2, 52) = 2.35, p = .11$].

4.2.2. Perceived Ease of Use, Perceived User-Friendliness, and Perceived Ease of Learning (RQ3d-f)

Our analysis did not discover any significant effects of the homepage design on perceived ease of use, perceived user-friendliness, or perceived ease of learning [$F_{ease\ of\ use}(2, 52) = 1.56, p = .22$; $F_{user-friendliness}(2, 52) = .86, p = .43$; and $F_{ease\ of\ learning}(2, 52) = 1.36, p = .27$]. Table 5 reports the means for all of the dependent variables pertaining to RQ3.

Table 5: Means for all of the dependent variables across three experimental conditions (Study 2).

	Progressive	List-view	Thumbnail
Reading time	86.11 (28.87)	76.42 (22.44)	67.44 (19.29)
Recall	2.39 (1.19)	2.89 (1.04)	3.00 (1.24)
Perceived ease of use	4.06 (.59)	4.31 (.68)	4.43 (.68)
Perceived user-friendliness	3.96 (.46)	4.11 (.71)	4.23 (.64)
Perceived ease of learning	4.25 (.60)	4.46 (.58)	4.57 (.59)
Attitude toward content	4.14 (.61)	3.66 (.80)	3.78 (.67)

Note: Numbers in parentheses are standard deviations. The reading time was measured in seconds. The scale for recall ranged from 0 to 4. Other dependent variables were measured with a 5-point scale.

4.2.3. Predictors of Users' Satisfaction (RQ4)

To answer RQ4, we conducted a multiple regression analysis. Our goal was to determine the factor(s) that could predict users' satisfaction with the browsing experience. The regression analysis showed that, together, reading time, recall, perceived ease of use, perceived user-friendliness, perceived ease of learning, and attitude toward content accounted for a significant portion of the variance in the dependent variable--users' satisfaction, $F(6, 48) = 19.22$, Adjusted $R^2 = .67, p < .001$. Of the five factors, perceived ease of use ($\beta = .37, p = .029$), perceived ease of learning ($\beta = .40, p = .006$), and attitude toward content ($\beta = .21, p = .021$) significantly predicted users' overall satisfaction with the browsing experience.

4.3. Summary and Discussion of Study 2

In Study 2, we investigated the influence of the homepage design on the users' browsing experience. We discovered that the homepage design created a marginally significant difference in reading time. Readers who used the thumbnail design on the mobile device needed less time to find and read the article than people who used the progressive design. This finding suggests that the thumbnail design was the most efficient design for locating the information quickly and completing the reading task. The progressive design was the least efficient design.

In addition, perceived ease of use and perceived ease of learning significantly predicted the users' satisfaction. We also discovered that a positive attitude toward the content could also enhance users' satisfaction with their general browsing experience. This finding suggests that a simple and straightforward homepage design for news sites makes it easy to learn. At the same time, users' perceptions about the content quality are also significant in improving satisfaction with their browsing.

5. Discussion

Based on the two empirical studies, we derived two implications for mobile-page designers. We also compared our results with the current practices in the media industry. In addition, we identified several important issues for future investigation.

5.1. Discussion of the Major Findings

The first major finding for Study 1 was that, when readers are task-driven, they preferred simpler and more intuitive interfaces such as single-page (sliding vertically) and multi-page (tapping through different pages) designs that help them complete the task quickly and easily. The function of zooming (two fingers moving in opposite directions) has been available to users on different types of smartphones, but it was the least-preferred design for our study when readers were asked to read a news article on a smartphone. However, even though zooming was rated less favorably in our study, it may be useful and preferred when tasks are related to locating and enlarging information for details.

Thus, our major conclusion for Study 1 is, when users are task-oriented, it is important to provide interactive functions that help them accomplish their tasks efficiently. Users pay little attention to how they operate or navigate on smartphones, but care more about whether the interactive functions serve their goals. We also conclude that when the tasks involve cognitive information processing (such as reading news articles),

users prefer simple and intuitive designs.

In Study 2, we determined that the thumbnail design, which provides a visual preview of news topics, allowed users to quickly locate the article they were asked to read. The progressive design, which allowed users to tap through several levels (news section, news headline, and article summary) to obtain more information about an article before they actually read it, was the least efficient design. The progressive design was also the least-often used design in the media industry (Table 7).

5.2. Implications for Designers

5.2.1. Single-Page Design

Unlike desktop-computer users who focus on the screen, mobile users are often involved in multitasking when utilizing smartphones. For example, users may be in a conversation, commuting, or waiting to check out at a grocery store when they are browsing the Internet with their smartphones. As a result, smartphone users prefer to perform simpler and more intuitive actions, and expect to find the information of interest quickly. In our examination, the single-page design excels in terms of being rated highest for perceived ease of reading. Sliding vertically is a simple and intuitive action that requires less physical and mental effort. Therefore, users can focus on the content rather than the interface or operation.

With the single-page design, a user primarily swipes and slides to navigate between different paragraphs during the reading process. With the multi-page design, a user taps or clicks to read through different paragraphs. With the zooming design, a user is required to perform more complex actions (i.e., a combination of swiping and pinching gestures) to read an article (i.e., the swiping gesture for changing the focus and the pinching gesture for zooming). The compound action makes the zooming design harder and less intuitive than the other two design types. This result implies that users prefer an interface that requires the least effort during the reading process.

In order to understand the current trends in mobile-page interface design, we examined 14 popular mobile news websites. Our selection was based on ratings for the most popular mobile news websites (eBizMBA Guide, 2015). Google News was excluded because it is a portal that directs users to other new websites. We did not evaluate the zooming design because the design for our study was different from real scenarios (as noted in Section 3.1). We found that zooming was purely an option for readers in real

interactions with mobile webpages. For the zooming design in our study, an article was scaled to fit the small screen. Consequently, users had to first zoom in on the content before they were able to read the article. Many of the mobile websites (8 of the top 14 news sites, see Table 6) in the market have disabled that function.

Our evaluation of the real mobile websites is summarized in Table 6. The analysis shows that the majority of the mobile websites use the single-page design, and only the CNN mobile website uses both the single-page and multi-page designs. This result is consistent with our findings in that both users and mobile news providers prefer minimizing user actions.

For the multi-page design in Study 1, each subpage occupied approximately one screen, so the users only needed to tap through four pages to complete the reading. However, the size of smartphones varies dramatically. Based on the screen-size variance, it would be challenging for designers to automatically split an article into several subpages. Consequently, in general, each subpage is longer than the screen height, requiring a compound action (i.e., the combination of swiping and tapping) to read through different subpages. This complexity may help explain why the majority of the popular mobile websites chose to use the single-page design.

Table 6: Mobile-page interface design for popular mobile news websites.

Website names	Single-page	Multi-page	Zooming
1. Yahoo News news.yahoo.com	Yes	No	Disabled
2. Huffington Post m.huffpost.com	Yes	No	Disabled
3. CNN cnnmobile.com	Yes	Yes	Disabled
4. <i>New York Times</i> mobile.nytimes.com	Yes	No	Disabled
5. Fox News m.foxnews.com	Yes	No	Disabled
6. NBC News m.nbc.com	Yes	No	Enabled
7. Mail Online dailymail.co.uk	Yes	No	Enabled
8. <i>Washington Post</i> m.washingtonpost.com	Yes	No	Enabled
9. <i>The Guardian</i> theguardianmobile.com	Yes	No	Enabled
10. <i>Wall Street Journal</i> m.wsj.com	Yes	No	Disabled

11. ABC News abcnews.go.com/m	Yes	No	Disabled
12. BBC News m.bbc.com	Yes	No	Enabled
13. <i>USA Today</i> usatoday.com	Yes	No	Enabled
14. <i>LA Times</i> latimes.com	Yes	No	Disabled

5.2.2. A Homepage with a Thumbnail Design

Study 2 revealed that the thumbnail design is best in terms of reading time. In task-oriented browsing where a user is looking for a specific piece of information (such as in Study 2), the thumbnail design allows quick recognition of the content in an article without reading a text-based title. This feature is especially important for mobile browsing because mobile users are, in general, in an environment where smartphone usage takes place along with other activities such as walking or shopping. Consequently, users prefer to locate the information of interest by skimming the screen rather than reading details. The thumbnail design is suitable for skimming, making information easy to locate. This observation is consistent with the state-of-the-art homepage interface design for mobile news websites. Indeed, a majority (13 of the top 14) of popular mobile news websites (Table 7) uses the thumbnail design. We noticed that eight mobile news websites have a hybrid design that combines the thumbnail design to highlight breaking news and the list-view design. Under each category, the top one or two articles are displayed with a thumbnail to attract users' attention. Based on our findings in Study 2 and the evaluation of the real mobile news websites, we recommend using the thumbnail design when creating a homepage for mobile news websites.

Table 7: Homepage design for popular mobile news websites.

Website names	List-view	Thumbnail	Progressive
1. Yahoo News news.yahoo.com	Yes	Yes	No
2. Huffington Post m.huffpost.com	No	Yes	No
3. CNN cnmobile.com	Yes	Yes	No
4. <i>New York Times</i> mobile.nytimes.com	Yes	Yes	No
5. Fox News m.foxnews.com	Yes	Yes	No
6. NBC News	No	Yes	No

m.nbc.com			
7. Mail Online dailymail.co.uk	No	Yes	No
8. <i>Washington Post</i> m.washingtonpost.com	Yes	Yes	No
9. <i>The Guardian</i> theguardianmobile.com	Yes	Yes	No
10. <i>Wall Street Journal</i> m.wsj.com	Yes	Yes	No
11. ABC News abcnews.go.com/m	Yes	No	Yes
12. BBC News m.bbc.com	No	Yes	No
13. <i>USA Today</i> usatoday.com	No	Yes	No
14. <i>LA Times</i> Latimes.com	Yes	Yes	No

5.3. Future Investigation

5.3.1. Interactivity

Interactivity has been a very important factor that drives the development of technology. Designers must balance increased interactions between people and devices without adding to the users' cognitive load. Our study is valuable because it evaluated different types of interface designs and how they might influence users' perceived interactivity. In other words, we wanted to see whether designers share the same mindset as users regarding the interactivity of a technology interface. Our results showed a moderate-to-high level of perceived interactivity among all three designs in Study 1. Users viewed the single-page, multi-page, and zooming designs similarly in terms of perceived interactivity. Compared with the single-page and multi-page designs, the zooming design required more touches and finger movements on a smartphone screen. However, more movements or choices did not always lead to greater perceived interactivity. In Study 1, we discovered that perceived interactivity is crucial for retaining users on a smartphone or attracting new viewers to a mobile website. This finding confirmed the assumption that interactivity should be valued when designing an interface, especially when the goal is to retain users of a news website. The remaining question is, how can interface designs increase perceived interactivity?

With the rapid development of mobile hardware (e.g., large screen sizes or more powerful computing capacity), it is now possible to display advanced multimedia content such as 3D graphics or animation on

smartphones. A variety of multimedia content can provide more opportunities for users to interact with smartphones. However, is a rich media interface always advantageous? Is more always better for touch-screen devices? Future research should continue to investigate whether perceived interactivity can be enhanced with certain types of interface designs.

Another extension of the current study could focus on mobile social media. Surfing news articles on a smartphone is different from browsing social media such as Facebook or Twitter. Interactions on the latter require quick reading, instant feedback, and frequent updates for text, pictures, or other content types. The major findings in both our studies are that “simpler is better.” Does this principle apply to mobile social media as well? We speculate that people may require more functional options such as zooming, searching, and tapping when using social media on their mobile devices. They may also prefer less information at first and having the choice to view information step by step (as provided in the progressive design), because the volume of information presented on social media is often overwhelming. It would be interesting to analyze how mobile-page interface designs can be optimized for users’ interactions on mobile social-media sites.

Currently, interface designs that allow touch-based gestures using fingers (i.e., sliding, tapping) are the dominant interaction method for mobile browsing. However, touch-based gestures are not convenient in some interaction scenarios such as walking. The mobile devices’ built-in sensors can potentially provide a richer interaction model. Future research would find it worthwhile comparing touch-based gestures with accelerometer- and camera-based gestures, especially for unconventional interactive tasks.

5.3.2. Progressive Design

As Study 2 revealed, the progressive design led to the longest reading time and is used much less frequently. Nevertheless, for several reasons, future research should investigate this design more before abandoning it completely. First, progressive reading allows users to begin with an abstract of the article and then continue on to the details. This feature may be preferred when readers want to start with something simple and then gradually look for details. Second, expanding a list from the first level to the second level of information may make utilizing the screen more efficient because detailed information that is presented on one page can be seen as overwhelming.

In Study 2, we implemented the tapping gesture to expand the information (i.e., from the title to the

abstract or from the abstract to the entire article). Tapping may cause a fat-finger issue and is not suitable for some scenarios such as when people are moving. In the future, we will evaluate the performance of the progressive design based on a swiping gesture (i.e., a fast finger movement that can avoid the fat-finger issue). The progressive design has four levels (i.e., section, title, summary, and details from top to bottom). The list pattern (Mendoza, 2014) suggests three levels for displaying content. It is worthwhile investigating the effect of the number of levels on efficiency. Specifically, we will consider reducing the number of levels to three by combining the title and summary.

Time is critical in task-oriented browsing. On the other hand, for people simply browsing the Internet to kill time, their attitude towards the content is important for their subjective satisfaction. Study 2 shows that progressive reading has the highest score on attitude toward content (although not significant). Therefore, it is worthwhile investigating the performance and subjective satisfaction of the progressive design in scenarios that are not task-oriented.

5.3.3. User Experience

For Study 1 and Study 2, we identified a series of factors such as perceived user-friendliness, attitude toward content, and perceived interactivity that are closely related to the users' reading experience with mobile devices. Although we failed to establish that the mobile-interface design has a significant influence on all of these variables, our results did reveal that subtle differences in interface design could influence perceived ease of reading and reading time. Future studies can continue to investigate these factors because they are important when the goal is to enhance the quality of mobile-human interactions. Future work also includes conducting research on various types of mobile websites, such as online social networking or e-commerce websites. Users may prefer different types of interface designs for websites serving different purposes. In addition, this study focused only on young college students. Extending the investigation to users from other demographic backgrounds would help determine how demographic factors impact the usability of different interface designs.

5.4. Generalization and Limitation

To enhance the ability to generalize our findings, we also explored the web features that are currently used by popular news websites (see Table 6 and Table 7) to understand the adoption of these designs. For

mobile news websites, our research found that these websites primarily chose the thumbnail design for their homepages (13 out of 14) and widely adopted the single-page design (14 out of 14) for news webpages. In order to validate that the design features chosen are the ones that are commonly used not just for mobile news websites but also for other types of mobile web content, we selected 10 popular mobile e-commerce web sites (See Tables 8 and 9) and explored their mobile page designs (i.e., the mobile page for displaying a specific product) and homepage designs (i.e., the navigation menu that directs shoppers to a specific product).

We found some similarities and differences between the designs for news websites and e-commerce websites for mobile devices. Single-page design is still the most popular choice (10 out of 10). Seventy percent of the e-commerce mobile websites also adopted a multi-page design. However, only 2 out of the 10 websites we analyzed chose to enable the zooming function. Our results suggest that both news websites and e-commerce websites favor the single-page design, but e-commerce websites are more likely to adopt the multi-page design.

We also found that the mobile e-commerce websites generally tended to use all of the three homepage designs (i.e., list-view, thumbnail, and progressive) we conceptualized in this study. This finding suggests that mobile e-commerce websites have chosen to adopt a mixture of the three homepage design styles, whereas the mobile news websites commonly used the list-view and the thumbnail design but abandoned the progressive design. This difference may indicate that progressive reading is more useful for browsing a complex structure that covers thousands of products. Future studies should analyze the advantages of using a combination of the three types of homepage designs for product presentations on e-commerce websites.

Table 8: Mobile-page interface design for popular mobile e-commerce websites.

Website names	Single-page	Multi-page	Zooming
1. Amazon	Yes	Yes	Disabled
2. Walmart	Yes	Yes	Disabled
3. Costco	Yes	No	Disabled
4. Lowes	Yes	Yes	Disabled
5. Target	Yes	Yes	Disabled
6. Home Depot	Yes	Yes	Disabled
7. Walgreens	Yes	No	Enabled
8. Dell	Yes	Yes	Enabled
9. BestBuy	Yes	Yes	Disabled

10. Kohl's	Yes	No	Disabled
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Table 9: Homepage design for popular mobile e-commerce websites.

Website names	List-view	Thumbnail	Progressive
1. Amazon	Yes	Yes	Yes
2. Walmart	Yes	Yes	Yes
3. Costco	Yes	Yes	Yes
4. Lowes	No	Yes	Yes
5. Target	Yes	Yes	Yes
6. Home Depot	Yes	Yes	Yes
7. Walgreens	Yes	Yes	Yes
8. Dell	Yes	Yes	Yes
9. BestBuy	Yes	Yes	Yes
10. Kohl's	Yes	Yes	Yes

One limitation in our research is that our studies included participants aged 18-30 years old. This age group covers a large portion of active smartphone users in the market. However, future studies can certainly include a sample pool that has a wider age range.

6. Conclusion

The users' experience with mobile browsing may depend on how mobile webpages are structured and displayed. With the goal of understanding the effects of mobile-page and homepage designs on small-screen devices, we conducted two experimental studies to examine how users evaluated interface designs that are widely used on mobile news websites. We found that the designs for mobile news pages and the structures for website homepages can have a significant impact on perceived ease of use, reading time, and the overall reading experience.

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