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Web Versus Mobile Web: An Experimental Study of Device Effects and Self-Selection Effects

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Abstract
Due to a rising mobile device penetration, Web surveys are increasingly accessed and completed on smartphones or tablets instead of desktop computers or laptops. Mobile Web surveys are also gaining popularity as an alternative self-administered data collection mode among survey researchers. We conducted a methodological experiment among iPhone owners and compared the participation and response behavior of three groups of respondents: iPhone owners who started and completed our survey on a desktop or laptop PC, iPhone owners who self-selected to complete the survey on an iPhone, and iPhone owners who started on a PC but were requested to switch to iPhone. We found that respondents who completed the survey on a PC were more likely to be male, to have a lower educational level, and to have more experience with Web surveys than mobile Web respondents, regardless of whether they used the iPhone voluntarily or were asked to switch from a PC to an iPhone. Overall, iPhone respondents had more missing data and took longer to complete the survey than respondents who answered the questions on a PC, but they also showed less straightlining behavior. There are only minimal device differences on survey answers obtained from PCs and iPhones.

Keywords
Web surveys, mobile Web surveys, smartphones, unintentional mobile, iPhone, missing data, response times, break-offs, data quality, straightlining

Introduction

Survey researchers have been looking into ways to employ mobile phones with Internet access for self-administered data collection for almost a decade now (Fuchs, 2008; Okazaki, 2007). In recent years, there is an increasing spread of a new generation of mobile devices (such as smartphones, tablet computers, and eBook readers) that run special mobile Internet browsers and have screens large enough for adequate page viewing. Pew Research Center (2015a) estimates that 68% of the U.S. adult population had a smartphone as of July 2015. In the European Union, an average of 92%

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of all households had at least one mobile phone in 2014 and 52% of these households had a mobile phone with Internet access (European Commission, 2014).

The increasing popularity of mobile devices with Internet access has led to two distinct phenomena in research. First, survey researchers are now able to specifically target users of mobile devices for context- and location-specific data collection (Maxl, 2009). This researcher-driven use of mobile devices for survey data collection involves signal-contingent experience sampling—participants are periodically reminded via text or app-based messages on their smartphones to report behaviors or personal states—for ecological momentary assessment, transportation and time-use diary studies, and health monitoring (e.g., Link, Lai, & Bristol, 2014; Pew Research Center, 2015b; Sonck & Fernee, 2013) as well as passive mobile data collection (Revilla, Ochoa, & Loewe, 2016).

Second, and of particular relevance to survey researchers, an increasing number of respondents access web surveys on their mobile devices. Peterson (2012) coined the term "unintentional mobile respondents" for this respondent-driven use of mobile devices in Web surveys. He reported that, among 17 Web surveys conducted by Market Strategies in 2011 and 2012, between 1% and 30% of respondents started the Web survey on a mobile device, depending on the target population. The proportion of unintentional mobile respondents for both nonprobability and probability panels has grown during the last couple of years in the United States, Europe, and South America (Kinesis, 2013; Revilla, Toninelli, Ochoa, & Loewe, 2015). de Bruijne and Wijnant (2014) found that the share of unintentional mobile respondents in the Dutch Longitudinal Internet Studies for the Social sciences (LISS) panel increased from 3% in March 2012 to 11% in September 2013. About 16% of online respondents in the German GESIS panel named tablets and 8% named smartphones as their preferred mode to answer the Web questionnaires (Struminskaya, Weyandt, & Bosnjak, 2015). In the American Trends Panel, 27% of respondents completed their most recent Web survey on a smartphone and 8% used a tablet (Pew Research Center, 2015c). Given this trend, survey researchers are concerned about the impact of using a mobile device (a smartphone in particular) on survey participation and survey answers (Buskirk & Andrus, 2012; Callegaro, 2010).

In the current study, we describe a methodological experiment that varied the device assigned to a convenience sample of iPhone owners. iPhone owners who started our survey on a PC were randomly assigned to one of the two conditions: they were either allowed to proceed with the survey on the PC or were asked to switch from the PC to an iPhone to complete the survey. Respondents who started the survey on an iPhone were allowed to complete the survey on the iPhone. The setup of our experiment allows us to examine the influence on participation and response behavior of researcher-driven use of smartphones (i.e., requesting respondents to switch to a smartphone) and respondent-driven use of smartphones (i.e., unintended use of mobile device by respondents to answer a Web survey). The findings of the study provide additional empirical evidence for the influence of smartphone use and smartphone users in Web surveys on participation behavior and data quality.

Previous Research

The increased penetration of mobile devices has the potential to reduce coverage error in Web surveys in the long run (Metzler & Fuchs, 2014). An increasing proportion of subpopulations traditionally undercovered in Web surveys due to low Internet penetration, such as low income, low education, and minority groups, are now exclusively relying on mobile devices to access the Internet (Pew Research Center, 2015d). However, mobile devices seem to pose a potential threat to Web survey data quality due to nonresponse and measurement error. There is growing empirical evidence that response rates are lower and break-off rates are higher for those who use a smartphone to access a Web survey (Mavletova, 2013; Mavletova & Couper, 2013; Sommer, Diedenhofen, & Musch, 2016), even when the questionnaire is optimized for the smaller screen of mobile devices (Antoun, 2015; Buskirk & Andrus, 2014; Stapleton, 2013; Toepoel & Lugtig, 2014; Wells, Bailey,

& Link, 2013). Differential nonresponse is also manifested in smartphone respondents being younger (Arn, Klug, & Kołodziejski, 2015; de Bruijne & Wijnant, 2014; Mavletova, 2013; Sommer et al., 2016; Toepoel & Lugtig, 2014; Wells et al., 2013; Wells, Bailey, & Link, 2014), more likely to be female (de Bruijne & Wijnant, 2014; Sommer et al., 2016; Wells et al., 2013, 2014), from higher income groups (Toepoel & Lugtig, 2014), heavier mobile Web users (Mavletova, 2013; Mavletova & Couper, 2016), and primarily relying on smartphones to access the Internet (Wells et al., 2013, 2014) when compared to respondents who completed the Web survey on a desktop or laptop (PC). One explanation for the increased break-off among smartphone respondents is the higher level of response burden as reflected by longer response times (see table 1 in Couper & Peterson, 2016).

Theoretically speaking, two distinct features of mobile phones potentially make them different from PCs in terms of response behavior (Lugtig & Toepoel, 2016). First, the relatively small screen size limits the amount of information that can be displayed on a mobile phone screen. Second, while PCs usually rely on a combination of mouse clicks and character entry through a keyboard for survey responses, mobile phones predominantly use a touch screen where survey questions are answered via finger touches on the screen. Empirically, studies comparing substantive answers obtained from PCs to answers from mobile phones reported very few differences in answers after controlling for self-selection and nonresponse (Andreadis, 2015; de Bruijne & Wijnant, 2013; Peterson, 2012; Sommer et al., 2016; Toepoel & Lugtig, 2014). There is only weak empirical evidence for more socially desirable responding in mobile Web surveys than in Web surveys (Antoun, 2015; Mavletova, 2013; Mavletova & Couper, 2013). The literature is yet to provide conclusive evidence on the effects of responding to Web surveys on smartphones on missing data (Buskirk & Andrus, 2014; Lugtig & Toepoel, 2016; Mavletova, 2013; Mavletova & Couper, 2014; Struminskaya et al., 2015; Toepoel & Lugtig, 2014; Wells et al., 2013) and satisficing such as nondifferentiation, acquiescence, response order effects, and so on (Antoun, 2015; Buskirk & Andrus, 2014; Lugtig & Toepoel, 2016; Mavletova, 2013; Peytchev & Hill, 2010; Stapleton, 2013; Struminskaya et al., 2015; Toepoel & Lugtig, 2014).

Our Study

Most of the previous studies on mobile Web surveys either allow respondents to use a device of their own choice (smartphone, tablet, or PC) to fill out the Web survey (which is a nonexperimental allocation to devices) or randomly assign prescreened respondents to a device at the point of survey invitation. Our study combines the features of both designs; we randomly assigned iPhone owners who started our survey on a PC to either proceed with the survey on the PC or to switch from the PC to an iPhone to complete the survey. Respondents who started the survey on an iPhone were allowed to complete the survey on the iPhone.

More importantly, this experimental setup allows us to make three key comparisons. We first compare respondents who started and finished the survey on an iPhone (unintentional iPhone respondents) to respondents who started and finished the survey on a PC (PC respondents) in terms of participation and response behaviors. Given the increasing prevalence of unintentional mobile respondents for any given Web survey, this comparison addresses an important practical issue survey researchers face by looking into the effect of unintentional use of mobile phones (iPhones in this case) in a Web survey.

Second, we compare PC respondents to those who accessed the survey on a PC but were requested to switch to an iPhone (switchers). This comparison measures device effects—the effects of the device used to complete a Web survey. Lugtig and Toepoel (2016) showed that device has no effect on measurement error when respondents switch to a different device over time. However, their finding is observational in nature; it was the respondents' decision to switch devices across waves. Our comparison is based on random assignment and sheds further light on device effects due to device switching requested by researchers.

Third, we compare unintentional iPhone respondents to switchers. With this comparison, we will identify differences attributed to self-selection effects.

This study allows us to examine not only device effects and self-selection effects separately but also an unknown combination of the two that is often encountered by survey researchers and data users in any real-life Web surveys.

Method

Sample and Study Design

Participants for our study were recruited through Amazon Mechanical Turk (MTurk). MTurk is a microwork crowdsourcing Internet platform allowing so-called requesters to post a Human Intelligence Task (HIT)—such as tagging photos, transcribing audio into text, or searching for information on the Internet—that can be completed by "workers" for a monetary payment set by the requester. MTurk has become increasingly popular among academic researchers in political science (Berinsky, Huber, & Lenz, 2012), social science (Buhrmester, Kwang, & Gosling, 2011), and survey methodology (Antoun, Zhang, Conrad, & Schober, 2016) for recruiting respondents to Web-based experiments. From February to April 2014, we posted an HIT on MTurk inviting iPhone users[1] over the age of 18 years who live in the United States to participate in a short Web survey (see Appendix I for MTurk HIT). For full participation in our study, we offered an incentive of 35 cents.

Upon clicking on the link provided in the HIT, MTurk workers were transferred to a Web survey consisting of two parts (see Appendix II for full question wording). The screener included one question on iPhone ownership and one question about the device used at the moment. The main questionnaire consisted of 21 survey questions as well as five sociodemographic questions (age, gender, education, ethnicity, and race) and one question on frequency of Web survey participation in the past 30 days. The 21 items in the main questionnaire included individual rating scale questions on overall life satisfaction (Q1), self-rated health (Q2), attention paid to news on national TV (Q7), and general feelings (Q8) and three multi-item batteries on health behavior (Q3–Q6), affect (Q9–Q14), and materialism (Q15–Q21; Richins, 1987). All items were presented on individual screens, and all scales were fully verbally labeled, with the exception of the end-labeled scale used in the question on general feelings. The 21 items are subject to another independent methodology experiment manipulating scale direction (scales run from low to high or high to low) and scale alignment (scales are displayed horizontally, vertically, or as a drop-down menu). Horizontal scrolling is not needed to view the full scales presented horizontally but vertical scrolling is.

The Web questionnaire was programmed in Qualtrics Research Suite, which adapted the presentation of the questions based on whether a respondent used a PC or an iPhone (see Figure 1).

As shown in Figure 2, a total of 1,541 participants used a PC (such as a desktop PC, desktop Mac, MacBook, or other laptop as identified by the user agent string) to start the Web survey and 30 broke off during the screener. Among the 1,511 participants who completed the screener on a PC, 648 were randomly assigned to the condition that allowed them to complete the main questionnaire on their PC (PC respondents). Eight hundred and sixty-three participants were randomly assigned to the condition requesting them to switch to an iPhone to complete the main questionnaire.[2] The user agent string of 71 participants indicated that they started the Web questionnaire on a non-iPhone mobile device and they were prompted to switch to an iPhone as well. We combined both groups into the switchers group. To make the switch to the iPhone as easy as possible, we gave participants the option to either type a TinyURL into their iPhone's Web browser or use a quick response (QR) code scanner to access the main questionnaire. One hundred and nine participants started the Web questionnaire on an iPhone and were allowed to stay on the iPhone for the main questionnaire. This is the unintentional iPhone respondents group.

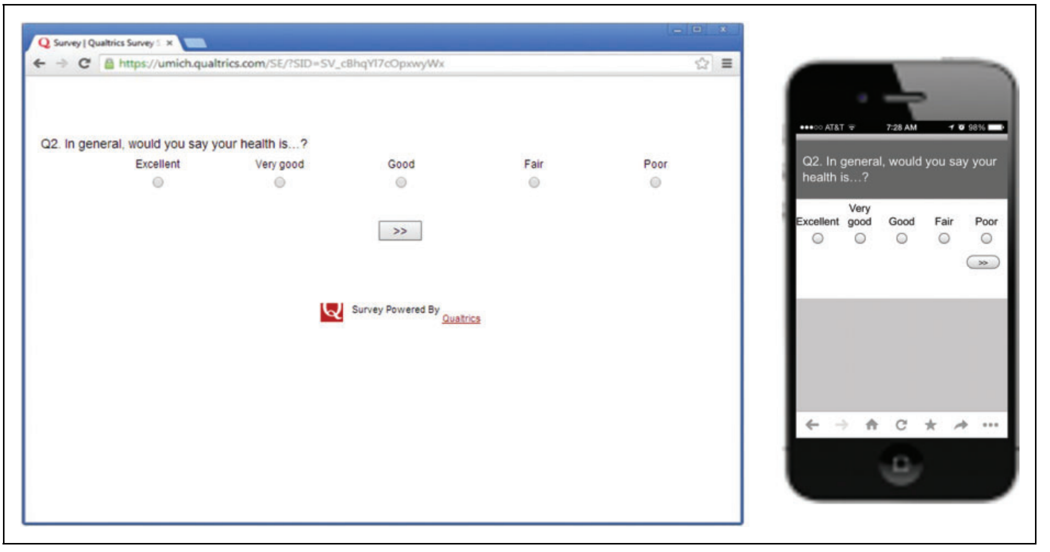

Figure 1. Presentation of questions on PC (left) and on iPhone (right).

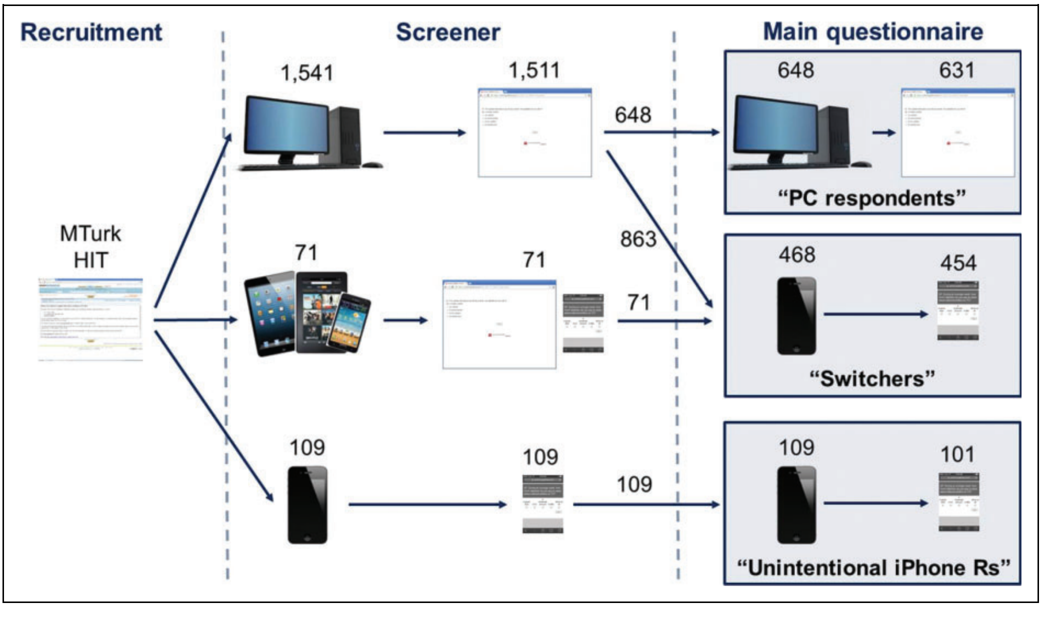

Figure 2. Experimental design.

Analysis Plan and Hypotheses

In terms of participation behavior, we first looked at *response rate to the main questionnaire* upon completing the screener using χ^2 tests with Yate's correction for unequal sample sizes. We hypothesize that switchers have a lower response rate to the main questionnaire than PC respondents and unintentional iPhone respondents because the former group has to switch to a different device in order to respond to the main questionnaire while the latter two groups use one device for the entire survey.

We next examined *break-off rates* conditional on starting the main questionnaire, again using χ^2 tests with Yate's correction. Couper and Peterson (2016) showed that even relatively short questionnaires are susceptible to significantly longer response times when completed on a mobile device than on a PC. Since response times are known to be related to response burden (Bradburn, 1977), we hypothesize that respondents using an iPhone (i.e., unintentional iPhone respondents and switchers) are more likely to break off the survey than PC respondents.

As measures of response behaviors, we examined response times, item nonresponse, and satisficing. *Response times* are operationalized as time taken to complete the main questionnaire in seconds, and we used Welch's unequal variances *t*-test to account for unequal sample sizes when comparing response times across the three groups. Again, based on the findings from previous research, we hypothesize that unintentional iPhone respondents and switchers take longer time to complete the main questionnaire than PC respondents.

In terms of *item nonresponse*, we calculate the proportion of respondents who provided missing data to at least 1 survey item in the main questionnaire and used χ^2 tests with Yate's correction to compare the groups. While some studies found that smartphones increase missing data compared to Web surveys completed on PCs (Lugtig & Toepoel, 2016; Mavletova & Couper, 2014; Struminskaya et al., 2015; Wells et al., 2013), others reported no difference (Buskirk & Andrus, 2014; Mavletova, 2013; Toepoel & Lugtig, 2014). Using again the argument of response burden, we expect to see more respondents to provide missing data on iPhones than on PCs.

We also created three indicators of satisficing behavior in our survey. First, we identified *straightliners*, that is, respondents who selected the same response category for all items in at least one of the three multi-item scales, and compared the prevalence of straightliners across the three groups (χ^2 tests with Yate's correction). Second, we compared the three groups based on an *acquiescence index* that sums up the number of times respondents answered *strongly agree* to the 7 Likert-type materialism items. Higher values of the index indicate stronger acquiescence. Third, we created a *midpoint responding index* to count the number of times respondents had selected the middle category in the 21 rating scale questions as a measure of midpoint response style. Again, Welch's unequal variances *t*-test is used to compare the three groups on acquiescence and midpoint responding. Struminskaya et al. (2015) and Lugtig and Toepoel (2016) found more straightlining behaviors among PC respondents than mobile Web respondents on multi-item grids. Since we display 1 survey item on one screen, we expect low levels of straightlining, acquiescence, and midpoint responding in the multi-item batteries used in our survey and hypothesize no differences across the three groups of respondents.

Lastly, we investigated *substantive answers* to the survey items. We created three indexes summing up answers to the three subscales (health behavior, affect, and materialism) after recoding negatively worded items. We examined the means of the three indexes (Welch's unequal variances *t*-test) as well as the internal consistency of the three indexes. For the latter, we calculated Cronbach's αs and compared pairs of coefficients using Feldt's test. For the 4 items that did not form a scale, we analyzed mean answers to them separately (Welch's unequal variances *t*-test). Peytchev and Hill (2010) found that the cognitive process of answering survey questions on a mobile device seems to be highly comparable to other survey modes (including PC Web), we do not expect to find significant differences in substantive responses to the questions across the groups of respondents. Table 1 summarizes the comparisons and hypotheses of our study.

To control for differential initial self-selection to the device, differential compliance to completing the main questionnaire on the requested device, and possible impact of scale features manipulated in the methodology experiment, we included as covariates in the multivariate models respondent age (as a continuous variable), gender (male vs. female), education (with college degree

Table 1. Key Contrasts and Hypotheses.

Variable	Effect of Unintentional Use of Mobile Phone: PC Rs Versus Unintentional iPhone Rs	Device Effect: PC Rs Versus Switchers	Self-Selection Effect: Switchers Versus Unintentional iPhone Rs
Response rates to main questionnaire	PC Rs = unintentional iPhone Rs	PC Rs > switchers	Switchers < unintentional iPhone Rs
Break-off rate for main questionnaire	PC Rs < unintentional iPhone Rs	PC Rs < switchers	Switchers = unintentional iPhone Rs
Response times	PC Rs < unintentional iPhone Rs	PC Rs < switchers	Switchers = unintentional iPhone Rs
Item missing	PC Rs < unintentional iPhone Rs	PC Rs < switchers	Switchers = unintentional iPhone Rs
Satisficing	PC Rs = unintentional iPhone Rs	PC Rs = switchers	Switchers = unintentional iPhone Rs
Substantive answers	PC Rs = unintentional iPhone Rs	PC Rs = switchers	Switchers = unintentional iPhone Rs

Note. Rs = respondents.

vs. without college degree), ethnicity (Hispanic vs. non-Hispanic), race (White vs. non-White), Web survey experience (participated in more than 10 Web surveys in past 30 days vs. participated in 10 or fewer Web surveys in past 10 days), scale direction (low to high vs. high to low), and scale alignment (horizontal, vertical, and drop-down box). We used linear regression models for continuous dependent variables (such as response times and survey responses to individual items and indexes), logistic regression models for binary dependent variables (such as item nonresponders and straightliners), and negative binomial regression models for count dependent variables (such as the number of acquiescent answers and the number of midpoint responses).

We analyzed the data using `R` version 3.3.1 (R Core Team, 2016). For Welch's *t*-tests, linear regression, and logistic regression, we used the `t.test`, `lm`, and `glm` function, respectively, in the `stats` package of `R`. For χ^2 tests with Yate's correction for unequal sample sizes, we used the `CrossTab` function in the `gmodels` package (Warnes, 2013). For negative binomial regression, we used the `gml.nb` function in the `MASS` package (Venables & Ripley, 2002). Cronbach's αs were calculated and compared using the `cronbach.alpha` and `cocron.two.coefficients` functions in the `cocron` package (Diedenhof, 2013).

Results

Response Rates to Main Questionnaire and Break-Offs During Main Questionnaire

About 50% of switchers did not respond to the main questionnaire due to failure to switch from the PC (or a non-iPhone mobile device) to an iPhone. As hypothesized, 100% of PC respondents and the unintentional iPhone respondents—who did not need to switch to a different device—responded to the main questionnaire after completing the screener.

As shown in Table 2, conditional on starting the main questionnaire, the break-off rate is significantly lower for PC respondents (2.6%) than for unintentional iPhone respondents (7.3%). Switchers have a break-off rate of 3.0%. Contrary to our expectation, this is not significantly different from the break-off rate of PC respondents ($p > .05$). Although more than twice as high, the break-off rate for unintentional iPhone respondents is not significantly different from the break-off rate of switchers (3.0%; $p > .05$).

Table 2. Break-Off Rate, Response Time, and Missing Items Rate by Unintentional iPhone Use, Device, and Self-Selection.

		A	B	C
Variable	Overall (n = 1,186)	PC Rs (n = 631)	Unintentional iPhone Rs (n = 101)	Switchers (n = 454)
Break-off rate	3.2%	2.6%	7.3%	3.0%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 5.11$, $df = 1$, $p = .024$		
Device effect: A versus C		$\chi^2 = 0.03$, $df = 1$, $p > .05$		
Self-selection effect: B versus C			$\chi^2 = 3.45$, $df = 1$, $p > .05$	
Response time	2 min 43 s	2 min 27 s	3 min 5 s	3 min 0 s
Effect of unintentional iPhone use: A versus B		$t = -5.11$, $df = 128.1$, $p < .001$		
Device effect: A versus C		$t = -8.73$, $df = 1{,}025.9$, $p < .001$		
Self-selection effect: B versus C			$t = -.66$, $df = 129.5$, $p > .05$	
At least 1 missing item	4.5%	3.6%	9.9%	7.0%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 6.53$, $df = 1$, $p = .011$		
Device effect: A versus C		$\chi^2 = 5.67$, $df = 1$, $p = .017$		
Self-selection effect: B versus C			$\chi^2 = 0.59$, $df = 1$, $p > .05$	

Note. Bold indicates variables with significant differences ($p < .05$). To compensate for unequal sample sizes, χ^2 tests with Yate's correction and Welch's unequal variances t-test are used. Rs = respondents; df = degree of freedom.

Sample Composition

Table 3 examines respondents' sociodemographic characteristics and their experience with Web surveys. PC respondents consisted of significantly more males, more respondents without a college degree, and more respondents who reported to have participated in more than 10 Web surveys in the past 30 days than switchers at the $p = .05$ level. The differences go in the same direction for the comparison between PC respondents and unintentional iPhone respondents but fail to reach statistical significance due to the relatively small sample size of the latter group. Interestingly, unintentional iPhone respondents are made up of significantly fewer White respondents (73.0%) compared to both PC respondents (82.4%) and switchers (83.0%).

Response Times and Item Nonresponse

Table 2 shows that, consistent with our hypothesis, PC respondents were significantly faster in completing the main questionnaire (2 min 27 s) than unintentional iPhone respondents (3 min 5 s) and switchers (3 min 0 s). All differences remain statistically significant after controlling for sociodemographics, Web survey experience, and scale feature manipulations in a linear regression model ($p < .05$; details available upon request). We further found that differences between PC respondents and switchers in response times are conditional on scale alignment. Specifically, switchers are slower than PC respondents when scales are presented vertically or as a drop-down box, but significantly faster than PC respondents when scales are presented horizontally. As expected, switchers and unintentional iPhone respondents did not significantly differ in response times ($p > .05$).

With regard to item nonresponse, 3.6% of PC respondents had at least 1 item missing in the main questionnaire. As hypothesized, this is significantly fewer than the unintentional iPhone respondents (9.9%) and the switchers (7.0%). The comparisons hold when controlling for sociodemographics,

Table 3. Sociodemographics and Web Survey Experience by Unintentional iPhone Use, Device, and Self-Selection.

		A	B	C
Variable	Overall ($n = 1,186$)	PC Rs ($n = 631$)	Unintentional iPhone Rs ($n = 101$)	Switchers ($n = 454$)
Age	29.9 years	29.9 years	30.1 years	29.8 years
Effect of unintentional iPhone use: A versus B		$t = .24$, $df = 141.6$, $p > .05$		
Device effect: A versus C		$t = -.10$, $df = 957.9$, $p > .05$		
Self-selection effect: B versus C			$t = .29$, $df = 162.4$, $p > .05$	
Male	57.3%	60.7%	54.0%	53.2%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 1.34$, $df = 1$, $p > .05$		
Device: A versus C		$\chi^2 = 5.73$, $df = 1$, $p = .017$		
Self-selection effect: B versus C			$\chi^2 = 0.01$, $df = 1$, $p > .05$	
with college degree	59.7%	56.1%	63.4%	63.8%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 1.59$, $df = 1$, $p > .05$		
Device effect: A versus C		$\chi^2 = 6.18$, $df = 1$, $p = .013$		
Self-selection effect: B versus C			$\chi^2 = 0.01$, $df = 1$, $p > .05$	
Hispanic	8.7%	8.1%	8.9%	9.4%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 0.01$, $df = 1$, $p > .05$		
Device effect: A versus C		$\chi^2 = 0.38$, $df = 1$, $p > .05$		
Self-selection effect: B versus C			$\chi^2 = 0.01$, $df = 1$, $p > .05$	
White	81.8%	82.4%	73.0%	83.0%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 4.36$, $df = 1$, $p = .037$		
Device effect: A versus C		$\chi^2 = 0.04$, $df = 1$, $p > .05$		
Self-selection effect: B versus C			$\chi^2 = 4.76$, $df = 1$, $p = .029$	
>10 Web surveys in past 30 days	59.0%	62.8%	59.4%	53.6%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 0.29$, $df = 1$, $p > .05$		
Device effect: A versus C		$\chi^2 = 8.75$, $df = 1$, $p = .003$		
Self-selection effect: B versus C			$\chi^2 = 0.89$, $df = 1$, $p > .05$	

Note. Bold indicates variables with significant differences ($p < .05$). To compensate for unequal sample sizes, χ^2 tests with Yate's correction and Welch's unequal variances *t*-test are used. Rs = respondents; *df* = degree of freedom.

Web survey experience, and scale features manipulation in a logistic regression model ($p < .05$; details available upon request). Scale alignment again interacts with whether respondents are in the PC group or in the switcher group; more switchers than PC respondents provided missing data to at least 1 survey item when the scales are presented vertically or as a drop-down box, but not when the scales are presented horizontally. Switchers and unintentional iPhone respondents did not significantly differ in the prevalence of people with at least 1 missing item ($p > .05$).

Straightlining, Acquiescence, and Midpoint Responding

As Table 4 shows, more PC respondents (4.5%) straightlined in at least 1 of the item batteries than unintentional iPhone respondents (2.0%) and switchers (2.0%). The difference between PC respondents and switchers are statistically significant at the $p < .05$ level, but not the difference between PC respondents and unintentional iPhone respondents due to the relatively small sample size in the latter group. As expected, the prevalence of straightlining does not significantly differ between switchers and unintentional iPhone respondents ($p > .05$). Results from logistic regression models after

Table 4. Satisficing Indicators by Unintentional iPhone Use, Device, and Self-Selection.

Variable	Overall ($n = 1{,}186$)	A PC Rs ($n = 631$)	B Unintentional iPhone Rs ($n = 101$)	C Switchers ($n = 454$)
Straigthliners	3.3%	4.5%	2.0%	2.0%
Effect of unintentional iPhone use: A versus B		$\chi^2 = 0.77$, $df = 1$, $p > .05$		
Device effect: A versus C			$\chi^2 = 4.04$, $df = 1$, $p = .044$	
Self-selection effect: B versus C				$\chi^2 = 0.01$, $df = 1$, $p > .05$
Acquiescence	1.5	1.4	1.4	1.5
Effect of unintentional iPhone use: A versus B		$t = .13$, $df = 142.1$, $p > .05$		
Device effect: A versus C			$t = -1.19$, $df = 966.5$, $p > .05$	
Self-selection effect: B versus C				$t = .85$, $df = 161.3$, $p > .05$
Midpoint responding	5.0	5.1	4.8	5.0
Effect of unintentional iPhone use: A versus B		$t = -.20$, $df = 139.4$, $p > .05$		
Device effect: A versus C			$t = .79$, $df = 1{,}048$, $p > .05$	
Self-selection effect: B versus C				$t = .82$, $df = 140.5$, $p > .05$

Note. Bold indicates variables with significant differences ($p < .05$). To compensate for unequal sample sizes, χ^2 tests with Yate's correction and Welch's unequal variances t-test are used. Rs = respondents; df = degree of freedom.

controlling for sociodemographics, Web survey experience, and scale feature manipulations confirm results of the bivariate analysis (details available upon request).

As hypothesized, acquiescence and midpoint responding were not significantly different across the three groups ($p > .05$), even after controlling for sociodemographics, Web survey experience, and scale features manipulations in binomial logistic regression models (details available upon request). We further found that the differences between PC respondents and switchers on midpoint responding are dependent on scale alignment; PC respondents show more midpoint responding than switchers when scales are fully displayed (either horizontally or vertically; $p < .05$), but not when scales are shown as a drop-down box ($p > .05$).

Survey Answers

Table 5 shows that the mean ratings of the 4 individual items and the means of the three indexes do not differ significantly across the three comparisons (t-tests; $p > .05$). Results hold after controlling for sociodemographics, Web survey experience, and scale feature manipulations in linear regression models (details available upon request). We also found one interaction effect; unintentional mobile respondents scored significantly lower on the affect index than both switchers and PC respondents when scales are presented vertically ($p < .05$). The affect index scores do not differ across the three groups if the response options were presented horizontally or as a drop-down box.

In terms of internal consistency of the three indices, two indices (healthy behavior and materialism) did not show significant differences across groups in comparisons of their Cronbach's α values (Feldt's test; $p > .05$). As shown in Table 6, the affect items show significantly higher internal consistency for PC respondents (Cronbach's $\alpha = .855$) than for switchers (.807).

Discussion

In this study, we examined differences between regular Web respondents who accessed and completed a Web survey on PCs and mobile Web respondents who accessed and completed the Web

Table 5. Mean Ratings of Individual Items and Three Indexes by Unintentional iPhone Use, Device, and Self-Selection.

Variable	Overall ($n = 1{,}186$)	PC Rs ($n = 631$)	Unintentional iPhone Rs ($n = 101$)	Switchers ($n = 454$)
Individual items				
Q1	3.4	3.4	3.4	3.5
Q2	3.5	3.5	3.6	3.5
Q7	2.5	2.6	2.4	2.5
Q8	3.6	3.6	3.5	3.6
Indexes				
Health behaviors (Q3–Q6)	13.1	13.1	13.1	13.3
Affect (Q9–Q14)	22.6	22.5	22.8	22.7
Materialism (Q15–Q21)	23.1	23.2	22.9	23.0

Note. Bold indicates variables with significant differences ($p < .05$). To compensate for unequal sample sizes, Welch's unequal variances t-test is used. Rs = respondents.

Table 6. Cronbach's α by Unintentional iPhone Use, Device, and Self-Selection.

		A	B	C
Variable	Overall ($n = 1{,}186$)	PC Rs ($n = 631$)	Unintentional iPhone Rs ($n = 101$)	Switchers ($n = 454$)
Health behaviors (Q3–Q6)	.626	.631	.673	.612
Effect of unintentional iPhone use: A versus B		Feldt = 1.13, $df_1 = 630$, $df_2 = 100$, $p > .05$		
Device effect: A versus C		Feldt = 1.05, $df_1 = 630$, $df_2 = 453$, $p > .05$		
Self-selection effect: B versus C			Feldt = 1.13, $df_1 = 100$, $df_2 = 453$, $p > .05$	
Affect (Q9–Q14)	.836	.855	.838	.807
Effect of unintentional iPhone use: A versus B		Feldt = 1.12, $df_1 = 630$, $df_2 = 100$, $p > .05$		
Device effect: A versus C		Feldt = 1.33, $df_1 = 630$, $df_2 = 453$, $p = .001$		
Self-selection effect: B versus C			Feldt = 1.19, $df_1 = 100$, $df_2 = 453$, $p > .05$	
Materialism (Q15–Q21)	.776	.781	.762	.772
Effect of unintentional iPhone use: A versus B		Feldt = 1.09, $df_1 = 630$, $df_2 = 100$, $p > .05$		
Device effect: A versus C		Feldt = 1.04, $df_1 = 630$, $df_2 = 453$, $p > .05$		
Self-selection effect: B versus C			Feldt = 1.04, $df_1 = 100$, $df_2 = 453$, $p > .05$	

Note. Bold indicates variables with significant differences ($p < .05$) between pairs of Cronbach's α coefficients based on Feldt's test. Rs = respondents; df = degree of freedom.

survey on a mobile device (PC respondents vs. unintentional iPhone respondents), differences attributable to device (PC respondents vs. switchers), and differences attributable to self-selection (into iPhone; unintentional iPhone respondents vs. switchers). As anticipated, asking respondents to switch from a PC to a smartphone midway through the survey leads to a reduction of sample size by about half. This finding is comparable to studies on mode switching in self-administered surveys, such as from computer-assisted telephone interviewing to interactive voice response (Couper, Singer, & Tourangeau, 2004; Tourangeau, Miller Steiger, & Wilson, 2002) or from paper to Web (Bech & Kristensen, 2009; Millar & Dillman, 2012), demonstrating once again that mode switching is undesirable. Together with previous research (e.g., de Bruijne & Wijnant, 2013; Mavletova, 2013), our finding once more emphasizes that researchers should avoid asking respondents to use a smartphone if the invitation to the survey is delivered and opened on a different device (e.g., on a PC or tablet). If the research design requires respondents to access the survey on a smartphone only, respondents should ideally be contacted on the smartphone, for example, via text messaging (see de Bruijne and Wijnant (2014), Mavletova (2013), and Mavletova and Couper (2014) for the use of text message invitations to mobile Web surveys).

In line with findings from earlier research, we found a significant difference in break-off rates by the device used to start the survey. Unintentional iPhone respondents who came into the study on a smartphone were almost 3 times as likely to break off the survey as PC respondents. More than twice as many unintentional iPhone respondents broke off the main questionnaire as switchers. Although this difference is currently not significant, it would be with a larger sample size of unintentional iPhone respondents, and thus more statistical power. By contrast, switchers who were prompted to switch from PC to iPhone were not more likely to break off the survey than PC respondents, conditional on successful mode switch. A possible explanation is that half of the switchers quit the study when they were asked to switch from a PC to their iPhone. It is, therefore, safe to assume that only highly committed, mobile-willing respondents chose to comply with the mode switching request, reducing the propensity for break-off at a later point in the study. This finding is promising for studies where respondents are recruited to, for example, use their smartphones to regularly report behaviors or personal states or to answer a series of shorter questionnaires over several days. Once a respondent commits to the initial step, break-off at later points seems to be very low.

Our survey was relatively short, consisting of 21 items only. Respondents took, on average, 2.5 min to complete the main questionnaire on a PC and 3 min on an iPhone. In combination with our findings on the break-off rates, we take it to suggest that it is feasible for researchers to leverage mobile devices for survey data collection with very short questionnaires. We see the potential of breaking up one long questionnaire into multiple mini questionnaires for respondents to answer over the course of a couple of days or weeks; respondents are shown to find this type of mini questionnaires as more interesting (West, Ghimire, & Axinn, 2015). If our finding still holds, the mini questionnaires could lead to fewer break-offs than one single long questionnaire condition when used on a smartphone.

In terms of sociodemographic composition, we found significant differences in gender, education, and Web survey experience between PC respondents and iPhone respondents regardless of whether they are unintentional iPhone respondents or switchers. We also found fewer Whites in the unintentional iPhone respondents group than among PC respondents, confirming that minority groups are relying more on smartphones for access to the Internet (Pew Research Center, 2015d). We take this piece of finding to indicate that it is feasible to reach subpopulations for Web surveys who exclusively rely on mobile devices for Internet access and who are traditionally underrepresented in Web surveys limited to PCs or laptops both via respondent- and researcher-driven use of smartphones for survey data collection.

In terms of data quality, we found that iPhone respondents—again both switchers and unintentional iPhone respondents—were significantly more likely to have missing data and were less likely to straightline compared to PC respondents. In addition, substantive responses to questions on different topics as well as measures of acquiescence and midpoint responding did not differ by the device with which respondents started the survey nor by the device with which respondents eventually completed the survey, again consistent with existing literature. These findings confirm that mobile Web surveys are not inferior to Web surveys completed on PCs in terms of measurement error. This is good news to researchers who intend to collect data via smartphones. However, nonresponse issues (including response rates, break-off rates, item nonresponse rates, and sample compositions) need to be considered when collecting survey data via smartphones.

Interestingly, there are little differences in nonresponse and measurement between switchers and unintentional iPhone respondents. Sample composition and data quality are highly comparable between the two groups, consistent with the findings in Lugtig and Toepoel (2016) who showed that device switching has no effect on measurement.

We also found that some of the differences between PC respondent and switchers are conditional on scale alignment. Switchers are faster, are less likely to provide missing data, and show less midpoint responding than PC respondents when scales are presented horizontally. We take the finding to indicate that a full display of a scale without the need for scrolling is desirable for surveys intended to be completed on devices with a small screen size.

Of course, our study is not free from limitations. First, we recruited, for our study, from MTurk workers. MTurk workers are highly motivated to perform well in order to receive a promised incentive (Berinsky et al., 2012). In addition, MTurk workers can actively search for HITs of interest to them. As a result, they might be more motivated than respondents used in other studies. High motivation to finish the task might be, together with the short questionnaire, another explanation for the relatively low break-off rates we found in our study. MTurk workers are also younger, better educated, and less racially diverse than the general population (Pew Research Center, 2016). While this limits the generalizability of our findings to the general population, we used an experimental approach with random assignment to groups and statistically controlled for potential bias through self-selection and noncompliance in our analysis. In addition, Mullinix, Leeper, Druckman, and Freese (2015) compared the results of experimental studies conducted in a probability-based online panel to those conducted on several convenience samples (MTurk is one of the convenience sample examined); they found that results from the convenience samples generally provide estimates of causal effects comparable to those found on the population-based samples. Thus, we expect our findings to be comparable and robust if another sample was recruited. Of course, we recommend future research to replicate our study using samples from a general population to increase the external validity of our findings.

Second, the substantial switch failure limits the comparison between switchers and PC respondents and between switchers and unintentional iPhone respondents. The noncompliance to switch led to a reduction in sample size (and also in statistical power) and possibly a biased sample. Since sociodemographic information is collected at the end of the main questionnaire (after the device switch), we could not examine the characteristics of respondents who failed to switch to an iPhone. We could not separate the effects of device from noncompliance to device switch entirely. To account for possible bias due to differential noncompliance to switch, we controlled for demographic characteristics and Web survey experience in our analyses, and the results of the multivariate analyses confirm the findings of all bivariate analyses.

Third, our respondents are highly experienced with Web surveys; almost 60% of them reported to have participated in 10 or more Web surveys over the last 30 days. This makes our study population highly comparable to nonprobability online panels, where members are used to receiving many survey invitations and multiple panel membership is quite common (Keusch, Batinic, & Mayerhofer, 2014). In general, experimental research on the effects of mobile device use is very much limited to nonprobability online panels—with the exception of Antoun (2015) and de Bruijne and Wijnat (2013).

Lastly, due to the technical setup of our experiment, the switchers group includes both respondents who came into the study on a non-iPhone mobile device (and were then asked to switch to an iPhone) and respondents who came into the study on a PC and were assigned to switch to an iPhone. Unfortunately, among switchers, we cannot identify who switched from a PC and who switched from a non-iPhone mobile device. As a result, we cannot establish through our study whether respondents who came on a non-iPhone device behaved similarly to or differently from those who came on a PC. Lugtig and Toepoel (2016) demonstrated that measurement error is higher with a tablet and that device switch from PCs to tablets (and vice versa) does not lead to significant changes in measurement error. Future research should look into the characteristics of people who choose to start a survey on a tablet.

Appendix A

MTurk HIT

Short HIT:

iPhone users invited to complete short survey on iPhone or PC/MAC.

Long HIT:

iPhone users invited to complete short survey on iPhone or PC/MAC.

Researchers at the University of Michigan are conducting an academic survey about life and well-being. To take part in this survey, you must be 18 years or older, be a resident of the United States, and must have an iPhone. If you do not meet these qualifications, we will be unable to accept your HIT. By clicking on the link below, you will be transferred to a questionnaire that first collects some demographic information and then randomly assigns you to one of two groups. You will be asked to fill out the questionnaire either on your PC/Mac or on your iPhone using its native web browser Safari. All respondents are required to use the device assigned to them; if you do not use the assigned device, we will be unable to accept your HIT. This study will take no longer than 5 minutes to complete. At the end of the questionnaire, you will be given a code that you must enter in this HIT.

Do not close this page after clicking on the survey link.

Survey link: XXX

Please enter the code provided at the end of the questionnaire into the box below to receive credit for participating in our study.

Appendix B

Question Wording

INTRO SCREENER

Thanks for your interest in our HIT. To make sure that you are eligible for this HIT, we have to ask you a couple of short questions first.

S1: Do you have an iPhone?
Yes
No
S2: What device are you using right now?
PC/Mac/Laptop
Tablet (e.g., iPad, Samsung Galaxy Note, Kindle)
iPhone/other Smartphone
RANDOMIZATION VARIABLE: DEVICE

1. NO SWITCH PC
2. SWITCH TO IPHONE

FOR "PC RESPONDENTS" GROUP: START QUESTIONNAIRE

FOR SWITCHERS GROUP: Please type the following link into your iPhone web browser or scan the QR code below to access the survey. You have to use your iPhone to fill out the questionnaire; otherwise we will not be able to accept your HIT.

FOR BOTH GROUPS: CHECK ON DEVICE—META INFO Q

IF "PC RESPONDENTS" CONDITION AND DEVICE USED IS NOT PC AND NOT IPHONE, DISPLAY: Our system shows that you are not using your PC/Mac/Laptop to access this survey. You have to use your PC/Mac/Laptop to fill out the questionnaire; otherwise we will not be able to accept your HIT. Please type the following link into your PC/Mac/Laptop web browser to access the survey.

IF SWITCHERS CONDITION AND DEVICE USED IS NOT IPHONE, DISPLAY: Our system shows that you are not using your iPhone to access this survey. You have to use your iPhone to fill out the questionnaire; otherwise we will not be able to accept your HIT. Please type the following link into your iPhone web browser or scan the QR code below to access the survey.

INTRO MAIN QUESTIONNAIRE

You are eligible for participate in our short survey on life and well-being. Please click the next button to continue. At the end of the questionnaire, a code will be generated for you to enter in the code box in MTURK to receive your payment.

Q1: First, please think about your life-as-a-whole. How satisfied are you with it?
Completely satisfied—Very satisfied—Somewhat satisfied—Not very satisfied—Not satisfied at all
Q2: In general, would you say your health is . . . ?
Excellent—Very good—Good—Fair—Poor
Q3: Now we are going to ask you some questions about feelings about your life during an average week.
During an average week, how often do you eat foods that are high in fat and/or calories?
All of the time—Most of the time—Some of the time—A little of the time—Never
Q4: During an average week, how often do you eat fast food?
All of the time—Most of the time—Some of the time—A little of the time—Never
Q5: During an average week, how often do you eat a variety of fresh fruits and vegetables?
All of the time—Most of the time—Some of the time—A little of the time—Never
Q6: During an average week, how often do you do physical exercise?
All of the time—Most of the time—Some of the time—A little of the time—Never
Q7: During an average week, how much attention do you pay to news about national politics on TV?
A great deal—A lot—A moderate amount—A little—None at all
Q8: Now thinking only about yesterday, how did you feel?
1 Up—2—3—4—5 Down
Q9: Thinking about yesterday, how calm did you feel?
Very—Quite a bit—Somewhat—A little—Not at all
Q10: Thinking about yesterday, how happy did you feel?
Very—Quite a bit—Somewhat—A little—Not at all
Q11: Thinking about yesterday, how frustrated did you feel?
Very—Quite a bit—Somewhat—A little—Not at all
Q12: Thinking about yesterday, how sad did you feel?
Very—Quite a bit—Somewhat—A little—Not at all
Q13: Thinking about yesterday, how competent did you feel?
Very—Quite a bit—Somewhat—A little—Not at all
Q14: Thinking about yesterday, how nervous did you feel?

Very—Quite a bit—Somewhat—A little—Not at all
Q15: Next are several statements. Please indicate to what extent you agree or disagree with each of them . . . .
It is important to me to have really nice things.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
Q16: I would like to be rich enough to buy anything I want.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
Q17: I'd be happier if I could afford to buy more things.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
Q18: It sometimes bothers me quite a bit that I can't afford to buy all the things I would like.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
Q19: People place too much emphasis on material things.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
Q20: It's really true that money can buy happiness.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
Q21: The things I own give me a great deal of pleasure.
Strongly agree—Somewhat agree—Neither agree nor disagree—Somewhat disagree—Strongly disagree
D1: For classification purpose, please tell us in what year you were born:

____

D2: Are you male or female?
Male—Female
D3: Do you have a college degree?
Yes—No
D4: Are you Hispanic or Latino?
Yes—No
D5: Are you . . . .
White or Caucasian—Black or African American—American Indian or Alaska Native—Asian or Pacific Islander—Other
D6: How many web surveys have you completed in the past 30 days?
None—1–5 surveys—6–10 surveys—More than 10 surveys

That is all we have. Thank you very much for your time. Please remember to write down this code below and enter the code in MTURK to receive your payment!

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Notes

1. We restricted participation in our study to iPhone users to eliminate any potential confounding due to differences in display and use of other mobile operating systems (e.g., Android, Windows Mobile). In addition, we used the Web survey software Qualtrics Research Suite that automatically detected the use of iPhones through the user agent string.
2. We expected substantial dropout during the device switch and, thus, oversampled participants to the "switchers" group by a ratio of 4 to 3.

References

Andreadis, I. (2015). Comparison of response times between desktop and smartphone users. In D. Toninelli, R. Pinter, & P. de Pedraza (Eds.), *Mobile research methods: Opportunities and challenges of mobile research methodologies* (pp. 63–79). London, England: Ubiquity Press.

Antoun, C. (2015). *Mobile web surveys: A first look at measurement, nonresponse, and coverage errors*. Dissertation at the University of Michigan, Ann Arbor, MI.

Antoun, C., Zhang, C., Conrad, F. G., & Schober, M. F. (2016). Comparisons of online recruitment strategies for convenience samples: Craigslist, Google AdWords, Facebook and Amazon Mechanical Turk. *Field Methods*, *28*, 231–246.

Arn, B., Klug, S., & Kołodziejski, J. (2015). Evaluation of an adapted design in a multi-device online panel: A DemoSCOPE case study. *Methods, Data, Analyses*, *9*, 185–212.

Bech, M., & Kristensen, M. B. (2009). Differential response rates in postal and web-based surveys in older respondents. *Survey Research Methods*, *3*, 1–6.

Berinsky, A. J., Huber, G. A., & Lenz, G. S. (2012). Evaluating online labor markets for experimental research: Amazon.com's Mechanical Turk. *Political Analysis*, *20*, 351–368.

Bradburn, N. (1977). Respondent burden. PHS Publication. Health Survey Research Methods: Research Proceedings from the 2nd Biennial Conference, No 79-3207, 49-53.

Buhrmester, M., Kwang, T., & Gosling, S. D. (2011). Amazon's Mechanical Turk: A new source of inexpensive, yet high-quality, data? *Perspectives on Psychological Science*, *6*, 3–5.

Buskirk, T. D., & Andrus, C. (2012). Smart surveys for smart phones: Exploring various approaches for conducting online mobile surveys via smartphones. *Survey Practice*, *5*. Retrieved September 26, 2016, from http://surveypractice.org/index.php/SurveyPractice/article/download/63/pdf

Buskirk, T. D., & Andrus, C. (2014). Making mobile browser surveys smarter: Results from a randomized experiment comparing online surveys completed via computer or smartphone. *Field Methods*, *26*, 322–342.

Callegaro, M. (2010). Do you know which device your respondent has used to take your online survey? *Survey Practice*, *3*. Retrieved September 26, 2016, from http://www.surveypractice.org/index.php/SurveyPractice/article/view/250/html

Couper, M. P., & Peterson, G. (2016). Why do web surveys take longer on smartphones? *Social Science Computer Review*. Published online before print February 11, 2016. doi:10.1177/0894439316629932

Couper, M. P., Singer, E., & Tourangeau, R. (2004). Does voice matter? An interactive voice response (IVR) experiment. *Journal of Official Statistics*, *20*, 551–570.

de Bruijne, M., & Wijnat, A. (2013). Comparing survey results obtained via mobile devices and computers: An experiment with a mobile web survey on a heterogeneous group of mobile devices versus a computer-assisted web survey. *Social Science Computer Review*, *31*, 482–504.

de Bruijne, M., & Wijnat, A. (2014). Mobile response in web panels. *Social Science Computer Review*, *32*, 728–742.

Diedenhofen, B. (2013). *Cocron: Statistical comparisons of two or more alpha coefficients* (R Package Version 1.0-0). Retrieved September 26, 2016, from http://r.birkdiedenhofen.de/pckg/cocron/

European Commission. (2014). *Special Eurobarometer 414. e-Communications and Telecom Single Market Household Survey*. Retrieved September 26, 2016, from http://ec.europa.eu/public_opinion/archives/ebs/ebs_414_en.pdf

Fuchs, M. (2008). Mobile web surveys: A preliminary discussion of methodological implications. In F. G. Conrad & M. F. Schober (Eds.), *Envisioning the survey interview of the future* (pp. 77–94). New York, NY: John Wiley.

Keusch, F., Batinic, B., & Mayerhofer, W. (2014). Motives for joining nonprobability online panels and their association with survey participation behavior. In M. Callegaro, R. Baker, J. Bethlehem, A. S. Göritz, J. A. Krosnick, & P. J. Lavrakas (Eds.), *Online panel research: A data quality perspective* (pp. 171–191). Chichester, England: Wiley.

Kinesis. (2013). *Online survey statistics from the mobile future*. Retrieved September 26, 2016, from http://www.kinesissurvey.com/wp-content/uploads/2014/05/UPDATED-with-Q3-2013-Data-Mobile-whitepaper.pdf

Link, M. W., Lai, J., & Bristol, K. (2014). Not so fun? The challenges of applying gamification to smartphone measurement. In A. Marcus (Ed.), *Design, user experience, and usability. User experience design practice* (pp. 319–327). Cham, Switzerland: Springer.

Lugtig, P., & Toepoel, V. (2016). The use of PCs, smartphones, and tablets in a probability-based panel survey: Effects on survey measurement error. *Social Science Computer Review*, *34*, 78–95.

Mavletova, A. (2013). Data quality in PC and mobile web surveys. *Social Science Computer Review*, *31*, 725–743.

Mavletova, A., & Couper, M. P. (2013). Sensitive topics in PC web and mobile web surveys: Is there a difference? *Survey Research Methods*, *7*, 191–205.

Mavletova, A., & Couper, M. P. (2014). Mobile web survey design: Scrolling versus paging, SMS versus e-mail invitations. *Journal of Survey Statistics and Methodology*, *2*, 498–518.

Mavletova, A., & Couper, M. P. (2016). Grouping of items in mobile web questionnaires. *Field Methods*, *28*, 170–193.

Maxl, E. (2009). Mobile market research: Analysis through the mobile phone. In E. Maxl, N. Doering, & A. Wallisch (Eds.), *Mobile market research* (pp. 11–39). Cologne, Germany: Herbert von Halem.

Metzler, A., & Fuchs, M. (2014). *Coverage error in mobile web surveys across European countries*. Paper presented at 7th Internet Survey Methodology Workshop, December 1–3, 2014, Bozen-Bolzano, Italy.

Millar, M. M., & Dillman, D. A. (2012). Improving response to web and mixed-mode surveys. *Public Opinion Quarterly*, *75*, 249–269.

Mullinix, K. J., Leeper, T. J., Druckman, J. N., & Freese, J. (2015). The generalizability of survey experiments. *Journal of Experimental Political Science*, *2*, 109–138.

Okazaki, S. (2007). Assessing mobile-based online surveys: Methodological considerations and pilot study in an advertising context. *International Journal of Market Research*, *49*, 651–675.

Peterson, G. (2012). What we can learn from unintentional mobile respondents. *CASRO Journal*, *2012-2013*, 32–35.

Pew Research Center. (2015a). *Technology device ownership: 2015*. Retrieved September 26, 2016, from http://www.pewinternet.org/files/2015/10/PI_2015-10-29_device-ownership_FINAL.pdf

Pew Research Center. (2015b). *App vs. web for surveys of smartphone users*. Retrieved September 26, 2016, from http://www.pewresearch.org/files/2015/03/2015-04-01_smartphones-METHODS_final-3-27-2015.pdf

Pew Research Center. (2015c). *Tips for creating web surveys for completion on a mobile device*. Retrieved September 26, 2016, from http://www.pewresearch.org/files/2015/06/2015-06-11_tips-for-web-surveys-on-mobile.pdf

Pew Research Center. (2015d). *U.S. smartphone use in 2015*. Retrieved September 26, 2016, from http://www.pewinternet.org/files/2015/03/PI_Smartphones_0401151.pdf

Pew Research Center. (2016). *Research in the crowdsourcing age, a case study*. Retrieved September 26, 2016, from http://www.pewinternet.org/2016/07/11/research-in-the-crowdsourcing-age-a-case-study/

Peytchev, A., & Hill, C. A. (2010). Experiments in mobile web survey design. Similarities to other modes and unique considerations. *Social Science Computer Review*, *28*, 319–335.

R Core Team. (2016). *A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. Retrieved September 26, 2016, from http://www.R-project.org

Revilla, M., Ochoa, C., & Loewe, G. (2016). Using passive data from a meter to complement survey data in order to study online behavior. *Social Science Computer Review*. Published online before print March 17, 2016. doi:10.1177/0894439316638457

Revilla, M., Toninelli, D., Ochoa, C., & Loewe, G. (2015). Who has access to mobile devices in an online opt-in panel? An analysis of potential respondents for mobile surveys. In D. Toninelli, R. Pinter, & P. de Pedraza (Eds.), *Mobile research methods: Opportunities and challenges of mobile research methodologies* (pp. 119–139). London, England: Ubiquity Press.

Richins, M. L. (1987). Media, materialism, and happiness. *Advances in Consumer Research*, *14*, 352–356.

Sommer, J., Diedenhofen, B., & Musch, J. (2016). Not to be considered harmful: Mobile-device users do not spoil data quality in web surveys. *Social Science Computer Review*. Published online before print February 25, 2016, doi:10.1177/0894439316633452

Sonck, N., & Fernee, H. (2013). *Using smartphones in survey research: A multifunctional tool. Implementation of a time use app: A feasibility study*. The Hague, Netherlands: The Netherlands Institute for Social Research.

Stapleton, C. E. (2013). The smartphone way to collect survey data. *Survey Practice*, *6*. Retrieved September 26, 2016, from http://www.surveypractice.org/index.php/SurveyPractice/article/view/75/html

Struminskaya, B., Weyandt, K., & Bosnjak, M. (2015). The effects of questionnaire completion using mobile devices on data quality. Evidence from a probability-based general population panel. *Methods, Data, Analyses*, *9*, 261–292.

Toepoel, V., & Lugtig, P. (2014). What happens if you offer a mobile option to your web panel? Evidence from a probability-based panel of Internet users. *Social Science Computer Review*, *32*, 544–560.

Tourangeau, R., Miller Steiger, D., & Wilson, D. (2002). Self-administered questions by telephone: Evaluating interactive voice response. *Public Opinion Quarterly*, *66*, 265–278.

Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with S* (4th ed.). New York, NY: Springer.

Warnes, G. R. (2013). *gmodels: Various R programming tools for model fitting* (R Package Version 2.15.4.1). Retrieved September 26, 2016, from http://CRAN.R-project.org/package=gmodels

Wells, T., Bailey, J. T., & Link, M. W. (2013). Filling the void: Gaining a better understanding of tablet-based surveys. *Survey Practice*, *6*. Retrieved September 26, 2016, from http://www.surveypractice.org/index.php/SurveyPractice/article/view/25/html

Wells, T., Bailey, J. T., & Link, M. W. (2014). Comparison of smartphone and online computer survey administration. *Social Science Computer Review*, *32*, 238–255.

West, B. T., Ghimire, D., & Axinn, W. G. (2015). Evaluating a modular design approach to collecting survey data using text messages. *Survey Research Methods*, *9*, 111–123.

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