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Traditional and mobile devices in computer assisted web-interviews

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Abstract

Transport studies constantly rely on surveys among travelers. Computer assisted web interview is the most popular survey mode. However, respondents complete online surveys nowadays using smartphones, tablets or traditional devices. We address three questions related to this development: how important are mobile respondents; how to deal with mobile respondents; and what is the effect of mobile response in a survey? In order to answer these questions, we used a series of information dense meta-analyses and state-of-the-art literature. Our results reveal that one out of every three respondents used a mobile device in 2016. The profile of mobile respondents adheres to the profiles of hard-to-reach candidates. Four design strategies for mixed-device surveys are identified and discussed. By taking an active approach to mixed-device surveys, multiple issues associated with mobile response can be overcome, i.e. differences in completion times and break-offs can be minimized. Mobile respondents appreciate redesigned surveys. Our results are in favor of facilitating mobile respondents with an adaptive or responsive web design in surveys.

Keywords: Computer assisted web-interviews; data quality; mobile friendly; smartphone; tablet

1. The rise of smartphone and tablet respondents in web-based surveys

Transport research, like many other social studies, relies heavily on the results of surveys among travelers or other groups of interest. This also explains the relevance and importance of the international steering committee for transport survey conferences (ISCTSC). Nowadays, most surveys are conducted online, using so-called computer assisted web-interviews (CAWI; Macer and Wilson, 2016). Recently, CAWI has become a mixed-device survey mode, with

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desktops, laptops, smartphones and tablets included (Toepoel and Lugtig, 2015). One of the first concerns among survey research scientists was unintended or unanticipated mobile response: respondents use smartphones to complete a survey, yet the survey itself is not designed for small sized touchscreens (Peterson, 2012). Buskirk and Andrus (2012) call this 'the passive approach' to the new reality of mixed-device web-surveys.

For a number of reasons, unanticipated mobile device use in surveys has raised concerns about data quantity and quality (De Bruijne, 2015; Peterson, 2012; Lugtig and Toepoel, 2013; Peytchev and Hill, 2010). A traditional survey might not fit on the smaller screens of mobile devices, which implies the need for scrolling, with options potentially being overlooked by respondents (Peytchev and Hill, 2010). A touchscreen keyboard as input modus has raised concerns about typing errors, as well as the respondents' willingness to provide lengthy answers to open questions or to select conditional open answers ('other, namely…'). The use of 2G and 3G networks raised concerns about completion times and costs for mobile device users.

In this paper we examine three interrelated issues with respect to mobile response in web-based surveys. Our research questions are: [1] What is the importance of mobile respondents? [2] How to deal with mobile response within a (not mobile-friendly) survey? [3] What are the mode-effects in mobile-friendly surveys? For the answers to our research questions, we relied on a series of meta-analyses: the results from other studies were strategically combined and modelled. We present models for mobile device use in surveys, variability in mobile device use, completion times, break-off rates, and many other aspects. Our findings are enriched with state-of-the-art literature.

Our research questions serve to structure this paper. In section 2 we address the question of the relative importance of mobile respondents in online surveys, which we did by looking at the share of mobile respondents in a large collection of surveys, the number of participants that used a mobile device at least once, and the profiles of mobile respondents. In section 3 we examine the various options for the treatment of mobile respondents in surveys, which includes an overview of design strategies for facilitating mobile response. In section 4 we assess the impact of mobile survey administration on data quantity and response burden; this assessment focuses on surveys that actively integrate and support mobile response, in contrast to the passive approach to mixed-device surveys. We discuss response rate, break-off, attrition, completion time, missing items, and the respondents' survey evaluation. Finally, in section 5, we present our main conclusions and recommendations for web-based surveys.

Before proceeding, it is necessary to first explain some key terms used in this paper. With mobile devices we mean smartphones and tablets in this paper. Other mobile devices, such as smartwatches and e-readers, are disregarded in this paper. Mobile respondents are respondents who use their smartphones or tablets to complete online questionnaires. In multiple instances we refer to traditional devices: this denotes desktop computers and laptop computers. The meaning of optimized for mobile completion or mobile-friendly survey design refers to those surveys that feature active support and integration of mobile devices (section 3.2).

2. Assessing the relevance of mobile respondents

To assess the relevance of mobile respondents in surveys, we examined three aspects. We estimated the share of mobile response in recent surveys; we examined mode change and wave-to-wave variability of panel studies; and we studied profiles of mobile respondents. The first two aspects reveal the quantified relative importance. The third aspect offers insights into the question of whether mobile respondents belong to a hard-to-reach subgroup.

2.1. Share of mobile respondents

Based on the observations in 183 samples, we estimated the average share of mobile respondents in recent years, from 2009 to mid-2016. In order to establish the share of mobile respondents, we used two beta regression models - one per mobile device. In our models we accounted for the rapid rise of mobile device use (month-by-month), the use of a survey panel, type of panel, mobile friendly designs, target groups and regional differences. Invitation mode (e.g. SMS, e-mail, postcard) might also affect the device choice (Millar and Dillman, 2012), though this could not be accounted for, due to a lack of information for our meta-dataset.

The month-by-month increase of mobile respondents was substantial and highly significant (Table 1). The share of mobile respondents was estimated at 1% in total in 2009. By 2016, this figure had reached 33%. Indeed, one out of every three survey participants was a mobile respondent. Tablet use is most common in North-West Europe (ref.).

Table 1. Estimates and standard errors for shares of smartphone and tablet respondents

	Smartphone (n=171)	Tablet (n=119)
Time: Months (t_0 = Jan-2013)	0.04 (0.00)**	0.04 (0.00)***
Panel: No panel	0.52 (0.07)*	0.03 (0.05)
Panel: Opt-in panel	0.33 (0.05)**	-0.12 (0.12)
Survey: Mobile friendly	0.26 (0.08)	-0.35 (0.13)
Region: Other Europe	0.30 (0.08)*	-0.12 (0.15)
Region: North-America	0.51 (0.04)***	0.18 (0.04)*
Region: Rest of the world	0.21 (0.20)	-0.71 (0.19)
Target group: Young	0.18 (0.15)	-1.13 (0.10)**
Intercept	-3.62 (0.07)***	-2.91 (0.07)**
Pseudo-Rho^2	0.62	0.65

Notes: significance levels * < 0.05, ** < 0.01, *** < 0.001 (same levels in rest of this paper);
Ref. level: probability-based panel, not mobile-friendly, NW Europe, general population as target group.

2.2. Device switching

Two relevant types of device switching occur in surveys: switching during completion of a single survey, and switching between waves of a longitudinal study. The number of respondents that switched during the completion of a single survey, and hence used multiple devices in one questionnaire, is rarely known. There are two interrelated reasons for this knowledge gap. Four studies that include data about device switching during completion affirmed low rates of switchers. Callegaro (2010) reported that 7% of the survey participants had switched from a mobile to a traditional device once they concluded that the survey was unsuited for mobile completion. In a research project involving ten experimental conditions, mobile respondents demonstrated an overall low likelihood of switching while completing the survey: the share of switchers ranged from 0.4% to 2.3% (n=2,181; McGeeney and Marlar, 2013). Hupp et al. (2014) found that 93 of 570 respondents switched from a smartphone to either a PC or tablet while completing a non-optimized survey. Horwitz (2014) reported that 8.5% of smartphone respondents and 3.7% of tablet respondents switched to a computer while completing the lengthy survey (>30 min.).

Table 2 combines the main findings from five analyses of switching between waves of longitudinal studies. In line with our previous findings, there was an observable increase in mobile device use in recent years. The share of respondents using mobile devices at least once was much higher than in single wave observations, which not only implies switching between waves. Traditional device users are most devoted to their device; they are very likely to also use a traditional device in a subsequent wave. This consistency is lower for tablet users, and much lower for smartphone users, which indicates a more erratic nature in mobile device usage.

Table 2: Device usage in longitudinal studies

			Mobile	Avg. share per wave		Usage at least once	
Source	Waves	Period	friendly	*Smartphone*	*Tablet*	*Smartphone*	*Tablet*
Poggio et al. (2015)	8	2011-12	No	2.0%	1.4%	8.3%	
Lugtig and Toepoel (2016)	6	2013	No	2.4%	7.9%	5.5%	13.4%
Struminskaya et al. (2015)	6	2014	Yes	8.8%	9.3%	19.3%	17.0%
Lugtig, Toepoel & Amin (2016)	7	2014	Yes	12.1%	8.8%	19.1%	13.6%
Zijlstra et al. (2017)	4	2013-16	Semi	10.2%	15.1%	16.0%	18.6%

2.3. Profile of mobile respondents

As we demonstrate in this subsection, the profiles of mobile respondents differ from the profiles of other respondents. Their absence will result in a biased sample. Additionally, for many surveys, mobile respondents could be of particular interest, as they are part of a hard-to-reach subgroup.

We examined the differences in characteristics in the findings of 13 studies conducted in North America and Europe (De Bruijne and Wijnand, 2014; Toepoel and Lugtig, 2015; Bosnjak et al. 2013; Dewes, 2014; Schmidt and Wenzel, 2013; Poduska and Johnson, 2010; Peterson, 2012; Merle et al., 2015; Lugtig et al., 2016; Richards et al. 2016; Lambert and Miller, 2015; Cook, 2014; Zijlstra et al., 2017). Most of these studies used a logistic regression model for identifying key differences, with either smartphone or tablet usage serving as the dependent variable. The independent variables varied greatly from study to study and could not be combined for a thorough meta-analysis.

The primary observation in this analysis was that younger participants were more likely to self-select a mobile device for survey administration (see also Table 1). All models included age or age classes, and in all models smartphone respondents were significantly younger. Regarding gender, the results slightly favored women. Three studies reported a significantly higher share of men among mobile respondents, and six studies reported a higher share of women, while the differences in the remaining studies were insignificant. Marriage is associated with increased mobile response. Bosnjak et al. (2013) observed that widows and divorced persons were less likely to use mobile devices, while Lugtig et al. (2016) reported a positive effect from being married. The degree of urbanization appeared to have no clear impact, as all studies that included this variable reported insignificant results, except for Zijlstra et al. (2017), who found lower mobile response rates in rural areas. The results were mixed regarding income levels and employment status, although tablet use in Europe does appear to be more prevalent among higher income groups and those in full-time employment. The effect of education levels was largely insignificant. The attitude towards 'smart' technologies or internet use generally was far more important predictor for mobile response than most socio-demographic or economic characteristics (De Bruijne, 2015; Barlas and Thomas, 2015; Zijlstra et al., 2017). The overrepresentation of the technology-minded, already observable in opt-in web-panels, is likely to be even more pronounced among mobile respondents.

3. Towards mixed-device surveys

3.1. Three strategies for coping with mobile response

Callegaro (2010) provides three options for dealing with mobile response: [1] flag mobile device respondents in order to control for them in statistical models or delete them all together, if necessary; [2], block mobile devices; and [3] design a survey that is fully compatible with any device. We discuss these options individually.

The option to *flag mobile respondents* and subsequently delete them will result in a significant loss of cases as well as a bias (see section 2). The option to flag them and account for mode-effects seems the better option, although this remains a suboptimal solution, as not all differences are known or easily controlled for.

The second option, *access control*, is a seeming attractive, simple and effective option; however, blocking mobile respondents will result in lower overall response rates and as well as a bias. Blocked respondents do not routinely make extra efforts to complete a survey with another device (Peterson, 2012; Millar and Dillman 2012; McClain et al. 2012). When participants are requested to switch devices, there is an observably strong reluctance to follow such instructions (Toepoel, 2016; Wells et al., 2014; Keusch and Yan, 2016); in Toepoel (2016), for example, 39% of all respondents failed to follow the experiment's instructions, even though they did have access to the specified device.

The option to support and integrate mobile respondents is generally regarded as the way forward (Wells, 2015; Kelly et al. 2012; Callegaro, 2010; Weber et al., 2008). As Wells (2015, p. 529) states in his thorough review of this topic: "Mobile respondents should not be blocked, screened out or disqualified from surveys, or redirected to a PC. They should be accommodated and surveys should be optimized for mobile devices." This recommendation is supported by references to the rapid rise in mobile device use, its anticipated further growth, a reluctance to switch

devices for survey administration, and the fact that many tasks previously done on traditional devices are now done on mobile devices. Lugtig and Toepoel (2015: p. 158) conclude: "It seems only a matter of time before mobile phone or mobile devices in general are preferred for survey completion over regular desktop PC's. Therefore, the best option is to improve the surveys experience for mobile devices."

3.2. The active approach to mixed-device surveys

In this subsection we present an overview of design strategies for improving the survey experience for mobile and non-mobile device users. We discuss design principles, concerns and practical issues. Today, experts stress the need for mobile-optimal, device agnostic or mobile friendly surveys (Wells, 2015; Peterson, 2012; Lugtig and Toepoel, 2015). Meanwhile, these classifications are used interchangeably, few authors provide additional details, figures and illustrations as elaboration of their terms (e.g. Arn et al., 2015; Wells et al., 2014; Mitchell, 2015).

The search for a better survey experience remains an ongoing quest, as also illustrated by the semantic confusions and proliferation of studies that aim to reveal the best way of presenting surveys on multiple devices. In the literature we identified a total of four design strategies for mixed-device surveys. These four design strategies are described below.

Mobile-first: The philosophy of this design approach is: 'if a survey works on mobile devices, it will work on all devices'. Surveys designed according to the mobile-first approach present the same survey layout on all devices, just as the traditional designs did previously. The key difference is that the survey is now designed to be displayed on the smallest types of screens, with a touchscreen as input mode. A number of studies tested this approach (De Bruijne and Wijnand, 2013; Tharp, 2015; Barlas et al., 2015), and the results indicated that by paying too much attention to mobile respondents, the majority of participants were overlooked. Traditional devices are confronted with a sub-optimal survey experience, which implies that mobile-first does not mean device agnostic.

Responsive layout: Due to the rise of mobile devices, many websites were recently redesigned in order to improve reading and navigation on smartphones, with a popular approach for achieving this being the use of responsive frames (Marcotte, 2010; Arn et al., 2015), which are frames programmed to automatically rescale to screen size and screen orientation. The content of each window is scaled and reorganized accordingly. FluidSurveys and GoogleForms are examples of survey software using responsive layouts. In order to support automatic scaling, the responsive approach favors the use of vector files over pixel-based images.

Adaptive design: In the adaptive design approach, a specific design is created for each type of device. The information received from the respondent is used to determine the best option to send to their device (Gustafson, 2012; Arn et al., 2015). Grids and other complex question formats are presented differently, depending on which type of device is being used. For grids, this could be row-by-row for smartphone users, while desktop users are shown the full (original) grid. A potential disadvantage of adaptive designs is that they require more programming, as two or more separate layouts must be designed. Qualitrics software offers adaptive designs.

Survey simplicity: Many survey research experts recommend keeping the survey short and simple (eg. Link et al., 2014; Callegaro, 2012; Saunders, 2015). A traditional survey design with shorter and simpler questions and options can therefore be deemed a conscious step toward a mixed-device survey. One benefit of this is that making changes to the traditional survey software can be avoided. Barlas et al. (2015) successfully tested this approach. If a survey is too long or complicated, the option of cutting the full survey into smaller pieces should be investigated (Kelly et al., 2012). This simplicity strategy can be combined with the other three design strategies.

The following arguments support the recommendation of keeping surveys short and simple (see e.g. Link et al., 2014; Revilla et al., 2016): [1] navigation and reading is more burdensome with smartphones; [2] respondents are accustomed to making regular but brief use of their mobile devices, hence shorter surveys fit more naturally with regular mobile device use; [3] in web-based surveys, connectivity can become an issue for respondents who are on the move, as they may encounter dead spots; [4] many mobile respondents are charged per downloaded megabyte or have monthly data limits; [5] long surveys can result in battery drain.

We demonstrated in this section that taking an active approach to mixed-device surveys is a multidimensional challenge. It is not simply a question of using the best software. Optimization for multiple devices concerns also survey length, the readability of question and answer options, visualization, the amount of data to be downloaded and

uploaded, and navigational issues. Consequently, to state that a survey is mobile-optimal is a rather bold statement, as there are varying degrees of mobile-friendliness.

4. The effects of improved survey designs

In this section we offer an overview of the effects of improved mixed-device surveys. We discuss response rates, break-off rates, completion times, item nonresponse, and survey scores.

4.1. Response rates

As a result of instant internet access, their mobile character and high levels of private ownership, the assumption was that mobile phones with internet connectivity would boost response rates in mobile surveys (Weber et al., 2008). Many of those conditions have now been fulfilled: smartphones are constantly in stand-by mode, and many people not only own mobile phones, but carry them wherever they go. Hence, in panels, the rise in mobile device usage should be positively correlated to general response rates, provided that we do not reject this 'mobile impulse' hypothesis. Based on the data derived from longitudinal surveys (see sources Table 2), we tested this hypothesis. A simple scatterplot (not provided) reveals that there is no correlation between the share of smartphone users and the difference in response rates (ρ^2=0.00). Moreover, the correlation between a higher share of tablets and higher response rates is also very poor (ρ^2=0.10). Consequently, no evidence is found to support the hypothesis that longitudinal surveys have more respondents because of mobile devices and instant access.

Studies in which respondents are randomly assigned a particular device offer more compelling information about response rates. One can find further details about response rates per device in multiple experiments involving random assignment. Given the results of 11 samples in 8 studies (Buskirk and Andrus, 2012; De Bruijne 2015; Wells et al., 2014; Antoun, 2015; Cook, 2014; Mavletova, 2013; Mavletova and Couper, 2013; Toepoel, 2016), we observe that respondents assigned to a mobile device are less inclined to start a survey, with an OR of 0.40 (weights based on sample size). Smartphone users were more inclined to respond (OR=1.49) in only one experiment, by Wells et al. (2014), although candidates for this study were not selected based on device accessibility, but rather were pre-screened for their willingness to install a survey app.

Given these findings, we may conclude that mixed-device surveys do not boost response rates. Yet a lack of support for mobile respondents will result in lower response rates in the near future, as mobile device use increases. Hence, an active approach to mixed-device surveys is needed to prevent loss.

4.2. Break-off rates and panel attrition

Compared to traditional device users, mobile device users demonstrated a significantly higher likelihood of leaving surveys before completion: a differential factor of three to four was not uncommon (Mavletova and Couper, 2015; Poggio et al., 2015; Lambert and Miller, 2015; Stapleton, 2013; Schmidt and Wenzel, 2013). This observation holds for smartphone users only. Tablet users hardly differed from traditional device users in this respect. Moreover, some studies even reported higher completion rates among tablet users (Poggio et al., 2015). The differences in observational studies could be explained by self-selection effects, as there were clear dissimilarities in socio-economic characteristics (section 3.3). Higher dropout rates were also reported in experimental studies and surveys (Wells et al., 2014). Multiple studies reported a lack of a mobile-friendly design as a key determinant (Stapleton, 2013; Barlas et al., 2015; Sarraf et al. 2015), although higher break-off rates were still reported in surveys that took an active approach to mixed-devices (Barlas et al., 2015; McGeeney and Marlar, 2013).

A meta-analysis conducted by Mavletova and Couper (2015) confirmed that an active approach to mixed-device surveys will lower drop-out rates among smartphone respondents. The researchers compared the completion rates of mobile respondents in 14 studies and 39 independent samples. By narrowing the scope to mobile device users only, Mavletova and Couper avoid the problem of self-selection. When compared to a survey with a traditional design, the more mobile-friendly design lowered the odds of drop-outs among mobile respondents by 40% (OR=0.71). The opportunity to choose the preferred survey mode (PC or mobile) was also associated with lower break-off rates among mobile respondents (OR=0.62). More complicated survey designs, featuring grids, drop-down questions, images,

sliders or progress indicators, were associated with higher break-off rates (OR=1.30). This ratio increased to 1.91 when 5 or more of these complex elements were included, as compared to a survey devoid of these elements.

In the panel surveys discussed in section 2.2, we found some indications regarding attrition. Lugtig and Toepoel (2016) observed a higher likelihood of non-participation in subsequent waves among mobile respondents. Traditional device users exhibited relatively loyal behavior, with an 83% probability that they would participate in the next wave, as compared to 75% for mobile device users (OR=0.61). No significant differences were observed between tablet and smartphone users. Similar patterns were observed in the GESIS panel, although the German panelists were more obliging (Struminskaya et al. 2015). Traditional device users demonstrated a 95% probability of participating in the subsequent wave, and this probability was the same for tablet users (OR=0.96), although significantly lower for smartphone users (91%; OR=0.52). It is worth noting here that this was not necessarily solely due to the survey experience as pertaining to the devices used; rather, self-selection effects could also play a role, as previously explained in section 3.3.

We can conclude that incomplete cases are a serious issue in mixed-device surveys, as several studies have indicated that mobile respondents have a significantly higher tendency to abort a survey. Furthermore, there is some evidence that mobile respondents are less likely to participate in a panel's subsequent wave. Both risks can be mitigated by offering device agnostic designs and giving respondents the freedom to select a certain device. The findings also stress the need to keep surveys simple.

4.3. Completion time

Completion time is generally regarded as a proxy for response burden. Moreover, surveys that take longer to complete are considered to be a risk. Longer interview durations for mobile respondents, as compared to desktop respondents, were observed in many surveys (Schmidt and Wenzel, 2012; Gummer and Roβman, 2015; Couper and Peterson, 2017; Zijlstra et al. 2017). With their meta-analysis, Gummer and Roβman (2015) demonstrated that this was a structural phenomenon, although they did not account for survey design.

Using a multilinear regression model featuring data from 80 samples from 37 studies, we observed that the smartphone users' median completion time was 47% longer than the traditional device users' completion time, in cases in which the surveys were not mobile-friendly (Table 3). For the mobile-friendly versions of these surveys, the median completion time was 19% to 24% longer. There is small and insignificant difference in completion time ratios for experimental (random assignment) versus observational (self-selection) studies. In 10 out of 80 cases, the majority of mobile respondents were faster than the majority of traditional device users.

Table 3. Parameters and standard errors for two completion time models (weighted and unweighted)

	Weighted	Unweighted
Random Assignment	0.06 (0.10)	0.13 (0.10)
Mobile-Friendly	-0.27 (0.09)**	-0.23 (0.07)**
Mean times	-0.13 (0.08)	-0.19 (0.06)**
Truncated mean times	0.66 (0.18)***	0.31 (0.18)
Intercept	1.46 (0.06)***	1.47 (0.06)***

Notes: reference level is self-selection, not mobile-friendly and median completion time ratios;
Weights in the second model are based on the squared root of the sample size.

Couper and Peterson (2017) examined and substantiated three explanations for longer completion times by mobile respondents: [1] slower transmission of data over cellular or WiFi networks; [2] reading and navigation difficulties; and [3] the increased mobility of mobile respondents and higher risk of distraction during survey administration. Differences in completion times are likely to diminish in the near future, owing to faster networks and improved survey designs for mobile devices.

4.4. Missing items

In this subsection we examine differences in item non-response between traditional and mobile devices, which involved studying observational and experimental data. Due to smaller screens, some options might be overlooked on mobile devices. Further, respondents could be inclined to avoid open answers.

Multiple studies reported higher levels of missing items among the mobile respondents taking traditional surveys in which they were free to select their completion device (eg. Struminskaya et al., 2015; Sarraf et al., 2015; Lugtig and Toepoel, 2016), although this finding was not consistent throughout the literature (Guidry, 2012; McClain et al., 2012; McGeeney and Marlar, 2013). A potential explanation for the conflicting evidence could be found in the composition of the sample. Struminskaya et al. (2015) and Lugtig and Toepoel (2016) analyzed a probability-based online panel, while Guidry's (2012) sample consisted of students only. Hence, a higher level of item nonresponse could also be attributed to self-selection effects, as was also noted by Lugtig and Toepoel (2016, p. 87): "It could be that people who generally report with high measurement error have different device preferences from people who report with low measurement error." A further explanation for the conflicting evidence pertains to the survey length. McGeeney and Marlar (2013), and McClain et al. (2012), used relatively short surveys.

In terms of missing items among mobile respondents, we find smartphone users to be of primary concern. A differential factor of two or three between smartphone and desktop respondents is not unlikely (Struminskaya et al. 2015, Lugtig and Toepoel, 2016; Lambert and Miller, 2015; Sarraf et al., 2015). Missing items are less common among tablet users; sometimes they perform even better than traditional device users. These observations are in line with the expected negative effects of smaller screen sizes and the more complicated navigation on smartphones.

Experimental studies allow researchers to establish mode effects, while also controlling for self-selection effects or other biases. In their experiment, with a mobile-friendly survey, Keusch and Yan (2016) found two times more item non-response among iPhone users than among desktop respondents. Buskirk and Andrus (2014), whose survey was optimized to look app-like, did not observe significant differences in missing items in their survey.

In observational studies, the use of mobile-friendly surveys lowered the risk of item non-response among mobile respondents (Sarraf et al., 2015), which also implies that not all observed differences can be attributed to self-selection – mode effects are also present.

4.5. Survey design evaluation by respondents

Offering a good survey experience is perhaps one of the best ways to prevent drop-outs or attrition, with attractive designs and optimal functionality assisting in this endeavor. However, comparing satisfaction levels between various surveys is complex, as satisfaction is determined by multiple factors that cannot all be accounted for. Hence, in this context, comparisons within studies are more useful. Potentially useful sources include experimental studies that offer varying conditions to multiple groups, and longitudinal panels that change over time. It is often the case that both categories converge, as panelists are eagerly used in experimental studies.

We found clues about survey satisfaction among participants in three experimental studies that did not use panelists. Tharp (2015) tested two design approaches, namely, mobile-first and responsive designs (section 3.2). These approaches were compared to a traditional survey lay-out. The results of the mobile-first approach (n=2,400) were mixed, with the students using a smartphone rating the survey as more easy to complete, while desktop users rated the survey significantly lower in terms of its 'professional looks' and complained about the need for scrolling. The results for the responsive web design (n=20,900) were far more positive: for both smartphones and desktop users, the survey was rated higher on all evaluation items. Sarraf et al. (2015) found that the mobile-friendly version of an annual student survey had significantly better scores in terms of ease of use and visual design. Respondents using the new version were more optimistic about the ease of use, as compared to the old design. In their survey, Baker-Prewitt and Miller (2013) randomly assigned participants to multiple devices: PC, tablet and smartphone and mobile-friendly or traditional designs. The survey participants were then questioned about their preferred mode for survey completion. The overall scores strongly favored the traditional devices. The results also revealed a tendency towards self-selection or uncertainty avoidance, as the device in-use was more often selected. One out of three smartphone users stated that they would "definitely take another survey on the same device", regardless of whether they were presented with the optimized or non-optimized web survey, while this figure was two out of three for traditional device users.

Some studies using panelists reported on the respondents' survey evaluations. Under three experimental conditions, Saunders et al. (2012) observed no significant differences between mobile and traditional respondents. Mitchell (2015) reported significantly higher levels of survey satisfaction among mobile device users when presented with a mobile-friendly version of the survey, compared to a traditional version.

We found two studies that contained evaluations of new designs in longitudinal, probability-based panels. Arn et al. (2015) tested a new responsive design and observed a general improvement in all criteria used. The improvement was greater for smartphone users than for desktop users, and consequently the researchers found that "the old design is liked less by smartphone users than desktop users, but the new design is rated better by smartphone users" (p. 204). For the statements "it is easy to complete the questions in this layout" and "people will quickly learn to work with this layout", De Bruijne and Wijnand (2013) observed significantly higher scores among mobile web users using a mobile-first design. The ratings of two other statements, pertaining to the layout's attractiveness and professional look, did not significantly differ for mobile device users. Meanwhile, when presented with the mobile-first design, traditional device users were more pessimistic: the scores were significantly lower for all statements. Modest improvements for a small group of mobile respondents (15%) came at the expense of the majority of respondents (85%) using a traditional device. Consequently, the aggregate is negative.

There is little doubt that mobile respondents appreciate active support for mobile devices. In all studies, the updated look and functionalities outperformed the 'traditional' appearance. Responsive design performs relatively well. However, some traditional device users seem to be rather attached to the traditional design of surveys.

5. Discussion and conclusions

The unprecedented rise of smartphones and tablets over the past decade presents potential challenges for transport surveys. In this paper we discussed the various approaches to dealing with mixed-device surveys, we assessed the added value for mobile respondents, and we studied the effects of mobile respondents in mixed-device surveys. Multiple meta-analyses were used in combination with state-of-the-art literature.

We observed a rapid rise of mobile device use among respondents. According to our estimates, one out of every three respondents was a mobile respondent in 2016. The number of panelists that used a mobile device at least once significantly transcends the one out of three ratio cited above. Mobile respondents tend to be younger and may share other characteristics, rendering them part of an interesting, hard-to-reach group in the general population.

There are three basic strategies for mobile responds in surveys: [1] blocking; [2] identifying and treating; and [3] supporting and integrating. The share of mobile respondents and profile of these respondents strongly favors the latter option, which can be achieved by software improvements, simple question formats and a short and simple survey. Responsive or adaptive designs can offer a positive survey experience for both mobile and traditional device users. A mobile-first strategy should be avoided.

Various mode effects come into play. In this paper we studied response ratio, break-off rate, item nonresponse, and completion time. For tablet users, the results were generally positive or neutral, with hardly any effects recorded. However, when smartphones were used for survey administration, some negative effects occurred. Smartphone respondents are less inclined to respond, are more inclined to drop-out, have more missing items, and need more time to complete the survey. Most of these effects are significantly mitigated when using a mobile- friendly design.

Many of the remaining issues pertaining to mobile completion in likely be minimized in the near future. The improvement of cellular networks (to 4G or 5G) is a step in the right direction. Preloading web-based surveys can also be a solution for faster completion times. Reading and navigation issues could become less relevant, owing to the emergence of larger smartphone screens and improved navigation skills. Moreover, further improvements in resolution, speed, touch screen navigation and software imply a less burdensome experience for survey respondents.

References

Arn, B., Klug, S., Kolodziejski, J., 2015. Evaluation of an adapted design in a multi-device online panel: a DemoSCOPE case study. Methods, Data and Analyses 9.2, pp. 185-212.

Baker-Prewitt, J., Miller, J., 2013. Mobile research risk: what happens to data quality when respondents use a mobile device for a survey designed for a PC. CASRO online research conference 7-8 March 2013, San Francisco, US.

Barlas, F., Thomas, R., Graham, P., 2015. Purposefully mobile: experimentally assessing device effects in an online survey. AAPOR annual meeting, 14-17 May 2015, Hollywood, Florida, US.

Barlas, F., Thomas, R., 2015. The mobile influence: how mobile participants affect survey results. AAPOR annual meeting, 14-17 May 2015, Hollywood, Florida, US.

Bosnjak, M., Poggio, T., Becker, K.R., Funke, F., Wachenfeld, A., Fischer, B., 2013. Online survey participation via mobile devices. AAPOR annual meeting, 18 May 2013, Boston, MA, US.

Buskirk, T., Andrus, C., 2012. Smart surveys for smartphone: exploring various approaches for conducting online mobile surveys via smartphones. Survey Practice 5.1.

Buskirk, T., Andrus, C., 2014. Making mobile browser surveys smarter: results from a randomized experiment comparing online surveys completed via computer or smartphone. Field Methods 26.4, pp. 322-342.

Callegaro, M., 2010. Do you know which device your respondent has used to take your online survey? Survey Practice 3.6.

Cehovin, G., Vehovar V. 2013. Web survey software and mobile device support. Working paper. University of Ljubljana, Ljubljana, pp. 42.

Cook, W., 2014. Is mobile a reliable platform for survey taking? Defining quality in online surveys from mobile respondents. Journal of Advertising Research, June 2014, pp. 141-148.

Couper M., Peterson G., 2017. Why do web surveys take longer on smartphones? Social Science Computer Review (SSCR) 35.3, pp. 357-377.

De Bruijne, M., 2015. Designing web surveys for multi-device internet. PhD Thesis. Tilburg University, Tilburg.

De Bruijne, M. Wijnand, A., 2013. Can mobile web surveys be taken on computers? A discussion on a multi-device survey design. Survey Practice 6.4, pp. 1-8.

Dewes, F., 2014. An empirical test of the impact of smartphones on panel-based online data collection, in: "Online Panel Research, a data quality perspective". In: Callegaro, M. et al. (Ed.). Wiley: Chichester, pp. 367-386.

Guidry, K., 2012. Response Quality and Demographic Characteristics of Respondents Using a Mobile Device on a Web-Based Survey. AAPOR anual meeting, 17-20 May 2012, Orlando, Florida, US.

Gummer, T., Rossman, J., 2015. Explaining interview duration in web surveys: a multilevel approach. SSCR 33.2, pp. 217-234.

Gustafson, A., 2011. Adaptive Web Design. Crafting Rich Experiences with Progressive Enhancement. Easy Readers, Chattanooga, Tennessee

Horwitz, R., 2014. Usability of the ASC internet instrument on mobile devices. Proceedings of Statistics Canada Symposium 2014: beyond traditional survey taking, adapting to a changing world. Hull, Quebec, Canada.

Hupp, A., Schroeder, H., Piskorowski, A., 2014. Assessing the impact device choice has on web survey data collection. AAPOR annual meeting, 16 May 2014, Anaheim, CA, US.

Kelly, F., Johnson, A., Stevens, S., 2012, Benefits of modular design for mobile and online surveys. CASRO Journal, 2012-13, pp. 37-40.

Keusch, F., Yan, T., 2016. Web versus mobile web: an experimental study of device effects and self-selection effect. SSCR 36.1, pp. 1-19.

Lambert, A., Miller, A., 2015. Living with smartphones: does completion device affect survey responses? Res. High Educ. 2015, 56, 166-177.

Link, M., Murphy, J., Schober, M., Buskirk, T., Hunter Childs J., Langer Tesfaye, C., 2014. Mobile technologies for conduction, augmenting and potential replacing surveys; AAPOR task force on emerging technologies in public opinion research. AAPOR, Oakbrook Terrace, IL, pp. 55.

Toepoel, V., Lugtig, P., 2013. 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 32.4, pp. 544-560.

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, 34.1, pp. 78-94.

Lugtig, P., Toepoel, V., Amin, A., 2016. Mobile-Only Web Survey Respondents. Survey Practice 9.3.

Macer, T., Wilson, S., 2016. FocusVision 2015 annual technology report, Full report. Meaning Ltd.: London.

Marcotte, E., 2010. Responsive Web Design. Retrieved May 2, 2017, from: http://alistapart.com/article/responsive-web-design/.

Mavelova, A., 2013. Data Quality in PC and Mobile Web Surveys. Social Science Computer Review, 31.6, pp. 725-743.

Mavletova, A., Couper, M., 2013. Sensitive topics in PC and Mobile Web Surveys. General Online Research conference, 4-6 March 2013, Baden-Wuerttemberg, Germany.

Mavletova, A., Couper, M., 2015. A Meta-Analysis of Breakoff Rates in Mobile Web Surveys, in "Mobile Research Methods: Opportunities and Challenges of Mobile Research Methodologies". In: Toninelli, D, et al. (Ed.), Ubiquity Press, London, pp. 81-98.

McClain, C., Crawford, S., Dugan, J., 2012. Use of mobile devices to access computer-optimized web surveys: implications for respondent behavior and data quality. AAPOR annual meeting, 17-20 May 2012, Orlando, Florida.

McGeeney, K., Marlar, J., 2013. Mobile browser web surveys; testing response rates, data quality and best practices. AAPOR annual meeting, 18 May 2013, Boston, MA.

Merle, P., Gearhart, S., Craig, C., Vandyke, M., Brooks, M., Rahimi, M., 2015. Computers, Tablets, and Smart Phones: The Truth About Web-based Surveys. Survey Practice 8.5.

Millar, M., Dillman, D., 2012. Encouraging Survey Response via Smartphones: Effects on Respondents' Use of Mobile Devices and Survey Response Rates. Survey Practice 5.3.

Mitchell, N., 2015. The changing landscape of technology and its effects on online survey data collection. AAPOR annual meeting, 14-17 May 2015, Hollywood, Florida, US.

Peterson, G., 2012. Unintended Mobile Respondents. CASRO Technology Conference, New York, NY.

Peytchev, A., Hill, C., 2010. Experiments in Mobile Web Survey Design: Similarities to Other Modes and Unique Considerations, Social Science Computer Review 28.3, pp. 319-335.

Poduska, B., Johnson, P., 2010, Do mobile respondents differ from online survey respondents? Opiniology, pp. 3.

Poggio, T., Bosnjak, M., Weyandt, K., 2015. Survey Participation via Mobile Devices in a Probability-based Online-Panel: Prevalence, Determinants, and Implications for Nonresponse. Survey Practice 8.1.

Revilla, M., Toninelli, D., Ochoa, C., 2016. Do online panel need to adapt surveys to mobile devices? Internet Research 26.5, 1209-1227.

Richards, A., Powell, R., Murphy, J., Nguyen, M., 2016. Gridlocked: The Impact of Adapting Survey Grids for Smartphones. Survey Practice 9.2.

Sarraf, S., Brooks, J., Cole, J. Wang, X., 2015. What Is The Impact of Smartphone Optimization on Long Surveys? AAPOR annual meeting, 14-17 May 2015, Hollywood, Florida.

Saunders, T., 2015. Improving the survey experience for mobile respondents. Alert! Magazine, Q3, 2015.

Saunders, T., Chavez, L., Chrzan, K., Brazil, J., 2012. Scale orientation, grids and modality effects in mobile web surveys. AAPOR anual meeting, 17-20 May 2012, Orlando, Florida, US.

Schmidt, S., Wenzel, O., 2013. Mobile research performance: how mobile respondents differ from PC users concerning interview quality, drop-out-rates and sample structure. General Online Research conference, 4-6 March 2013, Baden-Wuerttemberg, Germany.

Stapleton, C., 2013. The Smartphone Way to Collect Survey Data. Survey Practice 6.2.

Struminskaya, B., 2014. Data quality in probability-based online panels: nonresponse, attrition and panel conditioning. PhD thesis. Utrecht University, Utrecht.

Struminskaya, B., Weyandt, K., Bosnjak, M., 2015. The effect of questionnaire completion using mobile devices on data quality. Methods, Data and Analyses 9.2, pp. 261-292.

Tharp, K., 2015. The impact of mobile first and responsive web design. AAPOR annual meeting 2015, 14-17 May 2015, Hollywood, Florida, US.

Toepoel, V., 2016. Buttons of balken, klikken of slepen: wat werkt er nu het beste op mobiele telefoons, tablets of PCs?, in "Jaarboek Marktonderzoekassociatie". In: Bronner et al. (Ed.). Spaar en Hout, Haarlem

Toepoel, V., Lugtig, P., 2015. Introduction: online surveys are mixed-device surveys. Methods, Data and Analyses, 9.2, pp. 155-162

Weber, M., Denk, M., Oberecker, K., Strauss, C., Stummer, C., 2008. Panel surveys go mobile. Int. J. of Mobile Communication 6.1, pp. 88-107.

Wells, T., 2015. What market researchers should know about mobile surveys. Int. Journal of Market Research 57.4, pp. 521-532.

Wells, T., Bailey, J., Link, M., 2014. Comparison of smartphone and online computer survey administration. SSCR 32.2, pp. 238-255.

Zijlstra, T., Hoogendoorn-Lanser, S., Wijgergangs, K., 2017. The impact of survey completion with a mobile device in a longitudinal transport study. European Transport Conference, 4-6 October 2017, Barcelona, Spain.