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Effects of smartphone use and recall aids on network name generator questions

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ABSTRACT

The increasing use of smartphones around the world provides new opportunities for network data collection using smartphone surveys. We investigated experimentally whether the use of smartphones and of a recall aid affects the number of reported names in a network name generator question. In a German online access panel (N = 3891), respondents were randomly assigned to answer the survey on their PC or on their smartphone and were randomly assigned to receive an open-ended recall aid question before the name generator question or after. Results showed that respondents on PCs and smartphones reported the same number of network contacts. This suggests that smartphone surveys have no negative effect on the network sizes in ego-centered network studies. However, requiring people to answer on smartphones resulted in a selection bias due to non-compliance, which may have led to an overrepresentation of persons with larger network sizes. The recall aid question did not lead to more reported names, but it proved to be an indicator of respondents' motivation and response quality. In sum, the study suggests that smartphones can effectively be used for network research in tech-savvy populations or when respondents can choose to complete the survey on another device.

Introduction

Past research has documented important survey design effects on the size of the network elicited from name generator questions in ego-centered network studies. Such name generator questions ask respondents to self-report the names of people in their personal network (Burt, 1984; Marsden, 2011). With respect to survey mode, there is mixed-evidence whether switching from traditional face-to-face interviews to online surveys reduces (Matzat and Snijders, 2010) or increases the network size (Fischer and Bayham, 2019), or has no effect on the number of names reported (Vriens and van Ingen, 2018). Within online surveys, the placement of a name generator question (Yousefi-Nooraie et al., 2017), the number of name boxes provided (Vehovar et al., 2008), and the use of name recall aids (Hsieh, 2015) can considerably affect network sizes. Regarding repeated measurement, Silber et al. (2019) showed that panel conditioning had only minor effects on the size of social networks in a German web survey.

Interestingly, the aforementioned study found that the network size of respondents who answered the questionnaire on their smartphones was slightly higher (3.48 friends) than that of respondents who answered on their PCs[1] (3.32 friends, Silber et al., 2019). While the difference between the devices was statistically non-significant, this result is an encouraging signal for researchers who consider administering their entire survey on smartphones. Perhaps the use of smartphones has a positive effect on the size of ego-centered networks, despite the smaller display and keyboard of smartphones. Such a conclusion, however, cannot be drawn with confidence from that study because respondents were not randomly assigned to a device. Thus, there is no way of telling whether the results emerged because respondents who answer on smartphones have actually slightly more friends than respondents who answer on PCs or because respondents are motivated to report slightly more friends on smartphones. It could even be that respondents who answer on smartphones have more friends but tend to underreport their network size due to the device they use for participation.

Previous methodological research showed that certain groups of respondents are more likely than others to use a smartphone to participate in an online survey when they can freely choose to do so. Specifically, younger (de Bruijne and Wijnant, 2013; Toepoel, 2017) and higher educated respondents (Fuchs and Busse, 2009) were overrepresented

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[1] PC includes desktop computers as well as laptops, running windows, macOS, Linux, and other operating systems.

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among smartphone participants. One study found women to be more likely than men to participate in smartphone surveys (de Bruijne and Wijnant, 2014) but other research could not replicate this finding (de Bruijne and Wijnant, 2013; Keusch and Yan, 2017).

Selective participation of certain groups in smartphone surveys may bias results of network studies if these groups differ in their sociability and thus have smaller or larger networks. For instance, women have been found to have larger social networks than men (Goodreau et al., 2009; Lewis and Kaufman, 2018; McLaughlin et al., 2010) and employed people have more social contacts than unemployed (Edin et al., 2003; Munshi, 2003). Likewise, people with a good health seem to have larger networks than those suffering from medical conditions (Michael et al., 1999; Schaefer et al., 1981). Moreover, some studies found that members of voluntary associations have larger social networks than people who are not members of such associations (Farkas and Lindberg, 2015; Putnam, 2000; Rotolo, 2000; but see Bekkers et al., 2008 who found no effect). Additional research has shown that inhabitants of urban areas are less likely to participate in voluntary association and show less community engagement (Oliver, 2000; Remmer, 2010). Hence, it can be assumed that inhabitants of urban areas are likely to have smaller social networks. If members of such groups are more or less likely to participate in network studies conducted on smartphones, the conclusions about the average network size in the population may be biased.

So far, little is known about the relationship between smartphone use to conduct ego-centered surveys and the elicited network size. To help close this research gap, the present research explored experimentally how the use of smartphones to answer online surveys affects the number of names elicited from name generator questions. Such insights are important because researchers will be inclined to collect network data on smartphones in the near future given the wide-spread use of smartphones globally (Poushter et al., 2018) and the rapid improvements made in the development of new visual tools to collect ego-centered network data online such as GENSI (Stark and Krosnick, 2017), OpenEddi (Eddens and Fagan, 2018), or Network Canvas (Hogan et al., 2016, 2019).

This study reports results of an experimental online study in which respondents were randomly assigned to complete the same web survey either on a PC or a smartphone. Despite the encouraging findings of Silber et al. (2019) in their non-experimental study, we expected to elicit fewer names on smartphones than on PCs when respondents cannot self-select the device on which they answer. This is because, we hypothesized that respondents may be discouraged from thinking about and entering additional names because of smaller screen sizes of smartphones compared to PCs and the accompanying necessity to scroll down to see the entire name generator question. Additional technical issues, such as longer page loading times or the difficulty to click with the finger on answer boxes, may negatively affect the number of names reported on smartphones. Finally, people are much more likely to use their smartphones than their PC in a distracting environment outside of their home, such as while waiting for public transportation or in line at the grocery store (Couper et al., 2017). This may further reduce respondents' motivation to repeatedly enter contacts in a name generator question.

Respondents were also randomly assigned to answer a recall aid question before or after reporting names in a name generator question. A general challenge of ego-centered network studies is that people tend to forget to mention a substantive number of their personal contacts (Brewer, 2000; Brewer and Webster, 2000). Previous work found that providing recall aids can increase the number of names reported in ego-centered network studies, both in face-to-face interviews (Marsden, 2011) and in online surveys on PCs (Hsieh, 2015). However, to our knowledge, no research has explored the effect of recall aids in smartphone surveys. We hypothesized that seeing a recall aid before the network prompt would counter the expected negative effect of the added difficulty of answering a smartphone survey because the names of network contacts are already available in the active memory.

Methods

The data for this study were collected with a web survey conducted between the 15th of July and the 31st of August 2018. Respondents were recruited from a German nonprobability online access panel using quotas for gender, education, age, and federal state. Before receiving the invitation via email, respondents were randomly allocated to either use a PC or a smartphone to complete the survey (device manipulation). All respondents were asked for their gender, age, and education at the start of the survey. After these questions, respondents violating the device assignment were screened-out.

Our two experiments were in the first part of a larger questionnaire and not preceded by any other experimental manipulation. Respondents had the possibility to proceed in the survey without answering a question but could not go back in the questionnaire to change an answer they had already given. The questionnaire layout was optimized for smartphones and displayed similarly on both devices.

A total of 50,063 panel members were invited, from which 6,750 opened the invitation link. 538 (8.0 %) broke off, and 2,838 (42.0 %) were screened-out. The majority of those screened-out were respondents assigned to the smartphone condition who tried to use a PC to complete the survey (2,563). The other 275 respondents were assigned to use a PC but were screened-out for trying to use a smartphone. Given these high numbers of screened-out respondents, we test below for a selection bias by comparing the characteristics of respondents who completed the survey with those who were screened-out using demographics and supplementary information obtained from the panel provider for all invited panel members. The final sample consisted of 3,327 respondents (completion rate 49.3 %) of which 1,787 answered using a PC and 1,540 using a smartphone. The median response time for the survey was 29.6 min and the median response time for the network name generator question was 2.5 min.

Randomized experiments

In the first experiment, half of the respondents were randomly assigned to use a smartphone for answering the survey and the other half was randomly assigned to use a PC. Both groups received the information about the device usage in the invitation email. In the second experiment, we randomly assigned respondents to one of two orders in which the name generator question and the recall aid question were asked. Half of the sample saw the open recall aid question first and answered then the name generator, and the other half saw first the name generator and then the recall aid question. This placement experiment allowed us to evaluate if the open question served as a memory trigger and helped respondents to recall more friends. The random assignments within the two experiments were independent of each other.

Measures

Name generator

Number of friends

The name generator question asked respondents to provide the first names of up to twenty friends: "Now we are interested in your closest circle of friends. Please enter the first names of your close friends." Respondents could enter names in up to 20 vertically arranged separated answer boxes. A screenshot of this question is provided in the Online Appendix A1. No other instruction on how to complete the name generator was given. To avoid that a few respondents (10.1 %) who named an exceptionally high number of friends have a high impact on the results, we truncated the measure and recoded all respondents that named 10 and more friends in a $\geq$ 10 category. Respondents who entered no names were considered to have a network size of 0 after our analysis revealed no significant differences between the PC and smartphone condition, suggesting that these were substantive answers (see

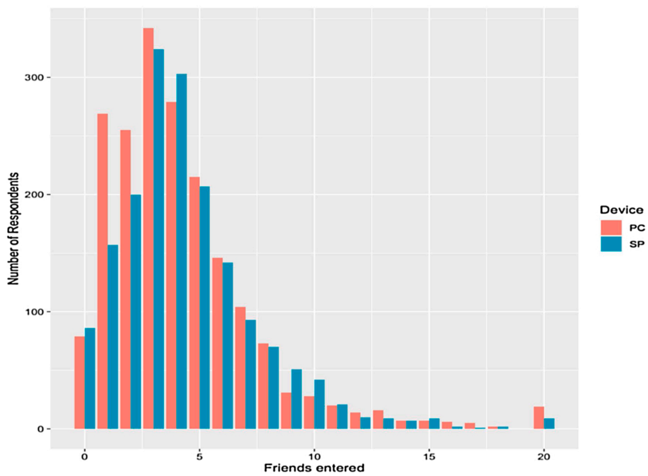

Fig. 1. Number of Friends entered in the Network Generator Question by Device.

Fig. 1).

Response time

We calculated two measures for response time. Response time was measured as a relative timestamp in relation to the start of the survey for every question. Therefore, the total response time for the name generator question was calculated by subtracting the timestamp of the name generator question from the time stamp of the subsequent question. To account for response effort, the response time needed per name was calculated as a second indicator by dividing the total response time for the name generator question by the number of friends reported.

Recall aid

The recall aid asked respondents: "When you think of your friends, what is important to you?" Respondents could type their answer in a single answer box (see Online Appendix A2). This question is different from typically used recall aids that ask respondents to think about friends in certain foci, such as friends from school, from work, or from leisure activities (Belli et al., 2001; Glasner and Van der Vaart, 2009). We worried that explicitly mentioning certain foci might prime respondents to think only about friends from these foci, ignoring anyone else. The idea of our research aid was to activate general retrieval cues that might help respondents access memories of their friends (Yan and Tourangeau, 2008), without priming them to a certain group of friends.

Quality of answer

For the analysis, two coders independently coded the answers to the open recall aid question into ten categories dependent on their content. For further analysis, we combined the categories into two categories: (1) "no answer" or "answer not meaningful" and (2) "meaningful answer." The category "answer not meaningful" refers to an answer that is either not related to the question or not meaningful at all (e.g., 'xxx', 'abc', and 'no idea').[2] As an indicator of inter-coder reliability, we calculated Cohens Kappa for the binary coding and found high reliability (k = 0.81).

Control variables

Because gender, age, and education were used for the quotas during the recruitment process, all respondents were asked about these characteristics as the very first questions of the survey, even before the screening by device took place. Skipping those three demographical questions was not possible. Therefore, these variables were also available for all respondents who were later screened-out because they failed to use the device to which they were randomly assigned.

Gender

Respondents were asked for their gender. Possible answers were male or female.

Age

Each respondent was asked: "How old are you?" Respondents had to give an open numeric answer.

Education

Education was asked as a closed-ended question: "What is your highest general school degree?" Respondents could select one of 9 response options representing German school degrees. It was also possible to enter a different school degree in an open format. For our analysis, we recoded education into three categories from low to high, in accordance with the tripartite school system of Germany (9-, 10-, and 12/13-year high school tracks). A screenshot of the question, showing all answer categories can be found in the Online Appendix A3.

Smartphone skills

To measure how experienced respondents were with their smartphone, we asked all respondents, "How do you generally assess your ability to use your smartphone?" Respondents could answer on a 5-point rating scale with the end-points labeled as "Beginner" and "Expert" (Keusch et al., 2017).

Supplementary information for selection Bias analysis

To test for a selection bias of groups that differ in their sociability, we requested supplementary information about the respondents from the panel provider. Those measures had been collected in a welcome survey, shortly after the registration of each new panel member. The requested indicators had been found to correlate with social network size in previous studies: employment status (Edin et al., 2003; Munshi, 2003), living in an urban or rural area (Oliver, 2000; Remmer, 2010), the number of medical conditions (Michael et al., 1999; Schaefer et al., 1981), and participating in voluntary organizations (Farkas and Lindberg, 2015; Putnam, 2000; Rotolo, 2000), which we tried to measure with the number of team sports respondents exercised.

Employment status

Being unemployed was coded as 1 and employed as 0.

Urban area

We divided panel members into two groups: those living in cities with more than 100,000 inhabitants were considered to live in an urban area (coded 1) and those living in cities or towns with less than 100,000 inhabitants were coded to live in a rural area (coded 0).

Number of medical conditions

The panel provider supplemented 15 dichotomous variables indicating whether the panel members had reported to suffer from each of 15 different medical conditions such as hearing problems or asthma (response categories: yes, no). These variables were summed to create an additive index ranging from 0–15. A complete list of medical conditions can be found in the Online Appendix B1.

[2] A total of 65.4% of respondents named values or emotions such as "trust," "honesty," or "happiness." 18.2% of the answers given referred to support, such as "they help me solving my problems." A further 10.8% were associated with activities like "going out together" or "meeting them to have fun." All other categories were represented in less than 5% of the answers; those included: having regular contact with friends ("people I have regular contact with"), answers that were focused on the friends themselves ("they are nice"), answers which refer to common interests ("we have the same hobbies"), or such referring to the amount of friends ("there are only a few real friends"). Finally, non-meaningful answers (e.g., responses such as "….." or "Xxx") represented less than 5% of the cases.

Practiced sports

The panel provider supplemented 25 variables describing whether or not a panel member participated in 25 different types of sports such as soccer, tennis, or volleyball (response categories: yes, no). We selected 18 sports, which are mainly practiced with others or in teams, as participation in such sports may be related to the network size. These variables were summed to create an additive index ranging from 0–18. A complete list of all 25 variables, including an indication of which variables were selected, can be found in Online Appendix B2.

Descriptive statistics for all variables are shown in Table 1. Bivariate correlations can be found in Table C1 in the Online Appendix.

Analysis

We use multiple imputation (predictive mean matching with 10 samples) to replace missing values in all regression models (Buuren and Groothuis-Oudshoorn, 2011). Analyses using listwise deletion instead of multiple imputation lead to very similar results (see Online Appendix C2 to C4). Since more people were screened-out in the smartphone sample than in the PC sample, we test for selection bias by comparing respondents who completed the survey with those who were screened-out separately for both devices. We then examine if the random allocation of respondents to the experimental conditions worked and investigate the influence of the device used to answer the survey on item nonresponse in the form of not entering any names. As a next step, we compare the distribution of the number of friends who were entered between the two devices. We also examine response times to uncover potential differences. Afterward, we focus on the effect of the recall aid experiment and on the combined effect of the device used and the recall aid on the number of names entered. Finally, we conduct five OLS regression models, to examine possible interactions between the independent variables and to control for demographics, smartphone skills, and the supplementary measures. In these regression models, the number of friends named in the name generator question serves as the dependent variable.

Table 1
Descriptive Overview for all Measures.

Variable	Range	Median	Mean	Standard Deviation	Missing Values
Metric					
Age		44	43.8	13.9	0
Smartphone skills	1–5	4	3.6	1.0	364
Number of medical conditions	0–14	1	1.2	1.6	339
Practiced sports	0–18	2	2.8	3.6	1120
Number of friends	0–20	4	4.1	2.6	0
Ordinal					
		Low Education	Medium Education	High Education	
Education		15.0 %	42.5 %	42.5 %	0
Nominal					
		Male	Female		
Gender		42.8 %	57.2 %		0
		Unemployed	Employed		
Employment Status		5.7 %	94.3 %		32
		Urban	Non-Urban		
Urban Area		65.2 %	34.7 %		157
		Desktop/ Laptop	Smartphone		
Device		51.8 %	48.2 %		0
		Meaningful	Non-meaningful		
Quality of answer to recall aid		93.0 %	7.0 %		0

Note: N = 3,891.
A correlation plot displaying the associations between these variables is provided in Online Appendix C (Fig. C1).

Results

Selection Bias

The results of the multivariate logistic regression model in Table 2 show that respondents who were older, male and those who were unemployed were more likely to be screened-out in the smartphone group because they tried to complete the survey on a computer. Also, those who suffered from more medical conditions were screened-out more often. However, we did not find significant differences regarding other factors, namely living in an urban area, the number of sports practiced, or education. In contrast to the smartphone screen-outs, respondents who were female, younger, and those with low or medium education were more likely to be screened-out in the PC group.

These results suggest that smartphone surveys are preferred over PC surveys by female respondents, those who are healthier, and those who are younger. Accordingly, a survey that is only conducted with smartphones could overestimate the average network size, as being female (Goodreau et al., 2009; Lewis and Kaufman, 2018; McLaughlin et al., 2010) and being healthy (Michael et al., 1999; Schaefer et al., 1981) are both associated with larger social networks. At the same time, allowing only the usage of PC's could lead to an underestimation of the network size, as men have been shown to have smaller social networks than women (Goodreau et al., 2009; Lewis and Kaufman, 2018; McLaughlin et al., 2010).

Randomization

To draw firm conclusions about the effects of the experimental manipulations, it is important that respondents were randomly allocated into experimental conditions. To check that the assignment worked, we used logistic regressions to predict the experimental group, separately for device and recall aid question placement for those who were not

Table 2
Logistic Regression Analyses Predicting Being Screened-out or not in the Smartphone Condition and the PC Condition.

	Screen-out smartphone	Screen-out PC
Gender female[a]	−0.48***	0.30*
	(0.06)	(0.14)
Low education[b]	−0. 16	0. 54*
	(0. 10)	(0. 23)
Medium education[b]	−0. 13	0. 60***
	(0.07)	(0.15)
Age	0.03***	−0.04***
	(0.00)	(0.01)
Employment status: unemployed[c]	−0.32*	0.07
	(0.14)	(0.29)
Urban area[d]	0.11	0.18
	(0.07)	(0.14)
Medical conditions	0.05*	0.00
	(0.02)	(0.03)
Practiced sports	0.02	0.04
	(0.02)	(0.03)
N	4494	2309
Pseudo-R^2 (McFadden)	0.34	0.34

Note: Logistic regression model with unstandardized coefficients and standard errors in parentheses.
* $p < .05$; ** $p < .01$; *** $p < .001$.
[a] Reference category is male.
[b] Reference category is high education.
[c] Reference category is employed.
[d] Reference category is Non-Urban Area.

screened-out. The results in Table 3 show systematic differences between respondents who participated using a smartphone and those using a PC. As can be expected based on the selection bias analyses, smartphone respondents were more likely to be female, younger, had a higher ability to use their smartphone, were less likely to have a medium education level, and less likely to suffer from a medical condition. It is thus crucial to keep these group differences in mind when interpreting the results of the device experiment. However, the assignment worked well for the recall aid question placement experiment as shown in Column 2 of Table 3. Specifically, there was no significant difference between respondents completing the survey under both placement conditions.

Item nonresponse and response time

To evaluate how to treat respondents who did not enter a single name into the name generator, we tested for a potential item nonresponse bias caused by the device. Table 4 shows that 166 respondents did not enter any friend. They were nearly equally distributed between PC respondents ($n = 80$, 0.02 %), and smartphone respondents ($n = 86$, 0.02 %). A Chi-squared test ($\chi^2 = 1.141$, $p = 0.285$) did not reveal any relationship between the device and item nonresponse. This means that there is no device-related item nonresponse bias originating from the name generator. This can be seen as first evidence for smartphones being an equally feasible device to generate ego-centered networks – at least for the respondents who complied with the device assignment. Completing a name generator with a smartphone did not lead to increased nonresponse in the name generator.

Besides the number of friends, the time a respondent needed to answer also poses an important element to evaluate the viability of smartphones for conducting ego-centered name generators. The median for answering the name generator was 9.0 s in total or 3.0 s per name across all respondents. A smartphone respondent needed on average 12.0 s in total or 3.5 s per name, compared to a PC respondent who needed on average 7.0 s in total or 2.7 s per name. A Mann-Whitney-U test revealed a significant difference for the overall time ($W = 1{,}373{,}700$; $p < 0.001$) and the time per name ($W = 1448100$; $p < 0.001$),

Table 3
Logistic Regression Analysis Testing Randomization to Device Assignment and Recall Aid Placement.

	Assignment to Mobile	Question Placement Recall Aid first
Gender female[a]	0.39***	−0.08
	(0.07)	0.07
Age	−0.02***	0.00
	(0.00)	(0.00)
Education low	0.07	0.07
	(0.11)	(0.10)
Education medium	−0.26***	0.04
	(0.08)	(0.07)
Smartphone skills	0.04***	0.00
	(0.04)	(0.04)
Employment status: unemployed[b]	0.19	0.08
	(0.15)	(0.14)
Urban area[c]	−0.08	0.03
	(0.07)	(0.02)
Medical Condition	−0.04*	−0.03
	0.02	(0.02)
Practiced Sports	−0.01	0.02
	(0.02)	(0.01)

Note. Logistic regression model with unstandardized coefficients and standard errors in parenthesis.
N = 3,891.
* p < .05; **p < .01; ***p < .001.
[a] Reference category is male.
[b] Reference category is Employed.
[c] Reference category is Non-Urban.

Table 4
Amount of Item Nonresponse to the Name Generator Question.

Device	Number of Item Nonresponse	Proportion of nonresponse	n total
PC	80	0.04	1931
Smartphone	86	0.05	1747
Total	166	0.04	3681

Note. ChiSq- test: relationship item nonresponse and device: ($\chi^2 = 1.134$, $df = 1$, $p = 0.29$).

indicating that answering the network name generator question on a smartphone was more time consuming. The greater amount of response time needed for smartphone respondents could have led to a greater response burden and thus potentially fewer reported names in the network name generator question.

Device experiment: number of reported names

Our next research question addresses whether the device affects the network size. Fig. 1 shows the distributions of the number of friends entered for smartphones and PCs. Both distributions show a peak for respondents who entered 3 friends. The majority of respondents in both groups entered 1–5 friends. Fig. 1 suggests that PC respondents entered 1 or 2 friends more often, while smartphone respondents were more likely to enter higher numbers of friends. However, a Kolmogorov-Smirnov test did not reveal a statistically significant difference between both distributions ($D = 0.15$; $p = 0.978$). These results suggest that smartphones are equally viable as PCs for collecting social network data – at least for groups that are willing to participate with a smartphone.

While the majority of respondents entered 10 or fewer friends, only a small group entered the maximum of 20 friends (0.9 %). This group was two times larger in the PC condition than in the smartphone condition. When conducting the analysis without truncating at 10 names, we found that smartphone respondents entered on average 4.40 friends, which was not significantly more than the 4.25 friends' respondents entered when using a PC ($t = -1.49$; $p = 0.14$)[3]. When truncating at 10, to avoid giving the few outliers a large impact on the results, smartphone respondents entered on average 4.25 names, while PC respondents entered significantly fewer (4.02) names on average ($t = -2.67$; $p = 0.01$).

In sum, smartphone respondents entered equally many or more friends than PC respondents. This result emerged despite the longer response time per name entered of smartphone respondents, indicating that the added difficulty of answering a smartphone survey did not have a negative impact on the number of friends that respondents reported. These preliminary results suggest that smartphones are indeed a viable option to use for ego-centered network name generators – at least for respondents who are willing to use a smartphone to fill in a survey.

Recall aid experiment: number of reported friends and quality of answer

Our second research question focuses on the use of a recall aid, to help respondents complete the name generator question. Comparing respondents who saw the recall aid before completing the name generator to those who did not, did not reveal a significant difference in the number of friends entered ($t = -0.73$; $p = 0.47$). This means that there was no statistical evidence for the recall aid helping respondents to report a larger social network.

Since it is likely that the recall aid has no effect on respondents who did not seriously consider the recall aid question, we conducted a *t*-test

[3] Additionally, we ran a post-hoc power analysis using the distribution of our sample and assuming an alpha of 0.05 and a power level of 0.95. Under these assumptions the mean difference between both samples would need to be at least 0.12 names on average. To find an effect with an alpha of 0.01 and a power of 0.99 the mean difference would need to be at least 0.14 names.

to compare only those respondents who gave a meaningful answer and saw the recall aid first, to respondents who saw the name generator first. As can be seen in Table 5, respondents who saw the recall aid first and gave a meaningful answer entered on average more friends (4.41) than those who did not see the recall aid before answering the name generator question (4.10). This difference was statistically significant ($t = 3.55$; $p < 0.001$). This could be seen as evidence for the recall aid helping respondents who gave a serious answer to think of more friends when answering the network name generator question.

However, our fully crossed experimental design allows us to also exclude respondents who gave non-meaningful answers from the group who saw the recall aid after completing the name generator. Interestingly, when comparing only respondents who gave at least one meaningful answer to the recall aid question and saw the recall aid question first to those respondents who gave at least one meaningful answer to the recall aid question and saw the name generator question first, the previously found significant difference vanishes ($t = -1.27$; $p = 0.20$). This suggests that the difference was not caused by the recall aid functioning as a memory trigger. Instead, respondents who gave meaningful answers to the recall aid question reported larger network sizes, independently of whether they first answered to the recall aid or first answered the name generator question. This means that the recall aid did not help respondents to remember their friends, but it functioned instead as a general indicator of response quality.

Combining both experiments: number of reported friends and quality of answers

Table 6 present the combined analysis of both experiments. There was no significant difference in the number of names reported between respondents who completed the name generator before the recall aid. Independently of whether a meaningful or non-meaningful answer was given to the recall aid, respondents on PCs and smartphones reported similar numbers of names (see the first three rows in Table 6). However, differences emerged in the group of respondents who saw the recall aid first. Row 6 shows that smartphone respondents entered significantly more friends (4.33) than PC respondents (4.01), when seeing the recall aid first. This pattern emerged no matter if they gave a non-meaningful or a meaningful answer to the recall aid (see Rows 4 and 5), although the difference was only marginally significant in the latter group ($t = -1.84$; $p = 0.07$). This suggests, again, that the smaller screen of smartphones and the smaller digital keyboard did not negatively affect the number of network contacts elicited from the name generator question. In sum, the difference between devices was only significant when analyzing respondents who were asked the recall aid before entering their friends. This suggests that seeing the recall aid first has a slight positive effect on the number of friends entered on smartphones.

Finally, we ran five OLS regression models to control for sociodemographic variables, smartphone skills, and the supplementary variables obtained from the panel provider. This was necessary considering the fact that the random allocation of respondents to either use a smartphone or a PC did not work properly given the selection bias.

Model 1 in Table 7 shows a significant effect of device on the number of friends entered when controlling for the effect of the recall aid. In line with the previous results, there is no significant effect of the recall aid.

When adding demographic variables and smartphone skills in Model 2, the influence of the device becomes smaller and is no longer significant, while being female has a strong positive significant effect and low and medium education have negative significant effects. In addition, respondents' ability to use a smartphone shows a positive significant effect. This means that women and respondents who are experienced using their smartphone were more likely to report a greater number of friends compared to men and those with less smartphone experience. Moreover, low and medium educated respondents entered fewer friends than high educated respondents.

Thus, Model 2 provides clear evidence that the previously found positive effect of using a smartphone on the number of names reported is *not* caused by the device but by several factors that differentiate smartphone respondents from PC respondents in our sample. The selection bias discussed above prevented a successful random allocation but increased the number of women, higher educated, and respondents with better smartphone skills in the smartphone sample. The device effect thus appeared because these respondents reported more names than men, those who were lower educated, and those with fewer smartphone skills.

Model 3 additionally includes the variables we received from the panel provider. While the previously entered variables remain largely unchanged, unemployment has a significant negative effect on network size and the number of practiced sports a significant positive one. This means that employed respondents were more likely to report a larger network size than the unemployed, which is in line with results found earlier (Edin et al., 2003; Munshi, 2003). Similarly, respondents who practiced more sports were more likely to report more friends. This finding is supported by previous research that found larger social networks among people who were members of voluntary organizations (Farkas and Lindberg, 2015; Putnam, 2000; Rotolo, 2000).

Model 4 additionally includes a measure indicating whether a respondent gave a meaningful answer to the open question and an interaction of this variable with the recall aid experiment. The results show that whether a meaningful topic was named has a strong positive influence on the number of friends entered. In contrast, the interaction between the position of the recall aid and reporting a meaningful topic is non-significant. This confirms the previous conclusion (Table 6) that the recall aid did not lead to reports of more network contacts. Respondents who gave a meaningful answer did not enter more friends because of the recall aid, but because they showed a higher motivation to complete the questionnaire effortfully.

Finally, in Model 5 the interaction is replaced by and interaction between the device used and the placement of the recall aid because Table 6 suggested that such an interaction effect may exist. Model 5 reveals no significant interaction effect between the placement of the recall aid and device used, showing that seeing the recall aid before the generator did not help smartphone respondents to complete the name generator to a greater extent than PC respondents. Again, our regression findings imply that the differences between the devices found in Table 6 were caused by respondent's characteristics, and not by the device used.

In sum, these results show that smartphones are an equally feasible option as PCs to conduct ego-centered social network research, at least for tech-savvy populations who are willing to answer online surveys on smartphones. Furthermore, the results suggest that respondents' likelihood to report a larger number of names is strongly related to their motivation and that this motivation can be measured by comparing meaningful and non-meaningful answers in an open-ended question.

Table 5
Effect of the Quality of the Recall Aid Answers on the Mean Number of Friends Reported.

Quality of answers to recall aid	Recall aid seen first	Recall aid seen second
Only non-meaningful answers	2.05 (142)	2.11 (109)
Only meaningful answers	4.41 (1651)	4.30 (1690)
All answers	4.16 (1793)	4.10 (1799)

Note. Mean values and total numbers in parentheses.
$N = 3{,}592$.
Number of friends entered was truncated at 10.

Discussion

Selection bias and network size

The study has several important implications for future network research using smartphones regarding selection effects, network sizes,

Table 6
Effect of the Recall Aid and Device on the Mean Number of Friends Reported.

Seen first	Quality of answer to recall aid	PC	Smartphone	Overall	T-test Smartphone vs. PC (p-value)
	Non-meaningful answers	2.09	2.10	2.11	0.98
Name Generator	Meaningful answers	4.25	4.34	4.30	0.46
	Total	4.03	4.18	4.10	0.23
	Non-meaningful answers	1.74	2.52	2.05	0.01**
Recall Aid	Meaningful answers	4.29	4.53	4.41	0.07
	Total	4.01	4.33	4.16	0.01**
Overall		4.02	4.25	–	0.01**
T-test name generator vs. recall aid seen first (p-value)		0.96	0.24	0.47	–

Note. Mean Values and an p-values for *t*-test.
N = 3,636.
*p < .05; **p < .01; ***p < .001 (two − tailed test).
Number of friends entered was truncated at 10.

Table 7
OLS Regressions Predicting Number of Friends Reported.

	Model 1	Model 2	Model 3	Model 4	Model 5
Device smartphone[a]	0.23**	0.09	0.10	0.07	−0.02
	(0.08)	(0.09)	(0.09)	(0.09)	(0.34)
Recall aid placement: first[b]	0.07	0.08	0.08	0.00	−0.109
	(0.09)	(0.08)	(0.09)	(0.32)	(0.08)
Gender female[c]		0.48***	0.49***	0.36***	0.36***
		(0.09)	(0.09)	(0.86)	(0.09)
Low education[d]		−0.77***	−0.67***	−0.58***	−0.58***
		(0.13)	(0.13)	(0.13)	(0.13)
Medium education[d]		−0.36**	−0.30*	−0.25*	−0.24*
		(0.10)	(0.10)	(0.01)	(0.10)
Age		0.00	0.00	0.00	0.00
		(0.00)	(0.00)	(0.00)	(0.00)
Smartphone skills		0.18***	0.17***	0.12***	0.11*
		(0.05)	(0.05)	(0.05)	(0.06)
Employment status: unemployed[e]			−0.34*	−0.30	−0.31
			(0.19)	(0.19)	(0.19)
Urban area[f]			0.10	0.12	0.19
			(0.09)	(0.09)	(0.09)
Medical conditions			−0.01	−0.01	−0.01
			(0.03)	(0.03)	(0.03)
Practiced sports			0.07**	0.08***	0.08***
			(0.02)	(0.02)	(0.02)
Quality of answer: meaningful[g]				2.08***	2.15***
				(0.25)	(0.16)
Smartphone*Recall aid placement: first					0.03
					(0.09)
Recall aid placement first*Quality of answer: meaningful				0.12	
				(0.33)	
Constant	3.99***	3.25***	3.06***	1.42***	1.27***
	(0.07)	(0.28)	(0.29)	(0.36)	(0.37)
N	3891	3891	3891	3891	3891
R^2	0.002	0.034	0.029	0.074	0.074
Adjusted R^2	0.015	0.023	0.027	0.071	0.071

Note. OLS Regression with unstandardized coefficients and standard error in parentheses.
Number of friends entered was truncated at 10.
[*] *p* < 0.05; ***p* < .01; ****p* < .001.
[a] Reference category is PC.
[b] Reference category is name generator seen first.
[c] Reference category is male.
[d] Reference category is education high.
[e] Reference category is employed.
[f] Reference category is non-urban area.
[g] Reference category is non-meaningful answer.

usage of recall aids, and satisficing response behavior. Particularly noteworthy is our finding that 62.5 % of participants who were randomly assigned to complete the survey on a smartphone and not on a PC did not comply with this request and were screened-out. As a consequence of this non-compliance, smartphone respondents were more likely to be female, younger, had a higher ability to use their smartphone, and were less likely to have a medium education level or to suffer from medical conditions compared to the PC group.

Such a selection bias can have severe consequences for social network research making use of smartphone surveys. In particular, many people who completed our survey on a smartphone belonged to demographic groups that are associated with having larger social networks. For instance, woman tend to report larger network sizes than men (Ajrouch et al., 2005; Goodreau et al., 2009; Lewis and Kaufman, 2018; McLaughlin et al., 2010) and younger people are more likely to report larger networks than older persons (Ajrouch et al., 2005).

Moreover, previous research has shown that larger and more functional social networks are associated with better health (e.g., Michael et al., 1999; Schaefer et al., 1981). As people with fewer medical conditions, woman, and younger people were overrepresented in our smartphone sample, the average network size of our smartphone respondents may have been overestimated. This suggests that we had found a smaller average network size in the smartphone sample, if our experimental assignment would have worked as planned.

However, not all results point to an overestimation of the network size in the smartphone sample. We found that employed people were less likely than unemployed to complete the survey on a smartphone, whereas employed people have been found to report larger social networks than those without a job (Edin et al., 2003; Munshi, 2003; Rollins et al., 2011). Considering this finding, it is also possible that we would have found a larger average network size among smartphone respondents under fulfilled experimental conditions. However, a smaller network size seems more likely, as we found three factors that hint at an overestimation of the network size on smartphones and only one factor that hints at an underestimation. This "true" network size could be more similar to the one of PC respondents or even slightly smaller. In sum, it is thus not certain whether the selection bias led to an overestimation of the network size among smartphone respondents, and more research on the impact of selection effects on network sizes in smartphone surveys is needed.

It should be noted that we also found a selection bias in the PC group. Those who followed the instruction to complete the survey on a PC were more likely to be male, had a higher education, and were older. Since some of these characteristics are associated with smaller networks (e.g., Goodreau et al., 2009; Lewis and Kaufman, 2018; McLaughlin et al., 2010), conducting ego-centered network surveys only with PCs may introduce a selection bias that leads to an underestimation of the average network size in a population. This selection bias illustrates that PCs cannot be seen as the gold standard to conduct ego-centered social network studies. Neither can responses of PC respondents be seen as entirely accurate. In line with previous studies on mode effects (Fischer and Bayham, 2019; Matzat and Snijders, 2010; Vriens and van Ingen, 2018), we have to conclude that none of the devices is clearly superior to the other when it comes to generating ego-centered social networks.

Device effects

When comparing the network size in a PC survey to the one elicited on smartphones, we found that the use of smartphones to complete the name generator of an ego-centered network study did not negatively affect the reported network sizes. Previous work found mixed-evidence on whether respondents in an online (PC) survey name fewer or more network contacts than respondents in a face-to-face survey (Fischer and Bayham, 2019; Matzat and Snijders, 2010; Vriens and van Ingen, 2018). Our results initially suggested that more names were elicited in the smartphone condition than the PC condition. However, this was due to the overrepresentation of certain groups that tend to report larger networks, induced by the selection bias. Thus, this study concludes that moving from PC to smartphone does not increase the number of reported names but it also does not negatively affect it. This finding is quite remarkable considering the increased difficulty of answering a survey on smartphones that have considerably smaller displays and keyboards than PCs. Thus, at least among those respondents who are willing to complete a smartphone survey, using smartphones for data collection of ego-centered social network data seems to be an excellent opportunity compared to more traditional online methodologies. In fact, allowing smartphones as a response device could even be an option to reduce nonresponse of groups in PC surveys that may prefer to answer on a smartphone, such as tech-savvy populations.

A possible reason for the promising results regarding the implementation of network name generator questions on smartphones could be that smartphones, as highly personalized devices used for private communication, help respondents to more easily recall their friends and therefore reduce cognitive effort. Respondents could also easily and quickly open their address books or recent conversations on the smartphone to recall important contacts, which can increase the number of names reported (Hsieh, 2015). While PC respondents may likewise access their contacts (e.g., recent email conversations), the majority of personal communication nowadays takes place via smartphones (e.g., via direct messenger apps). These factors might compensate for a longer response time that we found on smartphones, most likely due to the less comfortable input mechanics. It is also possible that a longer response time emerged from respondents leaving the survey to check their contact lists or social media apps for contacts. Another reason that could possibly have influenced the reported network size on smartphones is that some smartphone keyboards are able to autocomplete frequently written names, such as those of close friends. Future research could make use of para- and meta-data on respondents' behavior to investigate whether these factors are more relevant on smartphones than on PCs and test whether such behaviors increase the number of reported names.

Open question as data quality indicator

We did not find a positive effect of providing a recall aid before the name generator on the reported network size. This was the case for respondents who answered the questionnaire on their PC and for those who answered on their smartphones. Earlier studies suggest that reminding respondents of various social settings in which they could have interacted or of different types of relationships through asking multiple network generator questions leads to the reporting of more names (Brewer, 2000). A potential explanation for our null finding could thus be that the recall aid question was too general as we simply asked what respondents considered important with regard to their friends. Future research might thus be better advised to use more specific recall aids and probes that remind people of particular contexts and relationships.

When examining the responses to the open recall aid question more closely, we found their quality to be a strong predictor for reporting a larger number of friends to the name generator question. Specifically, whether respondents gave meaningful answers to the recall aid question or not was the strongest predictor of reported network size in our study. This suggests that the open question can serve as a proxy for a respondent's motivation to put effort into accurately engaging with a survey. The open question is therefore a potential tool to identify respondents who show satisficing response behavior. According to the theory of survey satisficing (Krosnick, 1991), some respondents are not willing to invest sufficient cognitive effort into answering a survey question adequately, but instead "satisfice" by providing an easily accessible answer such as selecting the first response option or saying "don't know" (Krosnick, 1991, 1999). This effect manifested itself in our survey in the form of respondents skipping the recall aid without answering at all or delivering a non-meaningful answer and also by providing no or only a few names to the name generator. Hence, this study suggests that including an open question previous or close to a network generator, can help to evaluate respondents' mindfulness (Vannette and Krosnick, 2014), which may be directly connected to the response quality.

In our study, when using the open-ended question as a proxy for response quality, only 7.1 % of the respondents showed problematic response behavior, by giving non-meaningful answers (which compares to other studies on survey satisficing, e.g., Gummer et al., 2018). However, this group of respondents significantly reduced the average number of names reported in the network generator question on both devices, so that researchers cannot simply ignore respondents who try to shorten the response process and provide an answer that requires less consideration and thinking. Asking an open-ended question previous to a name generator can help identifying such respondents in future studies.

Limitations

While our results provide first evidence that ego-centered network studies on smartphones are feasible, further research is necessary for several reasons. Our survey was based on a non-probability sample, drawn from an online access panel. Such panels are prone to several biases, such as selection biases caused by the non-probability nature of the selection of panel members and the large number of surveys in which most panel respondents take part (Hillygus et al., 2014; Matthijsse et al., 2015). Further, we detected a large selection bias caused by the device assignment. While our analyses corrected for the bias to some extent by including relevant demographic and supplementary variables that were obtained from the panel provider, such an approach can never completely rule out the bias. Screened-out respondents may differ on other potentially important variables that are associated with people's sociability. For instance, research found that personality traits are associated with network size (Kalish and Robins, 2006; Tziner et al., 2004) and future studies could account for those.

In addition, the selection effects we found may imply a general reluctance of certain groups to complete surveys on smartphones (de Bruijne and Wijnant, 2014; Fuchs and Busse, 2009; Toepoel, 2017) but it may also be a consequence of the way in which people were invited to participate in the survey. The link to the survey was sent via email and many people may still read their email on their computer and not on a smartphone. Network researchers should thus consider inviting their respondents in ways that are more likely to be read on the device the survey is supposed to be completed such as, for instance, via text messages or scannable Quick Response (QR) codes.

Finally, it should be recognized that our experimental study used only a single network name generator question but did not employ a complete social network module. Further methodological research should examine effects of smartphone use on additional indicators, such as multiple name generator questions, name interpreter questions, and questions about the network structure. Repeatedly answering the same question about all alters and reporting on the existence of all alter-alter ties can reduce respondents' willingness to effortfully answer all questions in a PC survey (Matzat and Snijders, 2010). This may be even worse on the small displays of smartphones. The small displays of smartphones also restrict the use of visual tools to collect ego-centered network data (Hogan et al., 2016; Stark and Krosnick, 2017), which have been found to increase respondents' motivation (Stark and Krosnick, 2017). Thus, while our results suggest that the network size is not lower in smartphone surveys in populations that are willing to complete such surveys, it remains unknown how smartphones affect the response quality of other network characteristics in ego-centered network studies.

Conclusion and recommendations

Despite the limitations, our results suggest that smartphones are a feasible device to conduct ego-centered social network research and could help to increase response rates and measurement accuracy by including groups that are unlikely to participate in surveys on a regular computer. Thus, based on our results, we recommend allowing the usage of smartphones as an additional option to answer web surveys, as the free device choice is likely to reduce nonresponse bias and increase measurement quality. At the same time, our results also imply that forcing respondents to use smartphones to complete a survey can result in selection biases, as specific groups of people may be unwilling to use this device. Hence, forcing respondents to make use of a specific device to complete the survey is not recommendable. This is true for both smartphones and PCs since we also found evidence of a selection bias in the PC sample.

A potential strategy to deal with selection biases due to the selected device may be post-stratification weighting. However, we recommend using such weights only in cases were bias in the data was detected and not as a general data handling strategy. Our study shows that identifying appropriate weighting variables beyond demographics is not trivial and that information on such variables, such as the individual health status or personality traits, is often not available. Thus, it appears best to try to minimize selection bias by improving the study design in the survey planning phase and by that avoiding the necessity of post-stratification weighting.

Nevertheless, our results also suggest that a smartphone-only survey is a feasible option for tech-savvy populations since tech-savvy respondents were particularly likely to take part in our survey on their smartphones. In addition, if researchers need their respondents to answer a survey on smartphones, for example, because the study includes additional measurements via an app, we recommend inviting respondents to the survey through a method that is likely read on smartphones, such as text messages or QR codes. This should prevent non-response caused by people's unwillingness to switch to a different device than the one on which they have read the invitation to the survey.

Lastly, our study suggests that an open-ended question about the network can be a valuable tool to identify respondents that are satisficing and not answering effortfully. Including such a question can help researchers to evaluate response quality efficiently. Given the widespread use of smartphones among people around the world (Poushter et al., 2018) and people's rapid adjustment to new technologies, researchers will soon be tempted to routinely collect network information on these devices. Our study suggests that this endeavor might be fruitful, but it also encourages more work on name interpreter questions as well as selection effects to uncover the full potential of this methodological avenue of social network research.

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Declarations of Competing Interests

None.

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.socnet.2020.06.006.

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