*Understanding Society*
**Working Paper Series**

**No. 2017 – 10**

**October 2017**

# Willingness to use mobile technologies for data collection in a probability household panel

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Understanding Society
THE UK HOUSEHOLD LONGITUDINAL STUDY

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## Non-technical summary

The emergence of mobile technologies, including smartphones and tablets, offers new possibilities for survey research. Survey respondents increasingly use mobile devices to complete online questionnaires. In addition, the in-built features of these devices, such as GPS, cameras and Bluetooth, enable the collection of new types of data. There are, however, various potential barriers to collecting new types of data with mobile devices: depending on the target population, not all subgroups will have access to mobile devices, and be able and willing to use them for the specified task.

This paper investigates the willingness of the general population to use mobile technologies for data collection. We asked 1,660 members of the *Understanding Society* Innovation Panel, a nationally representative household panel study in Great Britain, who reported using a smartphone or tablet, about their willingness to participate in various data collection tasks on their mobile devices. We find that willingness varies considerably depending on the type of activity involved: respondents are less willing to participate in tasks that involve downloading and installing an app, and in tasks that collect data of a more private nature. They are more willing to participate in tasks that require their active participation than in tasks where data are collected passively. Willingness to participate in a given task also varies between smartphones and tablets, and between respondents: respondents who report higher concerns about the security of data collected with mobile technologies and those who use their devices less intensively are less willing to participate in any of the mobile data collection tasks.

# Willingness to use mobile technologies for data collection in a probability household panel

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**Abstract**

We asked members of the *Understanding Society* Innovation Panel about their willingness to participate in various data collection tasks on their mobile devices. We find that willingness varies considerably depending on the type of activity involved: respondents are less willing to participate in tasks that involve downloading and installing an app, or where data are collected passively. Willingness also varies between smartphones and tablets, and between respondents: respondents who report higher concerns about the security of data collected with mobile technologies and those who use their devices less intensively are less willing to participate in any of the mobile data collection tasks.

**Keywords:** smartphone, tablet, app, GPS, Bluetooth, accelerometer

**JEL classification**: C81, C83

**Acknowledgements:** This study was supported by a +3 PhD grant from the Economic and Social Research Council (ESRC) awarded to Alexander Wenz [grant number ES/J500045/1], by an Overseas Institutional Visit grant from the ESRC awarded to Alexander Wenz, by a research grant from the ESRC Transformative Research scheme and the National Centre for Research Methods (NCRM) awarded to Annette Jäckle [grant number ES/N006534/1], by a research grant from the ESRC awarded to Nick Buck and Michaela Benzeval that funded the Innovation Panel data collection [grant number ES/K005146/1], and by an International Visitor Exchange Scheme grant from the NCRM awarded to Mick Couper and Annette Jäckle.

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## Introduction

Mobile technologies, including smartphones and tablets, can be used in various ways for data collection. On the one hand, mobile devices allow administering survey questionnaires in innovative ways: respondents can be asked to answer questions sent via text messaging, or to complete questionnaires in a mobile web browser or in a survey app installed on a smartphone or tablet. These forms of survey administration allow near real-time data collection, for example as part of ecological momentary assessment in psychological studies (Moskowitz & Young, 2006), that make it possible to collect more detailed and more wide-ranging measures across multiple time points while reducing the need to recall information. On the other hand, mobile technologies enable researchers to collect new forms of data from survey respondents by relying on the additional measurement capabilities of mobile devices. GPS data can be collected from the respondent's mobile device to measure their location and travel patterns (e.g., Geurs, Veenstra, & Thomas, 2013), or to trigger surveys at pre-specified locations using geo-fencing (e.g., Ginnis, 2017). Accelerometer data can similarly be collected from the respondent's mobile device (e.g., Lathia, Sandstrom, Mascolo, & Rentfrow, 2017), as can data from external devices that are connected via Bluetooth, such as activity trackers (e.g., Scherpenzeel, 2017), smart scales (e.g., Kooreman & Scherpenzeel, 2014), or transdermal devices (e.g., Greenfield, Bond, & Kerr, 2014). Such data can be used to measure physical activity as well as other biological features, such as weight, body fat, and stress. Other possibilities of mobile data collection include asking respondents to take photos with the camera of their smartphone or tablet, for example to scan payslips or shopping receipts (e.g., Jäckle, Lessof, Burton, & Couper, 2017), or to track how respondents are using their mobile device (e.g., Revilla, Ochoa, & Loewe, 2016), for example which websites they are visiting. These new forms of data, some of which cannot feasibly be collected with survey questionnaires, can supplement or potentially even replace data collected using questionnaire-based methods.

Depending on the population of interest, however, not all subgroups will have access to mobile devices. In 2016, 71 percent of households in the United Kingdom reported owning a smartphone and 59 percent reported owning a tablet, but there are large differences by age and socio-economic status (Ofcom, 2016). Socio-demographic differences in coverage are similar in the United States and in other Western countries (Poushter, 2016). To reduce coverage bias in studies with mobile data collection, sample members without mobile device access or Internet access could be provided with a smartphone or tablet and a mobile Internet

connection. This approach has already been implemented in two associated studies of the LISS Panel, a probability-based online panel in the Netherlands: the Smartphone Time Use Study and the Mobile Mobility Study (Scherpenzeel, 2017). Among those who have access to mobile devices, further potential barriers are whether individuals would actually be able and willing to participate in studies involving mobile data collection.

A few studies have started to examine the stated willingness of respondents to perform additional data collection tasks on their mobile device as part of a survey, and which factors are associated with willingness. Results suggest that the level of willingness is relatively high, but varies by data collection task: willingness is higher for tasks where respondents have control over the transmitted content than for tasks where data are collected automatically, even if those tasks require more effort from the respondent (Revilla, Couper, & Ochoa, 2017; Revilla, Toninelli, Ochoa, & Loewe, 2016). In addition, willingness varies with respondent characteristics. Respondents who use their device more intensively, measured by how often they download apps on their smartphone and the number of apps they regularly use, are more willing to participate in mobile data collection tasks (Keusch, Antoun, Couper, Kreuter, & Struminskaya, 2017; Pinter, 2015). In contrast, willingness is lower among people with higher privacy and security concerns and people with lower levels of trust that institutions will protect their data (Keusch et al., 2017; Revilla et al., 2017). Study characteristics also matter: willingness is higher for studies that are sponsored by a university rather than a government agency, studies that include incentives, and those that run over a shorter period of time overall (Keusch et al., 2017).

The previous literature examining stated willingness to participate in mobile data collection tasks has several limitations. First, all studies rely on data from opt-in online panels rather than probability samples of the general population. The sample members of these panels are self-selected and might be more cooperative than the general population. Second, existing research lacks a theoretical discussion of the underlying mechanisms of willingness. Third, while existing studies have examined the implications of respondent and study characteristics, no studies have examined the interactions of respondent and task characteristics in determining willingness.

In this paper, we examine the stated willingness of the general population to use mobile technologies for a range of data collection tasks, and what affects willingness. We propose a

framework of how characteristics of the data collection task (that might constitute potential barriers to participation), respondent characteristics, and interactions between the two, can affect willingness to participate in mobile data collection. We use data on 1,660 survey respondents of the *Understanding Society* Innovation Panel, a nationally representative household panel study in Great Britain, who reported using a smartphone or tablet, to examine the following research questions:

(1) How does willingness to use mobile technologies vary across different data collection tasks?
(2) How does willingness to do different tasks vary between smartphone and tablet?
(3) Which respondent characteristics predict willingness to do different tasks?
(4) Which task characteristics predict willingness, and does the effect depend on respondent characteristics?

**Task characteristics and respondent characteristics associated with willingness to participate in mobile data collection**

Mobile data collection tasks have various characteristics that constitute potential barriers to participation and which might affect the respondent's willingness to take part. In Table 1, we outline five key characteristics for a range of data collection tasks.

A first characteristic is that most data collection tasks require respondents to download and install an app on their smartphone or tablet to be able to take part in the data collection process. For some tasks, respondents also need to activate features on their device (for example turning on Bluetooth) or give data capture permissions (for example allowing the app to capture GPS coordinates of the mobile device). Only a few tasks, including administering a web questionnaire in the mobile browser or administering a questionnaire by text messages, can solely rely on apps that are already installed on the respondent's device and that do not need any additional permissions by the respondent.

Second, the data collection activities differ in how actively they involve the respondent in the data collection process, which affects how much control respondents have over the content measured. Some activities require respondents to actively complete measurements, such as answering questions in a survey app or taking photos. These activities give respondents full control over what information they provide to the researcher. Other activities, such as GPS

location tracking, rely on passive measurement and do not involve respondents in the data collection process once they have downloaded and installed an app and given consent to data collection. For these activities, the only control respondents have over what is measured is that they can switch off the data collection process. Passive data collection activities allow the collection of continuous data: the GPS location of a mobile device, for example, can be tracked continuously over a certain period.

Table 1. Characteristics of mobile data collection tasks

| Mobile data collection task | (1) Requires downloading and installing an app | (2) Role of respondent | (3) Requires uploading mobile data | (4) Technical demands | (5) Potential privacy threat |
|---|---|---|---|---|---|
| Questionnaire | No | Active | Yes | Low | Content-dependent |
| Survey app | Yes | Active | Yes | Low | Content-dependent |
| Device usage tracking app | Yes | Passive | Yes | High | Yes |
| Text messages | No | Active | No | Low | Content-dependent |
| Camera | Yes | Active | Yes | High | Content-dependent |
| Accelerometer | Yes | Passive | Yes | High | Content-dependent |
| GPS | Yes | Passive | Yes | High | Yes |
| Bluetooth linkage to external device | Yes | Passive | Yes | High | Content-dependent |

Third, all data collection tasks, except those that rely on text messaging for data transmission, require that data are uploaded as part of the data collection process, which might affect mobile data usage limits. The amount of data to be uploaded varies between activities, for example uploading photos is likely to require more data than uploading GPS coordinates at one point in time.

Fourth, mobile data collection tasks have different technical demands, including how much battery power and storage capacity they require. Tasks that collect data via sensors, such as GPS or accelerometer, as well as tasks that rely on apps that are continuously running in the background, such as an app that tracks how respondents use their mobile device, are likely to

reduce battery life more than tasks that rely on apps that are only used intermittently, such as answering questions sent via text messaging. The required storage capacity also varies between tasks, for example taking photos for data collection requires more storage capacity, as photos need to be stored on the mobile device before they are sent to the researcher, whereas other tasks require no additional storage capacity, for example tasks that use the mobile browser that is already installed on the respondent's mobile device. In Table 1, we classify the technical demands of tasks in relative terms; we code tasks as highly demanding if they consume a lot of battery power, require a lot of storage capacity, or both. How each task is implemented, for example how frequently GPS coordinates are captured, can affect the technical demands.

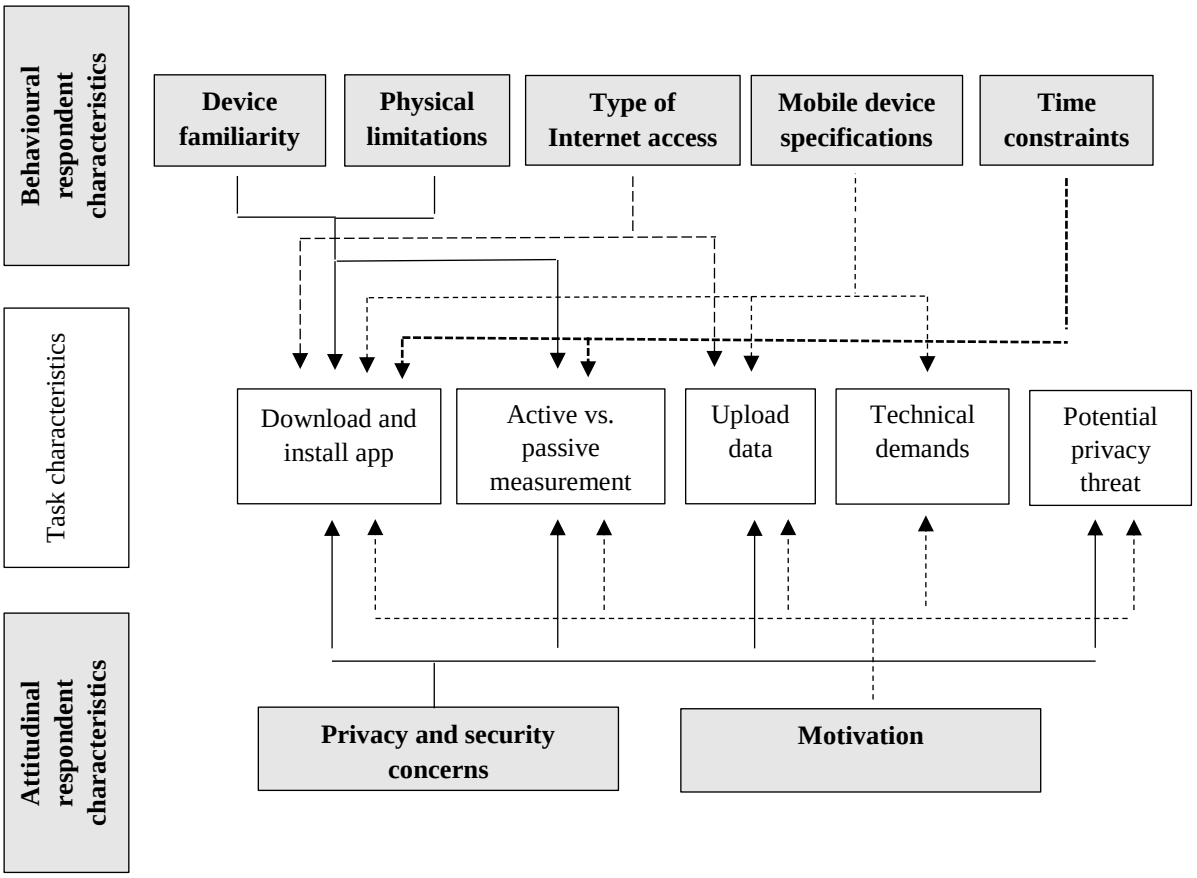
Finally, the data collection activities differ in the extent to which they potentially intrude on the respondent's privacy. GPS data are of a more private nature as they could possibly be used to identify an individual. Similarly, data from an app that tracks the respondent's usage of their phone are of a more private nature. For other tasks, privacy concerns are likely to depend on the content of the data collected. For example, accelerometer data might be perceived as private by some people, in a similar way as self-reports on physical activity might be sensitive for some people.

As data collection tasks differ in what they require from respondents, willingness to use them is likely to vary between tasks, but also between respondents: some requirements might constitute barriers to participation for some people but not for others. Figure 1 represents a conceptual framework of how respondent characteristics may interact with characteristics of data collection tasks, and how this interaction can affect willingness to participate in mobile data collection. The relevant respondent characteristics include both behavioural and attitudinal characteristics.

**Device familiarity** is the first behavioural characteristic**.** Respondents who feel more comfortable and confident with using their mobile device, who use their device more frequently, or who already use relevant device features for their own purposes might be more willing to participate in mobile data collection tasks. Device familiarity might especially affect tasks that require respondents to download and install an app, and those that actively involve respondents in the data collection process. Previous research has shown that device familiarity is associated with increased smartphone use to complete web questionnaires

(Couper, Antoun, & Mavletova, 2017), and a similar association can be expected between device familiarity and the willingness to use mobile technologies.

Figure 1. Task characteristics and respondent characteristics that can affect the willingness to participate in mobile data collection tasks




**Physical limitations.** Respondents with physical limitations, in particular visual impairment and limited manual dexterity, may find it harder to use mobile devices (McGaughey, Zeltmann, & McMurtrey, 2013) and may therefore be less willing to participate in mobile data collection tasks. Physical limitations are also more likely to affect technologies that require respondents to download and install an app, and to be actively involved in the data collection process.

**Type of Internet access.** The way that respondents connect their mobile device to the Internet may be another determinant of how willing they are to participate in mobile data collection. Respondents who only use mobile Internet and have limited mobile data allowances may be less willing to participate in mobile data collection than those with unlimited data plans or WiFi access at home. The type of Internet access is particularly

relevant for data collection tasks that require downloading an app and uploading a large amount of mobile data.

**Mobile device specifications.** The technical specifications of the mobile device that respondents use may also affect their willingness to participate in mobile data collection. Respondents may not have sufficient storage capacity on their device to download and install apps or to store data, they may use older mobile devices with shorter battery life and slower processing speed, they may not have an app store account, or they may use an operating system for which the data collection app has not been developed. Depending on the specification of their device, respondents may hence be less able and willing to participate in mobile data collection, in particular to complete tasks that require downloading an app, or that use a large amount of storage capacity and battery power.

**Time constraints.** Busy people, including respondents with long working and commuting hours, and those with young children and caring responsibilities, may be less willing to participate in data collection requests using mobile technologies. They may be particularly reluctant to complete tasks that require active involvement in the data collection process and repeated participation. People with time constraints were shown to have lower response propensities in surveys (Abraham, Maitland, & Bianchi, 2006; Groves & Couper, 1998), which suggests that a similar association can be expected between time constraints and willingness to participate in additional data collection requests that are beyond survey interviews.

**Privacy and security concerns** are the first attitudinal characteristic. Mobile technologies have the potential to automatically collect personally identifying information on a large scale, including photos, GPS coordinates and device use profiles. Respondents might consider these data collection activities intrusive to their privacy, and might be concerned about data security when providing sensitive information to researchers via mobile technologies (Chin, Felt, Sekar, & Wagner, 2012). Respondents who have greater concerns about privacy and data security might be less willing to participate in mobile data collection tasks, in particular to complete tasks that involve downloading an app, that are potentially intruding to privacy and tasks where respondents have little control over the transmitted content.

**Motivation.** Respondents who have a strong sense of loyalty or commitment to the study, who have previously been cooperative, and who are highly interested in the survey topic may be more willing to accept each of the potential barriers to participation in mobile data collection. Previous research on the willingness to comply with in-survey requests has, for example, found that respondents who were cooperative in previous survey interviews were also more likely to give consent to administrative data linkage (Sakshaug, Couper, Ofstedal, & Weir, 2012).

## Data and Methods

*Survey*

We use data from wave 9 of the *Understanding Society* Innovation Panel, a nationally representative household panel study in Great Britain funded by the UK Economic and Social Research Council and led by the Institute for Social and Economic Research at the University of Essex (University of Essex. Institute for Social and Economic Research, 2017). The Innovation Panel is based on a stratified, clustered sample of households in England, Scotland, and Wales (Lynn, 2009). All household members aged 16 and older are eligible and interviewed annually. At wave 9 the household response rate was 84.7 percent, with 85.4 percent of eligible adults responding in these households (AAPOR RR1) (Jäckle, Gaia, Al Baghal, Burton, & Lynn, 2017). The wave 9 sample included original sample members, plus refreshment samples added at waves 4 and 7. A random two-thirds of sample households were allocated to a sequential mixed-mode design, where non-respondents to the web survey were followed up by face-to-face interviewers. The other third of households were first approached by face-to-face interviewers. In the final phase of fieldwork non-respondents were given the option of completing the survey online or by telephone. Data for wave 9 were collected between May and September 2016. For details on the survey design and fieldwork see the documentation available at https://www.understandingsociety.ac.uk/documentation/innovation-panel. The data are available from the UK Data Service at https://discover.ukdataservice.ac.uk/catalogue/?sn=6849.

*Measures of willingness to use mobile technologies*

The questions about hypothetical willingness to participate in mobile data collection were asked of respondents who said that they use the Internet for personal purposes and have access to a smartphone, to a tablet, or both. Our analyses of willingness are therefore conditional on reported mobile device access.

We asked respondents with access to a smartphone: "How willing would you be to carry out the following tasks on your smartphone for a survey?" (very willing, somewhat willing, a little willing, not at all willing)

(1) Complete an online questionnaire on your mobile phone
(2) Download a survey app to complete an online questionnaire
(3) Download an app which collects anonymous data about how you use your smartphone
(4) Answer a couple of questions sent via text messaging
(5) Use the camera of your smartphone to take photos or scan barcodes
(6) Allow built-in features of your smartphone to measure the frequency and speed at which you walk, run or cycle
(7) Share the GPS position of your smartphone
(8) Connect your smartphone via Bluetooth to other electronic devices (e.g., wearables such as Fitbit).

Similarly, respondents who reported having access to a tablet were asked: "How willing would you be to carry out the following tasks on your tablet for a survey?" (very willing, somewhat willing, a little willing, not at all willing)

(1) Complete an online questionnaire on your tablet
(2) Download a survey app to complete an online questionnaire
(3) Download an app which collects anonymous data about how you use your tablet
(4) Use the camera of your tablet to take photos or scan barcodes
(5) Connect your tablet via Bluetooth to other electronic devices (e.g., wearables such as Fitbit).

If respondents reported using both devices, they were asked both sets of questions – first about their willingness to complete tasks on their smartphone, then about their tablet. In the face-to-face interview, the questions were implemented in the computer-assisted self-

interviewing (CASI) section to reduce potential mode effects due to the mixed-mode design of the Innovation Panel. In this section, the interviewer passed the laptop to the respondents and asked them to complete the questions on their own.

Of the 2,174 respondents who gave a full interview, 48 respondents were excluded because they participated in the CAPI interview but refused or were not able to do the self-completion section; 31 respondents were excluded because they gave a CATI interview in the final non-response conversion stage and were not asked the self-completion section; a further 190 respondents were excluded because they do not use or have access to the Internet. This leaves 1,905 Innovation Panel respondents who were asked about mobile device access. Among those respondents, 87.1 percent reported having access to either a smartphone or a tablet and were hence asked about willingness (N = 1,660). The remaining 12.9 percent have no access to either mobile device or provided missing values to both questions on mobile device access and were excluded from the analytic sample (N = 245). The majority of respondents with mobile device access use both devices (59.0 percent) whereas 24.0 percent only use a smartphone and 17.0 percent only a tablet.

The data were weighted for all analyses to account for unequal selection probabilities and differential nonresponse. Standard errors were adjusted to account for the stratified, clustered sample design of the *Understanding Society* Innovation Panel. All analyses were conducted using the svy procedures in Stata.

*Respondent-level predictors of willingness*

This section describes how we operationalised the respondent-level predictors of our framework. Descriptive statistics for the predictors are documented in Table 2. The full wording of questions is documented in the Appendix; numbers in parentheses index the corresponding questions in the Appendix.

**Device familiarity.** We use three measures of device familiarity which were asked separately for smartphone and tablet: frequency of use, intensity of use, and self-rated skill. We coded ***frequency of device use*** (Q4) as 1 if the device is used daily, and 0 otherwise. The categories were collapsed rather than included as an ordinal or continuous measure because the distribution is highly skewed. To measure ***intensity of use*** (Q5), we asked respondents how many different activities they carry out on their device. We include the number of activities

carried out as a count variable, ranging from 0 to 12. Finally, we asked respondents to rate their ***skills using a mobile device*** (Q6). We include self-rated skill as a continuous variable, ranging from 1 = Beginner to 5 = Advanced.

**Physical limitations.** We include an indicator of whether the respondent has any ***physical limitations***: coded as 1 if the respondent has any visual impairment apart from wearing standard glasses or has limited manual dexterity, and coded as 0 otherwise. Note from Table 2 that this variable is highly skewed: among the sample of mobile device users, most respondents do not have any physical limitations.

**Type of Internet access.** To measure how respondents ***access the Internet*** (Q2), we use an indicator coded as 1 if the respondent has WiFi at home, and 0 if not. Again, note from Table 2 that most people have WiFi access from home. We also asked smartphone users about the ***type of data plan*** (Q3) they have. The variable is coded as 1 if the respondent has a fixed data plan with a monthly data allowance, and 0 if the respondent has a pay-as-you-go contract or uses WiFi only.

**Time constraints.** We derived an indicator for the respondent's ***time constraints***: coded as 1 if the respondent is employed or self-employed and works for more than 40 hours per week, or commutes to work for more than one hour one-way, or has young children under the age of five in the household or other caring responsibilities, and coded as 0 otherwise.

**Security concerns.** We asked respondents to rate their ***security concerns*** (Q8) when providing information using various mobile technologies: whether they are not at all concerned, a little concerned, somewhat concerned, very concerned, or extremely concerned. They were asked about the same set of technologies as in the willingness questions: smartphone users were asked about eight different technologies, tablet users about five technologies. Respondents with access to both smartphone and tablet were asked this question only once, about security concerns on smartphone and tablet at the same time. To measure the average level of security concerns across technologies, we use the mean of the individual security concern items, ranging from 1 (if the respondent is not at all concerned about any technologies) to 5 (if the respondent is extremely concerned about all technologies).

Table 2. Descriptive statistics of respondent characteristics

| | | Smartphone users | | Tablet users | |
|---|---|---|---|---|---|
| | | % | N | % | N |
| **Frequency of use** | Every day | 81.2 | | 52.6 | |
| | Less than every day | 18.8 | 1,378 | 47.4 | 1,260 |
| **Number of activities** | Mean | 8.2 | | 6.7 | |
| | SD | 3.2 | | 3.4 | |
| | Min; Max | 0; 12 | 1,378 | 0; 12 | 1,258 |
| **Self-reported skill** | Mean | 3.7 | | 3.6 | |
| | SD | 1.1 | | 1.1 | |
| | Min; Max | 1; 5 | 1,378 | 1; 5 | 1,260 |
| **Physical limitations** | Yes | 4.5 | | 5.3 | |
| | No | 95.5 | 1,376 | 94.7 | 1,259 |
| **WiFi access at home** | Yes | 97.5 | | 98.6 | |
| | No | 2.5 | 1,379 | 1.4 | 1,261 |
| **Type of smartphone contract** | Fixed data plan | 84.2 | | -- | |
| | Pay-as-you-go contract, or WiFi only | 15.8 | 1,377 | -- | |
| **Time constraints** | Yes | 27.1 | | 23.5 | |
| | No | 72.9 | 1,379 | 76.5 | 1,261 |
| **Security concerns** | Mean | 2.6 | | 2.7 | |
| | SD | 1.0 | | 1.1 | |
| | Min; Max | 1; 5 | 1,366 | 1; 5 | 1,250 |
| **Item-nonresponse** | ≥1 items missing | 62.9 | | 62.6 | |
| | No items missing | 37.1 | 1,379 | 37.4 | 1,261 |
| **Consent to data linkage** | Yes | 59.8 | | 59.0 | |
| | No | 40.2 | 1,347 | 41.0 | 1,232 |
| **Mode of interview** | Face-to-face | 42.0 | | 42.0 | |
| | Web | 58.0 | 1,379 | 58.0 | 1,261 |
| **Number of eligible waves** | 1-3 | 35.1 | | 31.6 | |
| | 4-6 | 25.7 | | 24.9 | |
| | 7-9 | 39.2 | 1,379 | 43.5 | 1,261 |
| **Proportion of full interviews** | Mean | 0.9 | | 0.9 | |
| | SD | 0.2 | | 0.2 | |
| | Min; Max | 0.1; 1 | 1,379 | 0.1; 1 | 1,261 |
| **Gender** | Female | 53.9 | | 56.8 | |
| | Male | 46.1 | 1,379 | 43.2 | 1,261 |
| **Age** | Mean | 42.9 | | 47.7 | |
| | SD | 15.7 | | 16.7 | |
| | Min; Max | 16; 87 | 1,379 | 16; 91 | 1,261 |
| **Education** | Higher degree | 43.2 | | 44.0 | |
| | A-level | 26.0 | | 23.3 | |
| | GCSE | 23.8 | | 24.5 | |
| | No qualification | 6.9 | 1,368 | 8.2 | 1,254 |
| **Labour force status** | In work | 68.3 | | 61.9 | |
| | Not in work | 31.7 | 1,378 | 38.1 | 1,259 |
| **Individual monthly gross income in £** | Mean | 2,102.5 | | 2,037.4 | |
| | SD | 3,380.0 | | 2,892.2 | |

| | | | | | |
|---|---|---|---|---|---|
| | Min; Max | 0; 85,780.4 | 1,379 | 0; 85,780.4 | 1,261 |
| **Housing tenure** | Has own house | 75.0 | | 80.6 | |
| | Not own house | 25.0 | 1,378 | 19.4 | 1,260 |

**Motivation.** We include several measures of respondent motivation and engagement with the study. The first indicator is whether the respondent has any ***item-nonresponse*** in the survey, coded as 1 if the respondent has at least one missing item among the questions prior to the questionnaire module on willingness, and 0 otherwise. The second indicator is whether the respondent gave ***consent to link*** their survey data with credit rating data held by the Financial Conduct Authority (FCA), coded as 1 if the respondent gives consent, and 0 if not. As the consent rate to data linkage is considerably lower in web than in face-to-face (Burton, 2016), we also control for the ***mode of data collection***, coded as 1 if web and 0 if face-to-face. The third indicator is the ***number of waves for which the respondent has been eligible***: whether the respondent has been a member of the *Understanding Society* Innovation Panel for 1-3 waves, for 4-6 waves, or for 7-9 waves. The final indicator is the ***proportion of waves in which the respondent was eligible and gave a full interview***, ranging from 0.11 to 1.

**Socio-demographics.** Finally, we control for a set of socio-demographic characteristics, including gender, age, education, labour force status, income, and housing tenure. ***Gender*** was coded as 1 if female and 0 if male. We include a variable for ***age*** and one for ***age-squared*** as age was found to have a curvilinear relationship with willingness. ***Education*** was coded in four categories: whether the respondent has a professional or a university degree, has A-levels (equivalent to 13 years of schooling in the UK), has GCSE (equivalent to 11 years of schooling in the UK), or has no qualifications. ***Labour force status*** was coded as 1 if the respondent is in work (employed or self-employed), and 0 if not in work. To measure ***income***, we use a derived indicator of the respondent's monthly gross income that is provided with the data set, including earnings from employment and self-employment as well as unearned income from benefits, pensions and other sources. In the model, we take the natural logarithm as the distribution of income is highly skewed. ***Housing tenure***, used as a measure of wealth, was coded as 1 if the respondent lives in their own house (with a mortgage or owned outright), and 0 otherwise.

*Task-level predictors of willingness*

To examine the association between task characteristics and the willingness to participate in mobile data collection, we coded the characteristics of each of the eight types of mobile data collection tasks according to Table 1: whether the data collection task requires respondents to ***download and install an app*** (coded as 1 if yes 0 if no); whether respondents have an ***active role*** in the data collection process (coded as 1 if respondents are actively and 0 if they are passively involved); whether the task has relatively ***high technical demands*** (coded as 1 for high or medium technical demands and 0 for low demands); and to what extent the data collection ***intrudes on the respondent's privacy*** (coded as 1 if the activity represents a privacy threat and 0 if the privacy threat is content-dependent). We do not include an indicator of whether the data collection task involves uploading mobile data because it would only represent one activity: completing a survey by text messages.

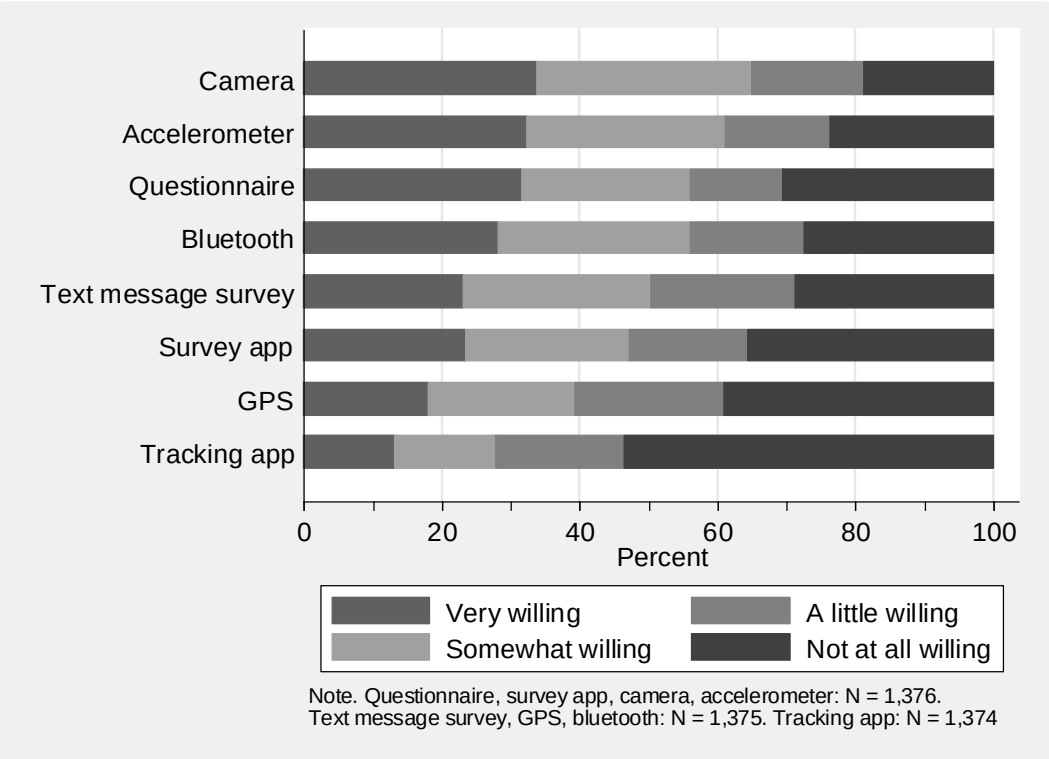
## Results

### *RQ1. How does willingness to use mobile technologies vary across different data collection tasks?*

Stated willingness to use mobile technologies on a smartphone for data collection varies considerably by data collection task (Figure 2, Table A1 in the Appendix). On the one hand, the majority of smartphone users would be very or somewhat willing to use the camera of their smartphone to take photos or to scan barcodes for a survey (65 percent). A similar proportion of respondents would be very or somewhat willing to allow the accelerometer built into their smartphone to measure their physical movement (61 percent). On the other hand, a much smaller proportion of smartphone users would be very or somewhat willing to share the GPS position of their phone (39 percent) and only 28 percent would be very or somewhat willing to download and use a tracking app that collects anonymous data about how they use their phone. More than half of respondents would be not at all willing to do this task.

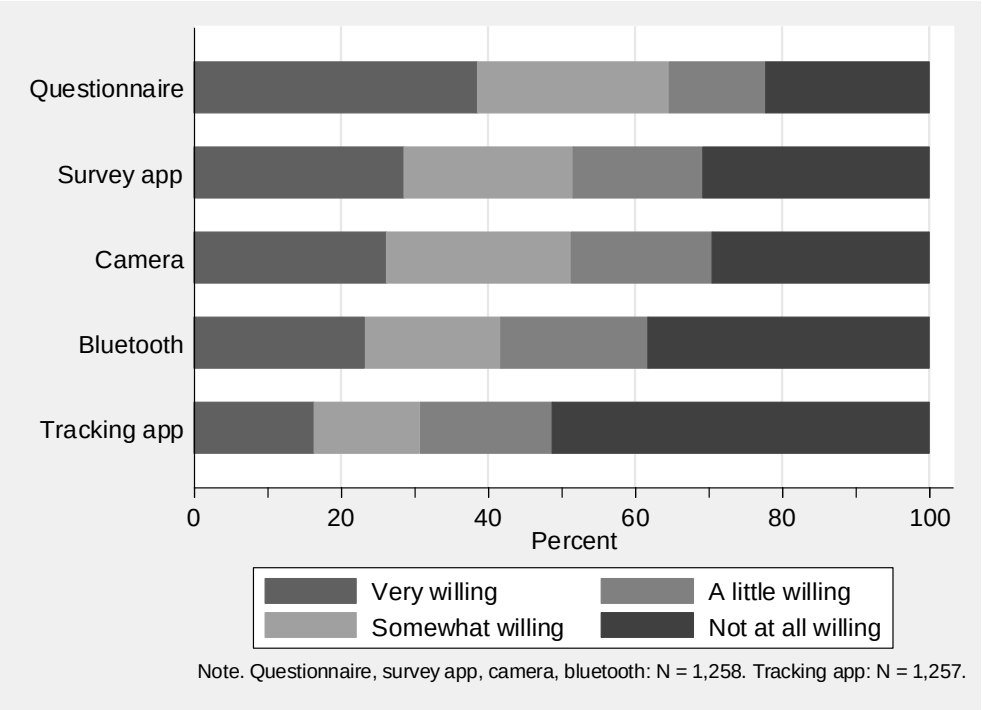
These findings suggest that not all smartphone users would be willing to use all kinds of technologies on their phone for data collection, and that they make a clear distinction between different tasks, depending on what type of technology the tasks involve.

Figure 2. Stated willingness to complete data collection tasks on a smartphone




When asking tablet users about their stated willingness to participate in mobile data collection, we find that willingness varies across data collection tasks in a similar way, but there are some notable differences compared to smartphone users (Figure 3, Table A2 in the Appendix). A smaller percentage of tablet users would be willing to use the camera of their tablet to take photos or scan barcodes for a survey (51 percent), presumably as they are less used to taking photos on their tablet. A larger percentage, however, would be willing to complete an online questionnaire on their tablet (65 percent), presumably because it is easier to complete surveys on devices with a larger screen size.

Figure 3. Stated willingness to complete data collection tasks on a tablet




Note. Questionnaire, survey app, camera, bluetooth: N = 1,258. Tracking app: N = 1,257.

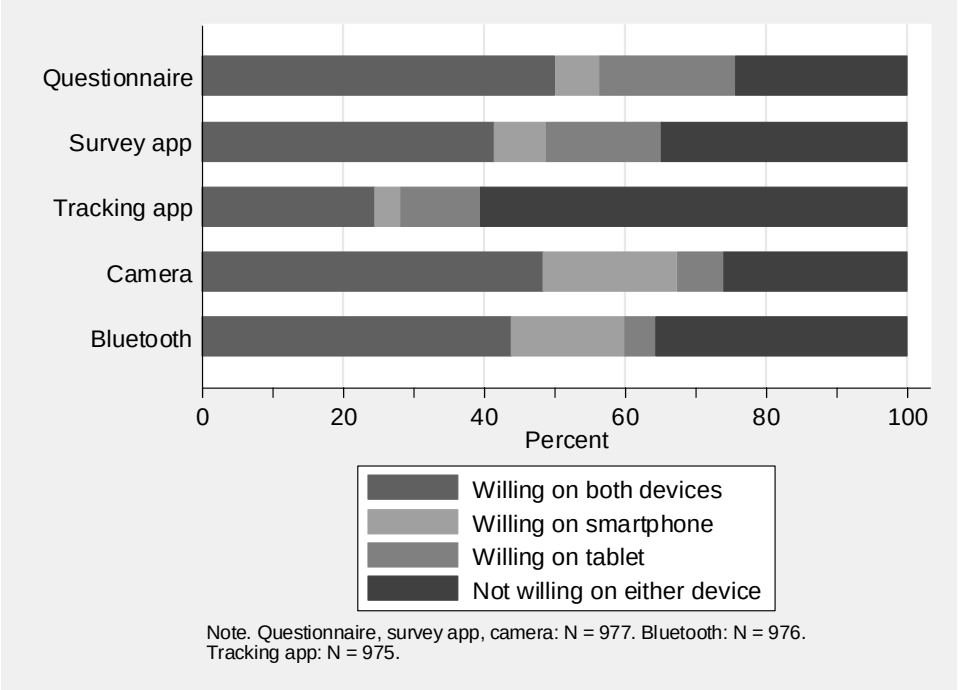
Comparing the willingness of smartphone users and tablet users gives a first indication that respondents also make a distinction between devices: they are more willing to complete certain tasks on a smartphone than on a tablet or vice versa. This first set of analyses, however, is based on two different albeit overlapping populations: those who use a smartphone compared to those who use a tablet. To better understand how willingness differs between smartphones and tablets, we restrict our analysis in the next section to the 980 respondents who have access to both devices.

***RQ2. How does willingness to do different tasks vary between smartphone and tablet?***

To simplify the analysis, we dichotomised the four-point willingness scale: we coded very willing and somewhat willing as *willing*, and a little willing and not at all willing as *not willing*. We then compared if respondents are willing to complete data collection tasks on both devices, only on one device, or on neither device. As shown in Figure 4 (and in Table A3 in the Appendix), we find that a large majority of respondents have consistent levels of willingness: they are equally willing or equally unwilling to complete data collection tasks on a smartphone or on a tablet. The level of consistency varies slightly by data collection task. Respondents are most consistent in their willingness to use a tracking app that collects anonymous data about how they use their mobile device (85 percent are equally willing or

equally unwilling), and least consistent in their willingness to complete a questionnaire in the mobile browser (still 75 percent are equally willing or equally unwilling).

Figure 4. Consistency of stated willingness among respondents with access to smartphone and tablet




Note. Questionnaire, survey app, camera: N = 977. Bluetooth: N = 976. Tracking app: N = 975.

To test the relationship between willingness to complete a given task on a smartphone and willingness to complete the task on a tablet, we computed Kendall's tau-b correlation coefficients, that measure the association between two ordinal variables. We find a moderate to strong positive correlation for all tasks, ranging from $\tau_b = 0.49$ for completing an online questionnaire to $\tau_b = 0.65$ for connecting to other devices via Bluetooth, which confirms the interpretation of Figure 4, that willingness is moderately consistent between devices.

Among respondents who expressed different levels of willingness across devices, the preference is task-related: the majority would be more willing to use their tablet to complete an online questionnaire, to use a survey app, or to use a tracking app that collects anonymous data about how they use their device, but would be more willing to use their smartphone to take photos or to connect to other devices via Bluetooth. These differences in preference may reflect how respondents use the devices. Respondents may use the camera of their smartphone more often than the camera of their tablet. For survey-related tasks including completing an

online questionnaire and using a survey app, respondents seem to prefer devices with a larger screen size.

These findings suggest that willingness is consistent for the majority of respondents, but some respondents make a distinction between different devices. We therefore cannot assume that all respondents who have multiple devices would be equally willing to do the same type of task on all devices.

***RQ3. Which respondent characteristics predict willingness to do different tasks?***

To understand which respondent characteristics are associated with willingness to complete different data collection tasks, we ran regression models for each of the individual tasks, using different specifications. First, we fitted a series of ordered logistic regression models using the ordinal willingness scale as dependent variable, separately for smartphone and tablet. Second, we dichotomised the willingness scale into *willing* (combining very willing and somewhat willing) and *not willing* (combining a little willing and not at all willing) and fitted a series of binary logistic regression models. Table 3 shows the results of the binary logistic regression models for willingness to complete data collection tasks on a smartphone. The binary logistic regression models for tablet and the ordered logistic regression models for smartphone and those for tablet all yield very similar results, so we do not present them in this paper.

We show the average marginal effects that denote the increase in the predicted probability of being willing for a one-unit change in the explanatory variable. The average marginal effect of frequency of smartphone use in the first model, for example, shows that respondents who use their smartphone every day have a 6.5 percent higher predicted probability to be willing to take photos on their smartphone for a survey compared to those who use their device less frequently, although the effect is not statistically significant. To recall the different levels of willingness across data collection tasks, we also show the proportion of smartphone users who reported that they are very or somewhat willing to complete the individual tasks in the first row of the table (shaded).

Table 3. Logistic regression models predicting willingness to complete data collection tasks on a smartphone. Average marginal effects.

| | Camera | Accelerometer | Questionnaire | Bluetooth | Text messages | Survey app | GPS | Tracking app |
|---|---|---|---|---|---|---|---|---|
| % Willing (n = 1,379) | 64.8 | 60.9 | 55.9 | 55.9 | 50.1 | 47.0 | 39.1 | 27.6 |
| **Device familiarity** | | | | | | | | |
| Use smartphone every day | 0.065 | -0.035 | 0.085 | -0.045 | 0.082 | 0.039 | -0.021 | 0.025 |
| | (0.041) | (0.029) | (0.045) | (0.040) | (0.057) | (0.049) | (0.052) | (0.051) |
| Number of activities on | 0.014* | 0.035*** | 0.036*** | 0.028*** | 0.018* | 0.036*** | 0.027*** | 0.030*** |
| Smartphone | (0.007) | (0.005) | (0.005) | (0.006) | (0.009) | (0.006) | (0.005) | (0.006) |
| Self-rated skill | 0.039* | 0.033* | 0.043* | 0.053** | 0.011 | 0.053* | 0.029 | 0.017 |
| | (0.018) | (0.016) | (0.018) | (0.018) | (0.020) | (0.021) | (0.018) | (0.017) |
| **Physical limitations** | -0.045 | -0.119 | -0.017 | 0.061 | -0.075 | -0.053 | 0.083 | 0.000 |
| | (0.056) | (0.064) | (0.075) | (0.083) | (0.075) | (0.081) | (0.088) | (0.073) |
| **Internet access** | | | | | | | | |
| WiFi access | -0.139 | -0.056 | -0.170 | -0.084 | -0.167 | -0.137 | -0.169 | -0.103 |
| | (0.095) | (0.079) | (0.094) | (0.093) | (0.109) | (0.097) | (0.099) | (0.088) |
| Fixed data plan | -0.010 | -0.028 | 0.022 | 0.014 | -0.031 | 0.005 | -0.054 | -0.057 |
| | (0.042) | (0.034) | (0.040) | (0.042) | (0.042) | (0.041) | (0.044) | (0.036) |
| **Time constraints** | -0.065 | -0.019 | -0.016 | -0.050 | 0.025 | 0.002 | -0.048 | -0.013 |
| | (0.035) | (0.036) | (0.036) | (0.034) | (0.039) | (0.037) | (0.039) | (0.034) |
| **Security concerns** | -0.143*** | -0.138*** | -0.114*** | -0.161*** | -0.171*** | -0.124*** | -0.197*** | -0.173*** |
| | (0.013) | (0.014) | (0.015) | (0.014) | (0.015) | (0.013) | (0.015) | (0.015) |
| **Motivation** | | | | | | | | |
| Item-nonresponse | -0.027 | -0.032 | 0.022 | -0.058* | -0.028 | -0.009 | -0.032 | 0.011 |
| | (0.031) | (0.034) | (0.029) | (0.027) | (0.031) | (0.031) | (0.029) | (0.031) |
| Consent to data linkage | 0.050 | 0.070* | 0.032 | 0.020 | 0.020 | 0.049 | -0.010 | 0.070* |
| | (0.029) | (0.032) | (0.029) | (0.028) | (0.036) | (0.033) | (0.029) | (0.030) |
| Mode of data collection: | 0.062 | 0.067* | 0.041 | -0.024 | -0.003 | 0.057 | -0.013 | 0.017 |
| Web | (0.034) | (0.031) | (0.028) | (0.033) | (0.027) | (0.031) | (0.028) | (0.033) |
| Number of eligible waves | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1-3 | 0.027 | 0.056 | 0.084* | 0.010 | 0.026 | 0.068 | 0.028 | 0.035 |
| | (0.037) | (0.031) | (0.039) | (0.041) | (0.042) | (0.039) | (0.033) | (0.032) |
| 4-6 | 0.057 | 0.039 | 0.033 | 0.005 | -0.008 | 0.023 | 0.055 | 0.034 |
| | (0.042) | (0.037) | (0.046) | (0.044) | (0.047) | (0.044) | (0.043) | (0.040) |
| 7-9 | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* |
| Proportion of full interviews | -0.016 | -0.127 | -0.060 | -0.081 | -0.004 | 0.039 | -0.334*** | -0.218* |
| | (0.094) | (0.100) | (0.092) | (0.096) | (0.095) | (0.105) | (0.093) | (0.084) |
| **Socio-demographics** | | | | | | | | |
| Female | 0.024 | 0.032 | 0.067* | -0.056 | 0.062* | 0.033 | -0.040 | 0.017 |
| | (0.036) | (0.025) | (0.027) | (0.031) | (0.028) | (0.033) | (0.029) | (0.027) |
| Age | 0.013 | 0.006 | 0.002 | 0.004 | 0.017* | 0.014 | 0.011 | 0.020** |
| | (0.007) | (0.007) | (0.008) | (0.008) | (0.006) | (0.008) | (0.006) | (0.006) |
| Age-squared | -0.00015* | -0.00010 | -0.00010 | -0.00012 | -0.00020** | -0.00024* | -0.00012 | -0.00029*** |
| | (0.00007) | (0.00008) | (0.00010) | (0.00009) | (0.00008) | (0.00009) | (0.00007) | (0.00008) |
| Education | | | | | | | | |
| Higher degree | 0.069 | 0.082 | 0.077 | 0.077 | 0.102 | 0.044 | 0.073 | 0.150*** |
| | (0.054) | (0.056) | (0.069) | (0.055) | (0.069) | (0.061) | (0.066) | (0.043) |
| A-level | 0.105 | 0.098 | 0.146* | 0.058 | 0.133* | 0.096 | 0.029 | 0.211*** |
| | (0.057) | (0.052) | (0.056) | (0.059) | (0.066) | (0.062) | (0.065) | (0.044) |
| GCSE | 0.073 | 0.065 | 0.088 | 0.052 | 0.118 | 0.064 | 0.029 | 0.175*** |
| | (0.057) | (0.053) | (0.070) | (0.058) | (0.075) | (0.068) | (0.063) | (0.046) |
| No qualification | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* | *-Baseline-* |
| In work | -0.036 | -0.011 | -0.036 | -0.050 | -0.113** | -0.067 | -0.071 | -0.130** |
| | (0.048) | (0.038) | (0.044) | (0.044) | (0.040) | (0.050) | (0.043) | (0.039) |
| Income (ln) | 0.004 | -0.002 | 0.006 | 0.013 | -0.005 | -0.006 | -0.006 | -0.002 |
| | (0.010) | (0.009) | (0.009) | (0.010) | (0.010) | (0.009) | (0.008) | (0.007) |
| Own house | 0.012 | 0.021 | -0.012 | 0.012 | 0.026 | 0.003 | -0.045 | -0.091* |
| | (0.037) | (0.039) | (0.035) | (0.035) | (0.038) | (0.044) | (0.040) | (0.038) |
| N | 1,318 | 1,318 | 1,318 | 1,317 | 1,317 | 1,318 | 1,317 | 1,316 |

Note. * p<0.05, ** p<0.01, *** p<0.001. Standard errors in parentheses; Listwise deletion dropped N = 58 respondents who had missing values in at least one of the predictors.

***Intensity of smartphone use***, one of our indicators of device familiarity, is predictive of willingness for all eight data collection tasks. Respondents who use their smartphone more intensively, measured by the number of activities they carry out on their phone, are significantly more willing to participate in mobile data collection across all activities. The effect has a similar magnitude across tasks: for every additional activity that respondents do on their smartphone, they have a 1.4 percent to 3.6 percentage point higher predicted probability of being willing to engage in mobile data collection. ***Self-rated skill using a smartphone***, a second indicator of device familiarity, is also predictive of willingness, but only for a subset of data collection tasks. Respondents who consider themselves proficient smartphone users are significantly more willing to take photos, to allow the accelerometer to measure their physical activity, to complete a web survey in a mobile browser or in a survey app, or to connect their smartphone to other devices via Bluetooth. There is no significant association, however, between self-rated skill and willingness to complete other data collection tasks. This finding suggests that the level of comfort using a smartphone is more likely to affect tasks that actively involve respondents in the data collection process, for example taking photos for a survey, as well as tasks that respondents use less frequently for their own purposes (only 50 percent of smartphone users reported that they use Bluetooth on their device). ***Frequency of smartphone use***, our third indicator of device familiarity, is not predictive of willingness for any of the data collection tasks. Contrary to what we expected, the willingness of respondents who use their smartphone every day is not significantly different from those who use their device less often.

The level of ***security concerns*** about mobile technologies is a second factor which is predictive of willingness across all data collection tasks. The more concerned respondents are about the security of providing information via mobile technologies, the less willing they are to complete each of the possible data collection tasks. The magnitude of the effect varies depending on the type of technology involved: it is larger for activities that are potentially threating to the respondent's privacy. Respondents with greater security concerns have a 19.7 percent lower predicted probability to be willing to share the GPS location of their phone, but only an 11.4 percent lower predicted probability to be willing to complete an online questionnaire in a mobile browser.

Our indicators of respondent motivation and engagement with the study are predictive of willingness for a subset of data collection tasks. Respondents who have ***item-nonresponse*** in

the Innovation Panel questionnaire are less willing to connect their smartphone to other devices via Bluetooth, but there is no significant association between item-nonresponse and willingness to complete other data collection tasks. Respondents who ***gave consent to data linkage*** are more willing to allow the accelerometer of their phone to measure their physical activity, and more willing to use an app that tracks how they use their phone. We do not find a significant effect on willingness for the other data collection tasks. Time in panel, measured by the ***number of eligible waves***, is predictive of willingness to complete a web questionnaire in the mobile browser: respondents who joined the *Understanding Society* Innovation Panel more recently and have only been eligible for up to three survey waves are more willing to complete a web questionnaire in their mobile browser than respondents who have been part of the panel for seven or more waves. This finding is opposite to our expectation that respondents who have been part of the panel for a longer time are more loyal with the study and hence more cooperative with additional data collection requests than those who joined the panel more recently. We do not find a significant association between time in panel and willingness to complete other data collection tasks. Prior cooperativeness with the panel, measured by the ***proportion of full interviews*** among eligible waves, is predictive of willingness to complete data collection tasks that are potentially threatening to respondent's privacy: respondents who have completed a larger proportion of full interviews are less willing to share the GPS location of their smartphone and less willing to use an app that tracks how they use their smartphone. Again, this finding is contrary to our expectation that panel members who have been cooperative in past waves are more willing to complete additional data collection requests. There is no significant association between the proportion of full interviews and the willingness to complete other data collection tasks.

We do not find a significant effect of ***physical limitations*** on willingness for any of the data collection tasks: respondents with physical limitations do not report lower levels of willingness compared to those without these limitations. Note, however, that only few respondents in our sample reported health problems: people with limited vision or manual dexterity might be less likely to use a mobile device in the first place. There might not have been sufficient variation in the data to produce an effect. We also do not find a significant effect of type of Internet access on willingness for any of the data collection tasks: respondents without ***WiFi access*** at home and those without ***fixed data plan*** are not less willing to participate in mobile data collection than respondents with these types of Internet access. Note, again, that the distribution of these two variables is highly skewed. Finally, ***time***

***constraints*** are also not associated with willingness for any of the data collection tasks: respondents who have long working or commuting hours, children under the age of five or other caring responsibilities are not less willing to participate in mobile data collection compared to those without these time constraints.

Among socio-demographic characteristics, we find that ***gender***, ***age***, ***age-squared***, ***education***, ***labour force status***, and ***housing tenure*** are significantly associated with willingness for some of the data collection tasks.

***RQ4. Which task characteristics predict willingness, and does the effect depend on respondent characteristics?***

To examine which task characteristics are associated with the varying levels of willingness that we observe across data collection tasks, we reshaped the dataset to a long format, so that the willingness ratings for the data collection tasks are nested within respondents. Given the small number of data collection tasks that we examined, we have limited variation in characteristics across tasks. We also ran models using the individual tasks as predictors of willingness. As will be shown in this section, however, the analysis of task characteristics reveals determinants of willingness that cannot be identified just by comparing the tasks.

We fitted multilevel logistic regression models predicting willingness to use mobile technologies on a smartphone with random intercepts for each respondent, and used the dichotomised willingness scale as the dependent variable to match the analysis for Research Question 3. Table 4 shows the average marginal effects of two multilevel logistic regression models: in the first model, we only include task characteristics as covariates; in the second model, we include task characteristics and respondent characteristics. On average across all data collection tasks, we find that 48.1 percent of respondents would be willing to participate in mobile data collection (n = 10,539).

Table 4. Multilevel logistic regression model predicting willingness to complete data collection tasks on a smartphone. Average marginal effects.

| | Model 1 | | Model 2 | |
|---|---|---|---|---|
| | AME | SE | AME | SE |
| **Task characteristics** | | | | |
| App download required | -0.071*** | 0.014 | -0.058*** | 0.012 |
| Active role of respondent | 0.075*** | 0.014 | 0.063*** | 0.012 |
| High technical demands | 0.211*** | 0.016 | 0.174*** | 0.014 |
| Potential privacy threat | -0.314*** | 0.011 | -0.257*** | 0.010 |
| **Device familiarity** | | | | |
| Use smartphone every day | | | 0.016 | 0.020 |
| Number of activities on smartphone | | | 0.031*** | 0.003 |
| Self-rated skill | | | 0.036*** | 0.008 |
| **Physical limitations** | | | -0.034 | 0.032 |
| **Internet access** | | | | |
| WiFi access | | | -0.143*** | 0.043 |
| Fixed data plan | | | -0.012 | 0.018 |
| **Time constraints** | | | -0.015 | 0.015 |
| **Security concerns** | | | -0.163*** | 0.006 |
| **Motivation** | | | | |
| Item-nonresponse | | | -0.016 | 0.013 |
| Consent to data linkage | | | 0.028* | 0.013 |
| Mode of data collection: Web | | | 0.024 | 0.013 |
| Number of eligible waves | | | | |
| 1-3 | | | 0.036* | 0.015 |
| 4-6 | | | 0.028 | 0.016 |
| 7-9 | | | *-Baseline-* | *-Baseline-* |
| Proportion of full interviews | | | -0.100* | 0.039 |
| **Socio-demographics** | | | | |
| Female | | | 0.022 | 0.013 |
| Age | | | 0.011*** | 0.003 |
| Age-squared | | | -0.00012*** | 0.00003 |
| Education | | | | |
| Higher degree | | | 0.088** | 0.027 |
| A-level | | | 0.119*** | 0.028 |
| GCSE | | | 0.097*** | 0.028 |
| No qualification | | | | |
| In work | | | -0.066*** | 0.017 |
| Income (ln) | | | -0.001 | 0.004 |
| Own house | | | -0.013 | 0.016 |
| **Random-effects parameters** | | | | |
| Respondent variance | 2.150 | | 1.653 | |
| ICC | 0.395 | | 0.334 | |

Note. * p<0.05, ** p<0.01, *** p<0.001.

Responses = 10,539 and respondents = 1,318. ICC = intra-class correlation.

N = 58 respondents had missing values in at least one of the predictor variables and were dropped from the analysis using listwise deletion.

In the first model, we find that all four task characteristics are significant predictors of willingness to participate in mobile data collection. Respondents have a 7.1 percent lower predicted probability of willingness to participate in tasks that ***require downloading and installing an app*** on their smartphone compared to tasks without this requirement. This result supports our expectation that downloading and installing an app is a potential barrier to participation. Data collection tasks that ***actively involve respondents in the data collection process*** have higher levels of willingness than passive tasks: respondents have a 7.5 percent higher predicted probability to report that they are willing to participate in active tasks compared to passive tasks, presumably because they have more control over the content of the data if they are actively involved in the data collection process. Surprisingly, respondents are more willing to complete tasks that have relatively high ***technical demands***, such as those requiring a lot of battery power or storage capacity, compared to tasks with relatively low technical demands: they have a 21.1 percent higher predicted probability of willingness to complete more technically demanding tasks than those with relatively low demands. This effect might be driven by other aspects of the tasks: albeit technically demanding, the tasks might be frequently used by respondents (e.g., using the camera), and might have higher acceptance levels than tasks that have low technical demands but are rarely used by respondents. Finally, we find that tasks that are ***potentially threatening to the respondent's privacy*** have lower levels of willingness, which confirms our expectation that a potential privacy threat might represent a possible barrier to participation. Respondents have a 31.4 percent lower predicted probability of willingness to complete tasks that potentially threaten their privacy compared to tasks where the potential privacy threat is content-dependent. When we control for respondent characteristics in the second model, we find that the effect of each of the task characteristics remains significant, although the magnitude of the predicted probabilities decreases slightly.

Regarding respondent characteristics, the multilevel model confirms most of the findings of the task-specific models shown in Table 3: characteristics that have a significant effect on willingness for all or most of the data collection tasks in the task-specific models also have a significant effect in the multilevel model. There are, however, some differences. First, the multilevel model suggests that respondents with ***WiFi access*** at home are significantly less willing to participate in mobile data collection whereas in the task-specific models, WiFi access does not significantly affect willingness for any of the data collection tasks. Second, a set of respondent characteristics have significant effects on willingness in the multilevel

model although in the task-specific models, they significantly affect willingness for only a subset of one or two tasks: ***consent to data linkage***, ***number of eligible waves***, and ***proportion of full interviews***.

In addition to examining the main effect of task characteristics on willingness, we empirically tested the interactions of task characteristics and respondent characteristics that we proposed in our framework. Among all interaction effects that we specified in Figure 1, we only find significant interaction effects between frequency of smartphone use and task characteristics as well as between prior survey cooperativeness and task characteristics (analysis not shown).

For respondents who do not ***use their smartphone every day***, the requirement to ***download and install an app*** does not significantly affect their willingness to participate in mobile data collection (main effect: $b = 0.005$, $p = 0.979$). Respondents who use their smartphone every day, however, are significantly less willing to participate in mobile data collection compared to less frequent smartphone users if the task requires downloading and installing an app (interaction effect: $b = -0.518$, $p = 0.027$). Infrequent smartphone users have similar levels of willingness for both ***active and passive tasks*** (main effect: $b = 0.035$, $p = 0.860$), whereas respondents who use their smartphone every day are more willing to participate in mobile data collection than infrequent users if the task actively involves them in data collection (interaction effect: $b = 0.532$, $p = 0.012$).

We also find significant interaction effects between prior survey cooperativeness and three of the task characteristics. First, respondents who have been relatively uncooperative in previous survey waves, measured by a low ***proportion of waves*** in which they gave a full interview, are equally willing to participate in ***active and passive tasks*** (main effect: $b = -0.998$, $p = 0.05$). Those who have previously been more cooperative, however, are more willing to complete tasks where they are actively involved in data collection than less cooperative respondents (interaction effect: $b = 1.567$, $p < 0.01$). Second, we find that relatively uncooperative panel members are more willing to complete tasks with relatively high ***technical demands*** compared to tasks with lower demands (main effect: $b = 2.437$, $p = 0.000$). Those who have been cooperative, however, have lower levels of willingness for tasks that are technically demanding compared to uncooperative respondents (interaction effect: $b = -1.213$, $p = 0.043$). Third, the results suggest that relatively uncooperative panel members are willing to participate in mobile data collection independent of whether the task is ***intruding on their***

***privacy*** (main effect: $b$ = -0.178, $p$ = 0.752). Cooperative respondents, however, are less willing to complete data collection tasks that are potentially threatening to their privacy compared to uncooperative respondents (interaction effect: $b$ = -1.868, $p$ = 0.002).

## Discussion

In this paper, we examine the stated willingness of the general population to participate in mobile data collection tasks, using data from a nationally representative household panel study in Great Britain. We provide novel evidence on how willingness varies between eight different mobile data collection tasks and on how willingness varies between different mobile devices (smartphones and tablets). We also provide novel evidence on the relative importance of respondent characteristics, task characteristics, and their interactions, by proposing and testing a theoretical framework of the determinants of willingness to participate in different mobile data collection tasks.

We find that the level of willingness varies by data collection task and, to a lesser extent, by device. Respondents seem to make a clear distinction between different tasks: fewer people would be willing to share the GPS position of their mobile device than to take a photo for a survey or to complete a questionnaire in a mobile browser. More than half of respondents would not be at all willing to download an app which collects anonymous data about how they use their mobile device. These findings are consistent with previous results based on online access (volunteer) panels in other countries (Revilla et al., 2017; Revilla, Toninelli, et al., 2016). The majority of people who use both a smartphone and a tablet have consistent preferences: they are equally willing or equally unwilling to use either of their devices for data collection. For some respondents, the device type, however, makes a difference: a tablet would be the preferred device for completing an online questionnaire in a mobile browser or survey app, whereas a smartphone would be the preferred device for taking photos or for connecting to other devices via Bluetooth.

We also find that willingness varies with respondent characteristics: those who use their mobile device more intensively and have lower levels of security concerns are more willing to use mobile technologies across all types of data collection activities. These findings are consistent with previous findings from access panels (Keusch et al., 2017; Pinter, 2015;

Revilla et al., 2017). Other respondent characteristics affect the willingness for a subset of activities: proficient mobile device users, for example, report being more willing to complete survey-related data collection activities, but self-rated skill using a mobile device does not affect the willingness of other activities.

The difference in willingness between different data collection tasks is related to the characteristics of the tasks: respondents are more willing to participate in tasks where they actively complete the measurements than in tasks where data are collected passively. This finding is consistent with previous results from an access panel in Spain, Portugal and Latin America (Revilla et al., 2017; Revilla, Toninelli, et al., 2016). In addition, we find that respondents are less willing to participate in tasks that require downloading an app and in tasks that measure highly private information. Somewhat surprisingly, respondents are more willing to participate in tasks that place higher technical demands (such as battery usage) on their devices; however, this may be an effect of the specific tasks we studied.

Finally, we find some evidence that the effect of task characteristics on willingness depends on respondent characteristics: for respondents who use their device every day, the requirement to download an app reduces willingness, while the requirement to actively complete the measurement increases willingness. For respondents who use their devices less frequently neither task characteristic affects willingness. This could be because frequent users are likely to have a larger number of apps and files stored on their device, and therefore less available storage space than infrequent users. Conversely, they are likely to be more confident in actively completing tasks using their device, and might find active completion less burdensome than infrequent users.

These findings suggest that willingness to participate in mobile data collection depends on the type of data that researchers want to collect as well as on characteristics of the population of interest that they want to study. Researchers who aim to implement mobile data collection in surveys might adjust the data collection request to the potential barriers of participation that the specific tasks entail. When asking respondents, for example, to complete data collection tasks that require downloading and installing an app on their mobile device, researchers might provide additional instructions or screenshots to respondents on how to access the app store and to download and install apps on their device. For data collection activities that are potentially intruding on the respondent's privacy, including sharing GPS coordinates,

researchers might leverage data confidentiality and other data security aspects of the study as part of the data collection request.

In order to maximise participation rates in studies with mobile data collection, researchers might also consider tailoring data collection requests to respondents based on information available from a screening questionnaire. Respondents who have access to a mobile device but are not sufficiently familiar with using the device or use the device less intensively could be offered one-time support by an interviewer who helps them to install and use a data collection app, or could be provided with assistance during data collection, for example by setting up a support hotline. Respondents who report high levels of security concerns could receive invitation letters that contain more information about procedures to ensure data confidentiality. Those with lower levels of motivation and engagement with the study could receive motivational statements in the invitation letter which state the importance of the respondent's participation for the study or could be provided with higher levels of incentives, particularly in studies that ask respondents to share data from their accelerometer, to connect their mobile device to other devices via Bluetooth, or to use an app that tracks how they use their mobile device.

A limitation of our study is that we measure hypothetical willingness to participate in mobile data collection rather than actual willingness. While questions on hypothetical willingness allow us to examine the willingness of the general population to use mobile technologies across a large range of data collection tasks, these measures, as other subjective measures in surveys, might be influenced by context effects (Sudman, Bradburn, & Schwarz, 1996) and might not reflect actual behaviour. A study by Jäckle, Lessof, Burton, and Couper (2017), however, provides evidence that the hypothetical willingness measures of the *Understanding Society* Innovation Panel, that we draw upon in our paper, are predictive of actual participation in an associated mobile app study. Although the data collection task of the mobile app study, scanning shopping receipts, is slightly different to the tasks that we cover in this paper, the authors find a significant association between hypothetical and actual willingness: respondents who indicated that they are very or somewhat willing to download and install a survey app on their mobile device have a 4.5 percent higher predicted probability of using an app to provide data about their expenditure compared to respondents who are a little or not at all willing.

Another limitation is that we focused on a relatively small set of feasible mobile data collection tasks. While we classified the characteristics of these tasks a priori, we did not investigate the full set of potential tasks: we would need 32 (= $2^5$) tasks to fully test our theoretical model with five task characteristics. We would be hard pressed to find realistic mobile data collection tasks to fit each of these cells. The aim of this paper, however, is to give researchers an idea which task characteristics to consider when examining willingness on a particular data collection task.

While this paper focuses on willingness to participate in mobile data collection generally, a potential avenue for further research is to examine compliance over time in repeated data collection tasks, and the factors that are associated with compliance. Respondents might be willing to engage in mobile data collection for one-off tasks but might drop out of tasks that are continuous or require repeated participation. In studies that track the GPS location of a smartphone, for example, respondents might decide to turn off the GPS function of their mobile device once they realise that GPS consumes a considerable amount of battery power. More research is also needed to further understand some of the findings of this paper. Further research could explore, for example, why frequent smartphone users appear less willing to participate in mobile data collection if the task requires downloading and installing an app, or why cooperative panel members appear less willing to complete some of the data collection tasks.

As survey researchers and others continue to find ways of exploiting the powerful mobile devices that many people carry around with them all day, we need to be mindful of what tasks people might be willing to do, and who might be willing to do what tasks. This paper begins to lay out the issues and provides initial empirical evidence on these important sources of variation in willingness to perform additional data collection tasks using these devices.

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## Appendix

### *RQ1. How does willingness to use mobile technologies vary across different data collection tasks?*

Table A1. Stated willingness to complete data collection tasks on a smartphone

| | Very willing | Somewhat willing | A little willing | Not at all willing | Missing | Total |
|---|---|---|---|---|---|---|
| Camera | 32.0 | 30.7 | 16.8 | 20.2 | 0.2 | 100.0 |
| Accelerometer | 31.0 | 28.3 | 16.0 | 24.5 | 0.2 | 100.0 |
| Questionnaire | 27.9 | 24.4 | 15.2 | 32.2 | 0.2 | 100.0 |
| Bluetooth | 26.6 | 26.8 | 17.2 | 29.2 | 0.3 | 100.0 |
| Text message survey | 21.9 | 27.0 | 21.2 | 29.5 | 0.3 | 100.0 |
| Survey app | 21.3 | 22.2 | 17.8 | 38.5 | 0.2 | 100.0 |
| GPS | 17.0 | 19.7 | 23.5 | 39.5 | 0.3 | 100.0 |
| Tracking app | 10.7 | 14.8 | 19.1 | 55.0 | 0.4 | 100.0 |

N = 1,379.

Table A2. Stated willingness to complete data collection tasks on a tablet

| | Very willing | Somewhat willing | A little willing | Not at all willing | Missing | Total |
|---|---|---|---|---|---|---|
| Questionnaire | 36.3 | 27.8 | 13.6 | 22.0 | 0.2 | 100.0 |
| Survey app | 26.5 | 24.0 | 17.8 | 31.4 | 0.2 | 100.0 |
| Camera | 25.0 | 25.8 | 19.7 | 29.3 | 0.2 | 100.0 |
| Bluetooth | 20.9 | 19.1 | 19.5 | 40.3 | 0.2 | 100.0 |
| Tracking app | 14.4 | 15.9 | 17.9 | 51.5 | 0.3 | 100.0 |

N = 1,261.

### *RQ2. How does willingness to do different tasks vary between smartphone and tablet?*

Table A3. Consistency of stated willingness among respondents with access to smartphone and tablet

| | Willing on both devices | Willing on smartphone | Willing on tablet | Not willing on either device | Missing | Total |
|---|---|---|---|---|---|---|
| Questionnaire | 46.9 | 6.1 | 22.2 | 24.4 | 0.3 | 100.0 |
| Survey app | 38.9 | 6.4 | 17.9 | 36.5 | 0.3 | 100.0 |
| Tracking app | 22.2 | 4.0 | 13.1 | 60.2 | 0.5 | 100.0 |
| Camera | 47.9 | 16.4 | 7.0 | 28.4 | 0.3 | 100.0 |
| Bluetooth | 42.1 | 14.7 | 5.2 | 37.6 | 0.4 | 100.0 |

N = 980.

***Questionnaire***

| | Variable | Question wording |
|---|---|---|
| Q1 | Access to mobile technologies | Which of the following devices do you use to connect to the Internet?<br>*Desktop computer; Laptop; Smartphone; Tablet; Feature phone / non-touchscreen mobile phone; E-book reader (e.g., Kindle); Smartwatch; Other* |
| Q2 | WiFi access | Do you have WiFi access at home?<br>*Yes; No* |
| Q3 | Type of smartphone contract | Do you have a fixed data plan or a pay-as-you-go contract to get mobile Internet on your smartphone?<br>*Fixed data plan; Pay-as-you-go contract; No fixed data plan or pay-as-you-go contract (use WiFi only)* |
| Q4 | Frequency of mobile device use | How often do you use a smartphone for activities other than phone calls or text messaging?<br>*Every day; Several times a week; Several times a month; Once a month or less* |
| | | How often do you use a tablet?<br>*Every day; Several times a week; Several times a month; Once a month or less* |
| Q5 | Activities carried out on mobile devices | Do you use your smartphone for the following activities?<br>*Yes; No*<br>Browsing websites<br>Email<br>Taking photos<br>Looking at content on social media websites/apps (e.g., looking at text, images, videos on Facebook, Twitter, Instagram)<br>Posting content to social media websites/apps (e.g., posting text, images, videos on Facebook, Twitter, Instagram)<br>Making purchases (e.g., booking train tickets, buying clothes, ordering food)<br>Online banking (e.g., checking account balance, transferring money)<br>Installing new apps (e.g., from iTunes, Google Play Store)<br>Using GPS/location-aware apps (e.g., Google Maps, Foursquare, Yelp)<br>Connecting to other electronic devices via Bluetooth (e.g., smartwatches, bathroom scales)<br>Playing games<br>Streaming videos or music<br>Other |
| | | Do you use your tablet for the following activities?<br>*Yes; No*<br>Browsing websites |

| | | |
|---|---|---|
| | | Email<br>Taking photos<br>Looking at content on social media websites/apps (e.g., looking at text, images, videos on Facebook, Twitter, Instagram)<br>Posting content to social media websites/apps (e.g., posting text, images, videos on Facebook, Twitter, Instagram)<br>Making purchases (e.g., booking train tickets, buying clothes, ordering food)<br>Online banking (e.g., checking account balance, transferring money)<br>Installing new apps (e.g., from iTunes, Google Play Store)<br>Using GPS/location-aware apps (e.g., Google Maps, Foursquare, Yelp)<br>Connecting to other electronic devices via Bluetooth (e.g., smartwatches, bathroom scales)<br>Playing games<br>Streaming videos or music<br>Other |
| Q6 | Self-reported level of skill | Generally, how would you rate your skills of using a smartphone on a scale from 1 = Beginner to 5 = Advanced?<br>*1 Beginner; 2; 3; 4; 5 Advanced* |
| | | Generally, how would you rate your skills of using a tablet on a scale from 1 = Beginner to 5 = Advanced?<br>*1 Beginner; 2; 3; 4; 5 Advanced* |
| Q7 | Willingness to participate in mobile data collection | How willing would you be to carry out the following tasks on your smartphone for a survey?<br>*Very willing; Somewhat willing; A little willing; Not at all willing*<br>Complete an online questionnaire on your mobile phone.<br>Download a survey app to complete an online questionnaire.<br>Download an app which collects anonymous data about how you use your smartphone.<br>Answer a couple of questions sent via text messaging.<br>Use the camera of your smartphone to take photos or scan barcodes.<br>Allow built-in features of your smartphone to measure the frequency and speed at which you walk, run or cycle.<br>Share the GPS position of your smartphone.<br>Connect your smartphone via Bluetooth to other electronic devices (e.g., wearables such as Fitbit). |
| | | How willing would you be to carry out the following tasks on your tablet for a survey?<br>*Very willing; Somewhat willing; A little willing; Not at all willing*<br>Complete an online questionnaire on your tablet.<br>Download a survey app to complete an online questionnaire. |

| | | |
|---|---|---|
| | | Download an app which collects anonymous data about how you use your tablet.<br>Use the camera of your tablet to take photos or scan barcodes.<br>Connect your tablet via Bluetooth to other electronic devices (e.g., wearables such as Fitbit). |
| Q8 | Security concerns | In general, how concerned would you be about the security of providing information in the following ways?<br>*Not at all concerned; A little concerned; Somewhat concerned; Very concerned; Extremely concerned*<br>Complete an online questionnaire in your mobile browser.<br>Download a survey app to complete an online questionnaire.<br>Download an app which collects anonymous data about how you use your [smartphone/tablet/smartphone or tablet].<br>Answer a couple of questions sent via text messaging.<br>Use the camera of your [smartphone/tablet/smartphone or tablet] to take photos or scan barcodes.<br>Allow built-in features of your smartphone to measure the frequency and speed at which you walk, run or cycle.<br>Share the GPS position of your smartphone.<br>Connect your [smartphone/tablet/smartphone or tablet] via Bluetooth to other electronic devices (e.g., wearables such as Fitbit). |