Combining self-reports with passive mobile data collection: New forms of data collection lead to new forms of nonresponse

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Introduction

Smartphone usage continues to increase around the world (Taylor & Silver, 2019). For social and behavioral research, two features of the smartphone make them especially interesting as data collection devices (Harari et al., 2016; Link et al., 2014; Raento et al., 2009): (1) many users carry their phones around with them throughout the day allowing for *in situ* survey data collection; (2) the sensors built into the devices offer an entirely new way of collecting a variety of data from individuals in the background (i.e., passively). Combining these two forms of data collection using one device leverages the strengths of both self-report and passive measurement using sensors (e.g., GPS, accelerometer) and log files (e.g., no. of calls and text messages, Internet browsing, app usage).

To collect both self-reports and sensor data from smartphones requires users to download a designated research app that administers survey questions to participants and provides access to different sensors and log files on the phone. Depending on the scope of the study, participants will need to go through multiple steps of consenting to the different data collection features of the research app (e.g., self-reports, sensor data, log files) making the classic view of survey nonresponse as a binary outcome no longer sufficient (Couper, 2019). While some individuals might be unwilling to participate in such a study altogether, others might consent to all types of data collection involved. Again other individuals could be selective in their participation decision agreeing to some but not all features of data collection. Differential nonparticipation within a study that collects multiple types of data from the same participants makes the calculation of participation rates more complex (e.g., AAPOR RRs).

Against this background, we investigate nonparticipation in the IAB-SMART study which combined self-reports with passive mobile data collection using a research app among participants recruited from an annual longitudinal household survey in Germany (PASS). We show dropout at the different stages of the participation process and for the different types of data collected by the research app and discuss implications for how to report outcome meta data in such a study.

Data and Methods

We use data from the IAB-SMART study (Kreuter et al., 2018), an app-based data collection effort among smartphone owners recruited from the Panel Study Labour Market and Social Security (PASS) in Germany.

PASS

The Panel Study Labour Market and Social Security (PASS) is an annual, probability-based household panel survey of the German residential population aged 15 and older (Trappmann et al., 2019). The primary goal of PASS is to provide a data source for research on the labor market, poverty, and the welfare state in Germany. A dual sampling frame (population registers and welfare benefit recipient registers) is used to oversample welfare benefit recipients. The data collection mode of PASS is a sequential mixed-mode combination of computer-aided personal and telephone interviews.

IAB-SMART

The goal of the IAB-SMART study is to extend the traditional PASS survey effort measuring effects of long-term unemployment on social integration and re-integration into the labor market using a new data collection approach, namely a smartphone app that collects both self-reports via mobile surveys and passive measurement using sensors and log files. In January 2018, a random sample of 4,293 German-speaking PASS respondents aged 18 to 64 who had reported owning an Android smartphone[1] in Wave 11 (2017) was invited via mail to participate in the IAB-SMART study. To participate in the study, smartphone owners needed to visit the Google Play store, install the IAB-SMART app on their phone, and consent to several data collection functions (Kreuter et al., 2018). The field period of the study was six months. Participants received incentives in the form of points that could be converted to Amazon.de vouchers for downloading the app, allowing passive data collection, and responding to survey questions in the app.

Once installed on a smartphone and after the participant had consented to data collection, the IAB-SMART app collected data in two ways: (1) through short surveys (up to ten questions at a time) administered by the app at predefined times and when a participant's phone entered and left a predefined geolocation (geofencing) and (2) through passive data collection using sensors and log files on the smartphone. Five different passive data collection functions were available in the app, and participants could consent individually to any or all of them and revoke consent at any point during the field period:

1. *Mobile phone network quality and location information* were collected every 30 minutes together with information on network providers and network technology.
2. Metadata of participants' *incoming and outgoing calls and text messages* (i.e., time stamps and hashed numbers, not the content of text messages or phone calls) were logged.
3. Information on *characteristics of the social network* (gender and nationality of the phonebook entries) were collected by matching the first name of each contact with information from the website Genderize (https://api.genderize.io) and first and last names with information from the website NamePrism (www.name-prism.com).[2]
4. *Activity data* came from built-in sensors (accelerometer and pedometer) and are used to create measures of means of transportation (e.g., walking, biking, in a motorized vehicle) and periods of activity every two minutes.
5. *Smartphone usage* information on which apps are installed on the participant's smartphone and the frequency of their usage were collected as well.[3]

We identify multiple groups of participation patterns depending on the extent of compliance with our study protocol:[4]

1. *Verified Installers* (VI) are all invited sample members who downloaded the IAB-SMART app from the app store, went through the installation process, completed the short welcome survey in the app, and could be verified as eligible PASS Wave 11 participants by matching age and gender reportedin the welcome survy with PASS records.

[1]We restricted the study to Android devices because extensive passive data collection is limited under iOS (Harari et al., 2016), and other operating systems had too low of a market share to justify additional programming effort.
[2]In neither case were data transmitted to these websites. Only the ping results were saved and transmitted as classification probabilities together with the hashed names.
[3]No information was collected on what is done within an opened app.
[4]In our analysis, we do not distinguish between noncontact, refusals, and other nonparticipation in the study. Out of the 4,233 invitations sent out, 188 were returned as undeliverable (noncontacts), 19 individuals contacted us saying that they did not want to participate in the IAB-SMART study (refusals), and three reported not owning a smartphone (other nonparticipation).

2. *Function Participants* (FuncP) are all FIs who provided data at least once in a given data collection function of the research app. There are six groups of participants, one for each of the five passive data collection functions (*Network and Location Participants*, *Call and Text Message Log Participants*, *Social Network Participants*, *Activity Participants*, *Smartphone Usage Participants*) and one for the in-app surveys (*In-app Survey Participants*).
3. *Full Participants* (FullP) are all FuncPs who provided data at least once in all of the five functions and answered at least one question of an in-app surveys.

Results

Figure 1 presents the different participant groups in the IAB-SMART study. Out of the 4,293 PASS Wave 11 respondents who had reported owning an Android smartphone, 685 installed the app and entered a valid registration code (16.0% of the invited sample). Five of them did not respond to the welcome survey in the app nor did they provide any other type of data, and for another 57, the age or gender provided as part of the welcome survey did not match the PASS records. In the latter cases the IAB-SMART app might have collected data during the field period, but the person providing the data was not the invited PASS member but someone else in the household or a third person who probably received the invitation and verification code from the invited person. Since we cannot link the data from these cases with existing PASS data, we would drop these cases from any substantive analysis and count them as nonrespondents. This leaves us with 623 Verified Installers, 14.5 percent of our invited sample.

The number of function participants who provided at least data once varies across the five passive data collection functions. While 577 participants or 13.4 percent of the invited sample provided information on network quality and location (F1), only 525 participants (12.2%) provided data about the characteristics of their social network (F3) at least once. Per definition, all verified participants are also function participants for the in-app surveys (Qx).

Finally, 465 individuals can be classified as full participants because they provided data at least once in all of the five functions and answered at least one question of the in-app surveys. This is 10.8 percent of the sample invited to participate in the IAB-SMART study.

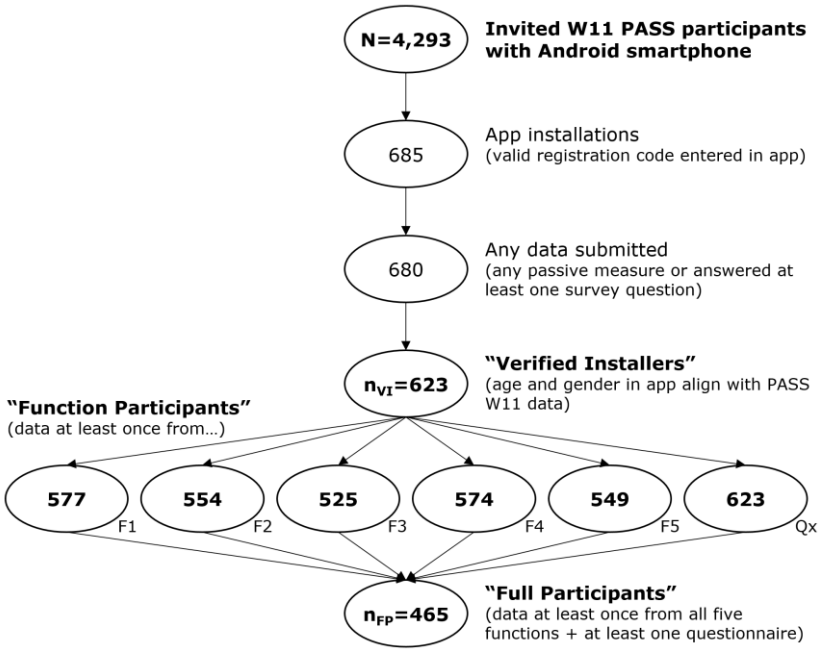

Figure 1. Flowchart of participation behavior in the IAB-SMART study (Note: F1 = Network and location; F2 = Call and text message logs; F3 = Social network; F4 = Activity; F5 = Smartphone usage; Qx = In-app surveys)

Discussion

We found that out of the 4,293 Android smartphone owners invited to the study, 14.5 percent downloaded the app, went through the installation process, completed the welcome survey, and were verified as eligible participants. This participation rate is somewhat lower than what other studies reported when recruiting participants from the general population (e.g., Elevelt et al., 2019; Scherpenzeel, 2017; Struminskaya et al., 2018). However, most earlier studies have collected one type of sensor data only (e.g., geolocation), usually over short periods. On the contrary, our study asked participants to provide extensive access to a variety of passively collected data, including geolocation, call and text message logs, characteristics of the social network, activity data, and app usage, over six months.

Interestingly, we found that once the IAB-SMART app was downloaded, there was relatively little variation in what specific types of data participants provided through the app; function participation ranged between 13.4 percent for data on network quality and location and 12.2 percent for information from the participants' phonebooks about the characteristics of their social networks. Although there is relatively little variation in the absolute numbers of participants who provided data through the five passive data collection functions of the IAB-SMART app, only less than 11 percent of all invited sample members provided all types of data at least once during the six months field period. This finding has practical implications, showing the complexity of calculating participation rates in such studies. Depending on the specific research question, the same person in a study that collects multiple types of data through a research app might be counted as a participant for some parts of the study and as a nonparticipant for others, depending on what type of data is used in the analysis.

The length of the field period might add even more complexity. For this paper, we defined participation as providing data through the app at least once during the six month field period. However, the full potential of this data collection approach lies in the continuous collection of high-frequent measurements to study behavior and change thereof over time, and missing data can accumulate over time (Bähr et al., 2020). In such a setting, it really depends on the specific research question for how long an individual needs to continuously provide data to truly count as a participant. In some cases, even short field periods (e.g., less than a week) might reveal interesting patterns, for example, about repetitive, daily behaviors. In other cases, long, uninterrupted measurement is necessary to understand changes over time.

The AAPOR (2016) Standard Definitions provide researchers with clear guidelines on how to report participation outcomes in surveys conducted in different modes. We call for the research community to develop similar guidelines on how to report participation meta data in studies that combine survey data collection with passive measurements from sensors and log files on smartphones and other devices, such as wearables, smart watches, and activity trackers.

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