What do researchers have to invest for collecting smartphone data?

Georg-Christoph Haas[1,2], Frauke Kreuter[1,2,3], Florian Keusch[2,3], Mark Trappmann[3,4], Sebastian Bähr[1]

[1]Institute for Employment Research, [2] University of Maryland, [3] University of Mannheim, [4] University of Bamberg

Introduction

Smartphone sensor data enable researchers to analyze phenomena that they cannot investigate with survey data alone. However, smartphone data may include very sensitive information, e.g., on geolocation or app usage, which individuals may perceive as too private to share with researchers.

In surveys, monetary incentives help to increase response rates. However, we do not know if incentives work the same way in studies involving smartphone sensor data. To date very few studies exist that systematically examine participation in smartphone sensor studies, and to our knowledge no study so far has examined if the knowledge regarding the effectiveness of incentives holds for smartphone sensor data as well (one exception is the vignette study by Keusch et al (2017) showing that incentives have a positive effect on participation in a hypothetical study involving passive mobile data collection).

Based on the sensitivity of smartphone sensor data one might argue that common incentive strategies will not be sufficient to motivate participation in such a study. However, from a respondent burden perspective one might argue just the opposite because individuals spend less time and effort in the data collection process compared to regular surveys. Thus, it might be much easier to recruit respondents for sensor based data collection projects.

Survey methodologists rely on incentives in various forms, and the effectiveness of incentives is well-documented (James and Bolstein, 1990; Willimack et al., 1995; Church, 1993; Singer, 2002; Singer and Ye, 2013; Toepoel, 2012; Mercer et al., 2015; Pforr et al. 2015). Based on the results from experimental research, the field has learned the advantage of cash incentives over in-kind incentives, the effectiveness of unconditional incentives compared to conditional ones, and the fact that higher incentives increase response rates more than lower ones but at decreasing marginal returns (Church, 1993; Singer et al., 1999; Singer and Ye, 2013, Mercer et al., 2015).

Interestingly, Cantor et al. (2008) and Dillman et al. (2014) point out that incentives can be used to establish trust. If this is the major mechanism we would expect a certain threshold to be needed to establish trust, but not necessarily expect increasing amounts to have an equally positive effect on participation.

The study presented here extends the existing literature on incentives in surveys to a novel form of data collection, i.e., mobile measurement using a smartphone app that combines passive data collection through built-in sensors and self-reports through survey questions. Overall, we provided incentives for three tasks: (1) for installing the app, (2) for activating data collections functions for 30 consecutive days, and (3) for answering survey questions; we randomly varied the amount and conditions of the incentives. This allows us to examine following research questions:

1. Do higher incentives for installation, function activation, and overall increase the participation rate?
2. Do participants activate more functions when offered an additional incentive to do so?
3. Does a higher installation incentive influence the number of initially activated functions?

Study description

We recruited participants for the IAB-SMART study from the panel study "Labour Market and Social Security" (PASS) to download an app to their Android smartphone that asked survey questions and collected passive measures over a period of six months. PASS is a yearly household panel survey of the German general population (aged 15+) with an oversampling of welfare benefit recipients. PASS is conducted in a mix of CATI and CAPI interviews by the IAB since 2007 (Trappmann et al. 2013). In the 11th wave (2017) respondents were asked about smartphone ownership and operating systems. Coverage analysis shows that Android users were more likely to be male, younger, and better educated than people without an Android smartphone (see Keusch et al. *under review*). Overall, 4,293 postal invitations were sent to PASS participants who reported owning an Android smartphone. To participate in the app study, respondents had to provide informed consent allowing us to combine their data from the app study with their data from PASS. Additionally, we asked for informed consent to combine all data with administrative data available at IAB (for details about the consent process and uptake, see Kreuter et al. (*under review*)).

Surveys: Overall, the IAB-SMART comprises eleven surveys packages. Surveys were launched at predefined times within the app and participants received a pop-up notification through the app whenever a new survey was available. The questions were timed relative to the time of installation, e.g., seven days after the installation of the app all participants received the same questions. The App informed participants about the availability of new questionnaires through in-app-notifications.

Sensors and other passive measurements: To collect smartphone data our app offers functions users could activate or deactivate at any time: (a) network quality and location information, (b) interaction history, (c) characteristics of the social network, (d) activity data, and (e) smartphone usage.

Experimental Design

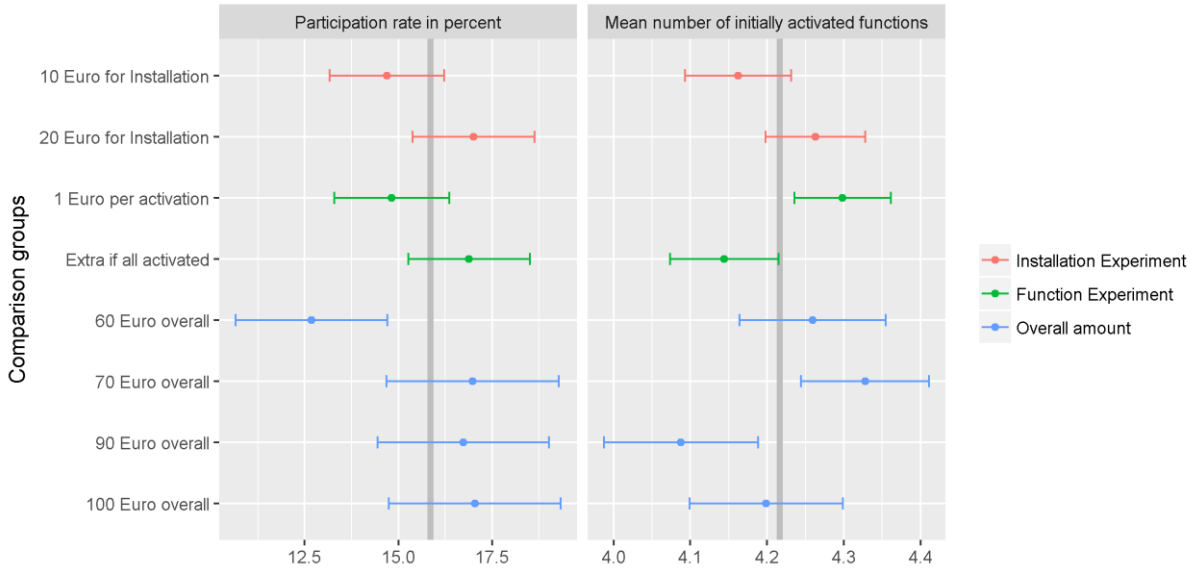
Participants could gain incentives in three different ways: (1) downloading the app, (2) answering survey questions, (3) activating passive data collection functions.

We conducted a 2x2 experiment on the installation and the function incentives. One random half of invited PASS members were promised **10 Euro for installing the app** and the other half was promised **20 Euro**. Independent of the installation incentive (completely crossed), one random half of invited PASS members was promised **one Euro for each function activated for 30 days**, and the other random half was promised **one Euro for each function activated for 30 days plus five additional Euro** if all five functions were activated for 30 consecutive days.

Consequently, the first group would receive 5 Euro and the second group 10 Euro per month for activating all five functions. Additionally, participants received up to 20 Euro for answering survey questions in the app over the field period of six months. We did not experimentally vary incentives for surveys Therefore, the overall possible incentive varied between 60 and 100 Euro depending on the assigned group. Respondents could cash-out their incentives directly in the app as amazon.de vouchers. We will report marginal effects of the treatments in the 2x2 factorial experiment on overall participation rate (i.e. share of app installations in each experimental group) and mean number of initially activated functions (i.e. the mean number of functions that were initially activated during the installation process). As part of our analysis, we will compare the following experimental groups: 10 Euro vs. 20 Euro for the installation and 1 Euro vs. 1 Euro plus extra if all functions activated. Additionally, we analyze whether the combination of the two factors (summarized as 60, 70, 90, 100 Euro overall) affects the decision to download the app and participate in our study and to initially activate functions.

Results

Figure 1: Participation rate (left) and mean number of initially activated functions (right), by experimental groups



The left panel in Figure 1 provides an overview of the participation rates in the different incentive groups. We find a small and significant ($p<0.05$) difference of 2.3 percentage point (p.p.) for the 20 Euro incentive over the 10 Euro incentive in our installation experiment. For the function experiment, we find a small (2.1 p.p,) but non-significant difference between the two experimental groups. We find an effect of the overall promised incentive on the participation rate. An overall incentive of 70, 90, and 100 Euro produced a 6-p.p. and significant ($p < 0.05$) higher participation rate than the 60 Euro overall incentive. We do not find either substantial nor significant effects of the incentives on the mean number of initially activated functions (see right panel in Figure 1).

Within the function experiment, one group receives an extra incentive (5 Euro) if participants activate all five functions and leave them on over a period of 30 days. We expect the share of participants that initially activated all five functions to be higher in the extra incentive group compared to the group without an extra incentive. However, we see no significant effect on the mean number of initially activated functions. In addition, when we compare the share of participants who initially activated all five functions within the function experiment, we find no effect on the share of participants who activate all five functions by the function experiment (results not shown here).

Conclusion

We find a small but significant effect that a higher incentive for installation (20 vs 10 Euro) increases the participation rate but we find no effect of our function experiment on participation rates. However, a larger amount of an overall promised incentive seems to motivate a greater proportion of individuals to install the app. Our results suggest that between 60 and 70 Euro lies a threshold that provides additional motivation for smartphone users to download a research app.

Interestingly, we do not find that our incentive scheme has any impact on the number of initially activated functions during the installation process.

Our analysis is based on data from May 1st and data collection is still ongoing (until August 30th 2018). Future analyses will evaluate the effect of incentives on the proportion of users who changed settings, the number of setting changes by participants and data collection functions, the timeliness of the installation, and the duration individuals allow data collection.

In addition, we will evaluate the impact of our incentive scheme on non-response bias, in particular vulnerable populations. Previous studies have found that vulnerable populations (e.g. welfare recipients and low-income groups) are less likely to participate in scientific surveys (e.g. due to less topic interest). However, due to a higher relative value for low-income groups, findings suggest that incentives are an effective way of reducing the resulting bias (Mack et al 1998, Groves et al 2006, Singer et al 1999).

Discussion

The assignment of incentive groups did not consider households, i.e. sometimes individuals within the same household are assigned to different incentive plans.

In the following, we limit our analysis to households with two invited individuals because it is not possible to assign households with one invited individual to different incentive plans and we do not have enough cases to evaluate differences between households with more than two invited individuals. Furthermore, with more than two invited individuals per household the dynamic of different incentive plans for each individual may be different.

Intuitively, we would expect a lower participation rate for members of the same household who received different incentive plans. However, we find a 3.2 p.p. higher participation rate for individuals from

different incentive plan households. The difference between groups is not significant (Chi2=1.4, p = 0.24).

The results of the chi-squared test suggest that the higher participation rate for households with different incentive plans is random. However, our sample is small and it may be possible that we cannot detect an effect with such a small sample. Therefore, we take a deeper look at the within-household incentive differences. Overall, we have four possible within-household incentive differences (10, 20, 30 and 40 Euro). For each within household incentive difference, four participation outcomes are possible: (i) the individual with the lower incentive participates, (ii) the individual with the higher incentive participates, (iii) both individuals participate, and (iv) nobody participates (see Table 1).

Table 1: Household participation rate (in percent) for each outcome by within-household incentive difference

Incentive difference in Euro	Lower Incentive participates in %	Higher Incentive participates in %	Both participate in %	Nobody participates in %	N
10	7.2	5.0	16.5	71.3	139
20	5.6	5.6	11.2	77.5	89
30	5.4	9.4	12.7	72.5	149
40	2.5	7.4	9.9	80.2	81
Total	5.5	4.6	13.1	76.8	458

Intuitively, we expect the individual with the higher incentive to participate. Table 1 shows that the within-household incentive difference affects individuals when the incentive difference is larger (30 and 40 Euro; both differences are significant at $p < 0.05$). However, for smaller within-household incentive differences (10 and 20 Euro) we see no effect on the participation rate of households. Interestingly, the highest share of participating households for each within-household incentive difference comes from both individuals participating. Furthermore, we see that the share of households with both individuals participating decreases with an increased within-household incentive difference. However, the small sample size makes it hard to interpret and trust those results.

We would appreciate to learn from other workshop participants about their experience in other household surveys, especially if they conducted incentive experiments. We would also appreciate comments on the theoretical explanation for the effects presented in our paper.

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