Utilizing smartphones to study disadvantaged and hard-to-reach groups

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Mobile technologies, specifically smartphones, offer social scientists a potentially powerful approach to examine the social world. They enable researchers to collect information that was previously unobservable or difficult to measure, expanding the realm of empirical investigation. For research that concerns resource-poor and hard-to-reach groups, smartphones may be particularly advantageous, by lessening sample selection and attrition and by improving measurement quality of irregular and unstable experiences. At the same time, smartphones are nascent social science tools, particularly with less advantaged populations that may have different phone usage patterns and privacy concerns. Using findings from a smartphone study of men recently released from prison, this paper discusses the strengths and challenges of smartphones as data collection tools among disadvantaged and hard-to-reach groups.

Smartphones, or programmable mobile phones, are increasingly viewed as groundbreaking new data collection tools for studying human behavior. They are flexible devices, which can collect a range of data, and they can be utilized in both small-scale projects and large-scale studies of population movement and patterns (Miller 2012; Raento, Oulasvirta, and Eagle 2009). Data can be collected passively in the background or interactively with the user. Smartphones can also be intervention tools, where information sent in real time is intended to change attitudes or behavior. Despite the potential capabilities of smartphones to improve our understanding of the social world, sociology has been slow relative to other disciplines in adopting these new technologies.

A growing body of scholarship has begun to document some of the many advantages and challenges of using smartphones to collect information for social science research (Miller 2012; Palmer et al. 2013; Raento et al. 2009; Schober et al. 2014). These papers and reports, as well as other case studies and pilot projects (Anhøj and Møldrup 2004; Bodker, Gimpel, and Hedman 2010; Eonta et al. 2011; Gaggioli et al. 2011; Gaumer et al. 2014; Goldberg et al. 2014; Jones, Drury, and McBeath 2011; Plowman and Stevenson 2012; de Reuver et al. 2012; Runyan et al. 2013), illustrate the new types of data that can be collected via phones. Notwithstanding the importance of these contributions, many of these studies are limited to traditionally advantaged populations, such as university students and faculty (Andrews, Russell-Bennett, and Drennan 2011; Bodker et al. 2010; Jones et

al. 2011; Raento et al. 2009; Runyan et al. 2013) and smartphone owners (Palmer et al. 2013; de Reuver et al. 2012; Runyan et al. 2013); or they consider small samples of a dozen or fewer participants (Anhøj and Møldrup 2004; Gaggioli et al. 2011; Plowman and Stevenson 2012). Because much of the scholarship comes from diverse disciplines, concerns specific to sociology are often not addressed. Questions remain regarding sample selection, representativeness, and the participation of diverse groups, such as resource-poor and less technologically skilled individuals, all of which are particularly relevant for sociology and allied disciplines.

The purpose of this article is to discuss the strengths and potential limitations of utilizing smartphones as research tools among disadvantaged, hard-to-reach groups with less technology experience. I focus on four main issues of concern for researchers considering smartphone studies with similar groups: sample selection and attrition, measurement of irregular and changeable patterns, missing data, and researcher effects. I illustrate these topics with findings from the Newark Smartphone Reentry Project (NSRP), which distributed phones to men recently released from prison and followed their experiences for three months. Other articles discuss more general aspects of implementation (Schober et al. 2014), as well as smartphone survey design (Buskirk and Andres 2013; Lai et al. 2009; Tourangeau, Couper, and Conrad 2004). I address these issues only as they relate to the specific characteristics of the NSRP sample.

In the next section, I describe the sample and design of the NSRP. I then discuss the four areas mentioned above using findings from the NSRP, and I conclude with recommendations for researchers seeking to use smartphones to collect data among disadvantaged, hard-to-reach, or less technologically skilled groups.

I. THE NEWARK SMARTPHONE REENTRY PROJECT (NSRP)

The NSRP examined job search and employment experiences of men recently released from prison. Formerly incarcerated individuals are among the most disadvantaged groups in the United States. They typically have low rates of education and employment, have high rates of mental health and chronic health conditions, and are more likely to be African American or Latino (Pettit 2012; Schnittker and John 2007; Western 2006). They also have unstable housing situations and are highly mobile, which leads to underrepresentation in conventional survey research (Pettit 2012). Challenges to contact and follow-up are further exacerbated during the first few months after release from prison, and this “reentry” period is a difficult transition time, when individuals need to find housing, employment, and reestablish relationships with family and friends. Because of the dual difficulties of studying a hard-to-reach group during an unstable time, longitudinal reentry studies are costly (Bushway, Stoll, and Weiman 2007) and often have low completion rates (Nelson, Deess, and Allen 1999; Visher, Debus-Sherrill, and Yahner 2010). Although reentry is an important context

in the NSRP, studying reentering individuals poses methodological challenges that are relevant to hard-to-reach groups more generally.

The NSRP focused on the role of social contacts, geographic context, and emotional wellbeing for job search and employment. To examine these areas, the project created an Android-based smartphone application[1] to collect an array of behavioral measures and respondent-reported information. Among the behavioral measures were indicators of social contacts from encrypted phone numbers and geographic context from GPS location estimates. These were passively collected by the application and did not require participant interaction. The application also sent participants three different types of surveys, which asked about social interaction, job search and work, and emotional wellbeing, among other topics. The first was a one-minute "experience sampling"[2] survey that was sent daily at a random time between 9am and 6pm. This survey collected randomly sampled, self-report "snapshots" of daily experiences. A second survey, which was three-to-four-minutes in length, was sent at 7pm daily and included more detailed questions about that day. A third, very brief survey (less than 15 seconds) was automatically triggered when participants received calls or text

[1] The Survey Droid application is available at the open-source code repository github.com. The framework of the application was created in partnership with an undergraduate class, in which groups of students took on client projects. I then hired two of the students from the class to finish building the application.

[2] Experience sampling surveys collect real-time information while people are in their everyday environments. These methods often sample a selection of experiences, as opposed to continuously documenting experiences, and are sometimes referred to as a type of Ecological Momentary Assessment (EMA) (Stone et al. 2007:373).

messages from new phone numbers, in order to collect real-time information on social contacts. To my knowledge, the ability to send surveys in response to participant behavior is unique to the NSRP application.

Participant sampling and recruitment

Participants were randomly selected from a complete census of eligible parolees released to Newark, New Jersey between 2012 and 2013, and they were followed for three months each. Parolees were eligible to participate if they were male, recently released from prison, searching for work, and neither gang identified nor convicted of a sex offense. Individuals were randomly assigned to either a smartphone group or an interview group, which participated in interviews every other week.[3] Because the NSRP focused on smartphones, only twenty percent of the eligible sample was assigned to the interview group, and the findings were used to help assess the efficacy of data collection via phones. Participants in both groups were offered comparable incentives, with the exception that the interview participants did not receive phone plans. Smartphone participants received phones (which they could keep at the end of the study) and plans with unlimited call, text, and data during their participation in the study,[4] as well as $15 gift cards for completing at least 75 percent of surveys each week. Interview participants received $15 gift cards for completing brief interviews

[3] The interview questions mirrored the smartphone survey questions, but they asked about the previous two-week period as opposed to real-time or daily experiences.

[4] I worked through the university's mobile carriers to provide phones and plans, which allowed me to purchase unlimited plans at a subsidized rate.

every other week, and were told at recruitment that they would receive smartphones at the end of the study. In total, 156 individuals participated in the project, including 135 smartphone and 21 interview participants.

As devices that facilitate social interaction and communication, smartphones are particularly well suited to experimentally test sociological questions of social networks, support, and contact. Among the smartphone participants in the NSRP, half were randomly assigned to a peer-based text-messaging forum that connected participants with each other. Through this group messaging application, participants received daily job information from researchers and could respond to the group with new information, questions, or updates on their search. The other smartphone participants received the same job information through individual text messages. The intention of the experiment was to expand the social networks of participants by connecting them to other similarly situated jobseekers.

A main concern at recruitment was that individuals would hesitate to participate because of the sensitive, detailed nature of the smartphone data. In general, individuals are increasingly concerned about the privacy of their information as smartphone consumers (Pew Research Center 2014; Boyles et al. 2012; Rainie et al. 2013). For groups that frequently experience negative interactions with government, issues of privacy, monitoring, and surveillance may be particularly relevant (Brayne 2014; Goffman 2009). Moreover, identification and recruitment of participants in the NSRP took place at the parole office. Even though the data were not shared with parole,

participants under supervision were likely to be quite wary of having their locations, phone logs, and survey answers collected by researchers. Given these concerns, the consent process involved a lengthy and comprehensive group meeting with potential participants. Lasting anywhere from one to two hours, the meeting described in detail the different types of data to be collected, the security protocols (see the discussion section for these details), and the risks of participation. Throughout the meeting, potential participants were encouraged to ask questions, and the group format spurred in-depth conversation about data features that might otherwise be missed by individuals meeting one-on-one with researchers.[5]

During the meeting, potential participants learned about certain smartphone application functions that were created specifically to address privacy concerns. These included an interface for participants to control at will the collection of call log, location, and survey data. Individuals were told that these functions allowed them to manage the collection of their data and that they could use them when necessary; however, they were also asked to apply the functions sparingly, as study participation was contingent on the collection of these data. These controls gave participants more agency over their participation, and they allowed me to monitor the use of functions and to assess when participants felt uncomfortable about providing information. A second smartphone application function addressed privacy concerns related to the phone numbers of participants' contacts. Unlike location and

[5] One-on-one meetings supplemented the group discussion, in order to address any additional concerns that participants did not raise in the group.

survey data, phone numbers are information about people who have not consented to participate in the project. In this regard, they are particularly sensitive forms of data that warrant additional protections. The NSRP application encrypted phone numbers prior to transmittal to the research server using a code specific to each phone, which was randomly generated when the application was downloaded to the phone. This approach ensured that each participant's set of contacts was encrypted with a separate code, unknowable to the research team. These design aspects complemented more standard privacy controls, which I describe in the discussion section.

Apart from privacy issues, another area of concern at the outset of the study related to participants' skill level and familiarity with smartphones. Previous experience with smartphones ranged substantially, with some individuals released from prison after serving long sentences and not familiar with the Internet or mobile devices. Even among those who had previously used smartphones, I found that many were not comfortable with advanced functions beyond calls and text messages. The NSRP adjusted for varying skill levels in two ways. First, it offered optional smartphone training sessions, which were conducted by the phone plan provider, to newly recruited participants. Second, smartphone survey questions were designed to prompt simple responses from participants, such as checking a box or moving a sliding bar. An exception was an open-ended question about the most important positive and negative events of the day. For this question, participants could use the voice translation feature on the phones, which

allowed them to transmit an answer without needing to navigate the touchscreen keyboard.

Data and measures

The NSRP collected a variety of different data types. In addition to information collected throughout the three-month period, interviews were conducted at the beginning and end of the study. The initial interviews were semi-structured and asked detailed questions about demographics, pre-incarceration experiences, and reentry contexts. Because smartphone-based surveys are not well suited to lengthy questionnaires, the initial interviews provided important background and contextual information. The interviews at the end of the study provided an opportunity for researchers to debrief about the study with participants. Criminal justice history for participants and nonparticipants was also collected from the New Jersey Parole Board, which enabled me to assess differences between those that did and did not participate.

In this paper, I analyze measures related to issues of participation, accuracy, and high-frequency observation. Although some of these measures have straightforward definitions (e.g., those that completed all study phases), others deserve special mention here:

Participant-initiated controls on smartphone data collection. As described above, participants could control the collection of their smartphone information at will, using buttons to turn off and on the collection of locations, call and text logs, and surveys. Information on these

status changes was relayed to the research server in real time and recorded with a timestamp.

Accuracy of location estimates. Accuracy is based on the value returned by the Android developer location call feature.[6] It refers to the number of meters that deviate from the latitude and longitude estimate, based on a radius of 68 percent confidence. If location errors are random with a normal distribution, the 68 percent confidence circle refers to a one standard deviation.

Emotional wellbeing. Real-time measures of emotional wellbeing, including happiness, sadness, stress, and anger, were collected from the experience sampling and daily smartphone surveys. Participants were asked how happy, sad, stressed, and angry they felt and were provided a bar ranging from 0 (not at all) to 100 (very), which they needed to move via touchscreen before proceeding to the next survey question. Similar questions were asked in the initial interview and the bi-weekly interviews with the interview participants. These questions were asked on a 5-point scale and were scaled up accordingly for comparability.

II. KEY FINDINGS FROM THE NSRP

In this section, I use NSRP data to illustrate four issues of concern with smartphone studies among hard-to-reach, highly mobile, and less technologically skilled groups.

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[6] The command is location.getAccuracy() and is described on the Android developer site (http://developer.android.com/reference/android/location/Location.html#getAccuracy%28%29).

How do smartphones impact sample selection, attrition, and participation?

Low participation and high attrition rates are concerns for studies with hard-to-reach groups, and smartphone studies offer incentives and conveniences of participating that are particular advantages. In the NSRP, 93 percent of eligible individuals assigned to the smartphone group agreed to participate (n=141 of the 152 eligible individuals contacted).[7] Among those, 96 percent (n=135) completed the initial interview, received the phone, and sent data from the phone. For comparison, 87 percent of eligible interview individuals agreed to participate (n=27 of the 31 eligible individuals contacted) and of those, 78 percent (n=21) completed the interview. Individuals who consented but cancelled the initial interview provided different explanations, including finding work, not having transportation to travel to the interview, and not having time to participate. As figure 1 shows, combining the consent and participation rates, 89 percent of eligible smartphone individuals participated compared to just 68 percent of interview individuals (95% CI: 84 to 94 percent and 52 to 84 percent, respectively,

[7] One advantage of the NSRP was the ability to compare participation rates and participant characteristics with the overall pool of potentially eligible parolees released to Newark. During the study period, 265 parolees were potentially eligible to participate. Of those, parole officers did not contact 82 individuals (or 31 percent) about the study; this occurred for a variety of reasons, such as officers not having the time to contact individuals in a timely manner, not having correct contact information, and individuals being noncompliant with parole. Of the 183 individuals contacted, 31 were assigned to the interview group and 152 were assigned to the smartphone group. A comparison of criminal justice characteristics among those contacted and not contacted found no significant differences between these groups and the participants.

$p<0.01$).

FIGURE 1 ABOUT HERE

Individuals assigned to the smartphone group were not only more likely to participate initially but they also sustained relatively high participation rates throughout much of the three-month study period (see Figure 1). By the end of the first six weeks, 80 percent of eligible smartphone individuals were still participating, compared to 61 percent of eligible interview individuals (95% CI: 74 to 86 percent and 44 to 78 percent, respectively, $p<0.05$). By the end of the project, there were no significant differences in participation rates between the two groups, as 63 percent of eligible smartphone individuals compared to 58 percent of interview individuals completed the final interview. It is important to emphasize that these completion rates are based on the total population of eligible individuals. Among those that participated in the initial interview, the completion rates for the smartphone and interview groups are 70 and 86 percent, respectively (differences between groups are not significant).

Although the project retained a higher proportion of smartphone individuals throughout most of the study, they were more likely to attrite and leave the project early. Indeed, the attrition rate among the smartphone group was 30 percent, where 40 of 135 smartphone participants did not complete all study components, compared to an attrition rate of 14 percent among the interview participants, where only 3 of the 21 interview participants did not complete all phases (attrition rates are not significantly

different). Although there were no measurable differences between the smartphone and interview participants across demographic and reentry characteristics,[8] anecdotal researcher observations provide suggestive indications that interview participants appeared more motivated to complete the study. This may be due, in part, to their comparably higher rate of initial self-selection and the incentive of receiving a phone at the end of study. It is possible that the interview group would have had lower participation and higher attrition if the phones were not offered as incentives for completing the project.

Compared to other longitudinal prison reentry studies, the smartphone group had relatively high participation and retention rates. For example, a month-long interview study of recently incarcerated individuals had a 56 percent completion rate (Nelson et al. 1999). Another project interviewed reentering individuals once within three months after release and again between four and eight months; 61 percent of the original sample completed both interviews (Visher et al. 2010). One exception to these comparably low rates is a recent Boston reentry study, which followed 122 individuals and re-interviewed 93 percent of the original sample after 2 months (Western et al. 2015). The Boston project used a variety of tracking techniques to follow participants, and the costs per participant were similar to the NSRP.[9]

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[8] These included age, education, relationship status, total children, perceived social support, general health, previous mental health diagnosis, shelter residence, length of recent prison stay, any previous prison experience, any formal labor market job, and age at first incarceration.

[9] Researchers with the Boston reentry study estimate costs of $200 to $250 per interview, including participant incentives and staff time for interviews

Unlike interview studies, smartphones enable the collection of very detailed, real-time self-report and behavioral data. In the NSRP, smartphone participants received many surveys on a frequent basis; however, survey length was short in order to reduce respondent burden. Throughout the three-month period, participants completed 25,033 of the 31,909 surveys sent to their phones (78 percent), or an average of 185 completed surveys per participant. As Figure 2 describes, these completion rates vary by individual. Most participants (68 percent) completed more than 75 percent of surveys received; however, a small number of participants (N=14, or 10 percent) completed less than 50 percent of received surveys.

FIGURE 2 ABOUT HERE

In addition to survey answers, NSRP participants sent behavioral data passively through their phones. These included encrypted phone numbers, as well as limited characteristics of calls and texts. Although data coverage for calls and texts was relatively high, 26 percent of participants (n=35) turned off the collection of these data from their phones at least once. On average, these participants disabled the function 2.3 times, for 19.6 hours each, over the study duration. In addition to call logs, participants passively sent location estimates from their phones every 15 minutes during daytime hours, and information was collected 87 percent of the time (359,167 of

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and follow-up (Western and Sirois, personal communication). In the NSRP, the costs of phones, service plans, incentives, and a research assistant to monitor incoming data were approximately $230 to $410 per participant for the three-month period. The range in cost depended on participation, where weekly gift cards for participation increased the cost per participant.

412,704 estimates). Approximately 6 percent of estimates were not collected because participants were in areas without GPS service or they had turned off their phone's master GPS controls.[10] An additional 7 percent was not collected because participants turned off the NSRP location function. I examine potential implications of these missing data in later sections; however, the relatively low rates of missing data due to non-participation are noteworthy given that the NSRP participants, as men on parole, arguably have more reasons than the average individual to keep their information private.

The participation rates for surveys, call log, and location information indicate that individuals are amenable to smartphone data collection methods. At the end of the study, I asked participants directly whether they preferred sending information through the phones or would rather participate in biweekly interviews. Of the smartphone participants who completed the final interview, two-thirds preferred smartphone surveys (see Table 1). Approximately 20 percent thought that weekly interviews would be more helpful, and 13 percent said they did not know or had no preference. Interestingly, there were no differences by age, previous smartphone ownership, or initial comfort with smartphones, as self-reported in the initial

[10] Android platforms no longer allow user-installed applications to override the phone's overall GPS settings, and participants could turn off the GPS on their phone, as opposed to the GPS setting on our application. When asked why their phone's GPS was off, participants offered a variety of reasons, including that they did not realize it, that they turned it off to conserve battery life, or that they did not want others, including phone companies, to follow their movements.

interview.

TABLE 1 ABOUT HERE

The most common reason for favoring smartphone surveys was convenience, and 56 percent stated that filling out smartphone surveys was less burdensome than interviews. Participants emphasized the benefits of not needing to travel, either because transportation was difficult or because they were already traveling throughout the day. As one participant stated, "After a long day of walking around, going to businesses, you don't want to come in [for an interview]." Other participants described the ease of filling out surveys while still doing other activities; this was particularly true for those with unpredictable schedules and those with family and work commitments.

Although a small minority, some participants stated that frequent interviews would feel less private (n=3), irritating (n=5), or uncomfortable (n=3) compared to smartphone surveys. As one participant noted, "I'm not really good in person, I'm not a people-person. I can deal with the phone. I wouldn't want to discuss with the person what I type on the phone." Several participants stated that "just knowing you have to go to an interview" or that "being in someone's office" was stressful. Interview settings can cause anxiety or coercion (Nosek, Banaji, and Greenwald 2002), but the reluctance to participate in interviews might be a greater concern among this population.

In contrast to these few negative expectations, 21 percent of

smartphone participants stated that they would prefer interviews to smartphones. These individuals stated that interview settings would provide more feedback, better facilitate in-depth discussion, and permit more personal interactions compared to smartphone surveys. According to one participant, “Face-to-face you get more intimate with the conversation. With the phone, you just answer the questions and throw it back in your pocket—it’s a yes or no question.” Responses from these participants suggest that they prefer in-depth and open-ended interviews as compared to smartphone surveys; however, they may not prefer structured interviews.

Taking together both the stated preferences for smartphone surveys and the higher initial participation rates among smartphone participants suggest that these designs may help reduce sample selection among hard-to-reach groups. At the same time, smartphone surveys are best administered when they are relatively brief and they often cannot explore complex events and situations. For projects that consider multifaceted issues, smartphone methods might be usefully complemented by periodic interviews.

How do smartphones facilitate measurements of detailed and irregular patterns?

Interview methods often confront challenges when measuring concepts that are difficult for respondents to accurately estimate or retrospectively report. Smartphones can improve these shortcomings by collecting self-report answers in real time and passively recording behaviors while

individuals are in their everyday environments (Schwarz 2007). In this section, I discuss the advantages and potential issues of interpreting two types of behavioral data—GPS coordinates and encrypted call logs—as measures of geographic locations and social networks. I also describe how the collection of real-time self-report answers can capture variation and regularity in one domain—emotional wellbeing—in ways that improve upon survey answers provided in interview settings.

Geographic locations. Studies on neighborhood effects or spatial context normally rely on residential address as a measure of location; however, this static measure does not capture the range of contexts that individuals inhabit (Palmer et al. 2013) and may be a particularly poor indicator in studies with hard-to reach or highly mobile individuals. The NSRP application passively collected location estimates every 15 minutes during daytime hours, and these measures reveal a much larger geographic world than suggested by residential address alone. NSRP participants lived in 129 census blocks but they traveled through 10,215 unique blocks throughout the study period.

Smartphone scholarship has noted two concerns with the technical aspects of collecting location data—the impact on battery life and the accuracy of estimates (Palmer et al. 2013; Raento et al. 2009). Neither of these issues were particular challenges in the NSRP, perhaps due to rapidly improving technology. For battery life, application pretesting suggested that collecting GPS estimates was not a noticeable drain on devices. This is not

to say that participants, who often lacked regular access to charging outlets, did not experience difficulties keeping their phones charged (see the below section on missing data); however, there were few indications that collecting location data contributed to these challenges. Similar to battery life, concerns about the accuracy of estimates also appear largely mitigated by technological improvements. Prior research documented quite variable accuracy ranges (Palmer et al. 2013; Raento et al. 2009), and accuracy estimates are measurably better in the NSRP relative to these studies. In the NSRP, mean accuracy was 44 meters compared to 311 meters in a study conducted just 2.5 years prior (Palmer et al. 2013). Although most location estimates are not precise enough to identify a participant's location in a particular building, the majority of estimates (75 percent) have a range of 48 meters or less (about one-third of a mile, see Figure 3). For most research, this level of granularity is more than adequate.

FIGURE 3 ABOUT HERE

Phone call and text logs. Phone numbers from calls and text messages are increasingly used as behavioral-based measures of social network size (Miritello, Lara, et al. 2013; Miritello, Moro, et al. 2013; Onnela et al. 2007; 2007b). Although call and text logs capture only one dimension of social interaction, they have been found to correlate with other communication means, such as face-to-face contact, email, and social media (Baym, Zhang, and Lin 2004; Eagle, Pentland, and Lazer 2009). They also improve upon many of the shortcomings of self-report methods, which are biased by

several types of error (Feld and Carter 2002; Marin 2004; Marsden 2003) and often focus on close relationships (for an exception, see McCormick, Salganik, and Zheng 2010). Despite these advantages, researchers have paid little attention to potential complications of multiple phones, phone sharing, and other behaviors that might bias call log measures. Resource-poor groups, in particular, are thought to have uniquely different phone usage patterns, and there is a general perception that low-income individuals are more likely to have multiple phone numbers over time. Individuals might use temporary devices ("burners") in order to protect their anonymity from law enforcement or to maintain privacy from others (McEwen 2011; Soghoian 2011). They also may encounter "access barriers" to service, resulting from frequently switching phone carriers, using no-contract plans, and relying on outdated hardware from used devices (Gonzales 2014). These are credible concerns; however, there are some indications that resource-poor groups are actually less likely to regularly share phones compared to more advantaged groups (Brick, Edwards, and Lee 2007).

The NSRP took several steps to address and assess phone sharing and multiple phone use. First, on the participant side, the project provided individuals with phones and phone plans in order to limit the potential of phone switching due to access barriers. Second, on the analysis side, the NSRP limited the analysis of phone numbers to reciprocal numbers with completed incoming and outgoing calls (Onnela et al. 2007; 2007b). This

method aims to exclude businesses, wrong numbers, and tangential contacts that may result from phone borrowing or temporary phone ownership. A third approach was to directly assess the extent of multiple phone numbers among social contacts through smartphone survey answers collected during the study. When a participant received a call or text message from a new phone number, a very brief survey was automatically triggered and participants were asked to provide the first name of the contact, if not already stated in the initial interview. Based on these answers, a very small percent of names (4 percent) was associated with more than one phone number. Five names (or 0.2 percent of names) across five different participants were associated with ten or more numbers. Because this analysis used first names only, the repetition of names could reflect either common given names of several different people or different phone numbers associated with one person. Although I am unable to distinguish between these two explanations, the small number of names with multiple numbers suggests that phone sharing and multiple phone ownership may not be as extensive as might be expected.

Smartphone surveys. In addition to behavioral information, the collection of self-report information in real time, while participants are in their everyday environments, is a unique advantage for research on temporary states or events that are often in flux (Anhøj and Møldrup 2004; Bolger, Davis, and Rafaeli 2003; Stone et al. 2007). Real-time self reports are also well suited to hard-to-reach individuals, whose experiences are often

more irregular compared to advantaged groups with stable routines. For these questions and populations, the ability to send surveys in real time improves upon interview methods, where error results from retrospective reporting and unnatural settings.

In the NSRP, a primary aim was to assess the role of emotional wellbeing during job search. Smartphones are well suited to collect emotional wellbeing measures, since wellbeing is situational and affected by interview settings (Axelson et al. 2003; Golder and Macy 2011; Kahneman and Krueger 2006). The frequency of measures provides a more informative portrait of wellbeing compared to single-point or less frequent estimates from interviews. To illustrate these advantages, Figure 4 displays real-time reports of happiness, sadness, stress, and anger as compared to initial interview answers for one randomly selected participant that completed the project. The real-time measures describe several peaks in sadness, stress, and anger that occur throughout the period, which are not captured by interview reports. Even compared to frequent interviews conducted with the interview group, the detailed smartphone measures afford a better understanding of both variation and regularity in emotional wellbeing. Figure 5 displays reports of happiness from interviews conducted every other week and from daily smartphone surveys for three randomly selected interview and smartphone participants that completed the project. The frequency of smartphone measures captures highs and lows in happiness, while also establishing patterns of longer-term trajectories. Based on

interview answers (top row, Figure 5), happiness appears comparably stable for the left and right participants, but it is quite variable for the middle participant. For this individual, more frequent measures might help better place his emotional swings within the context of his overall state.

FIGURE 4 ABOUT HERE

FIGURE 5 ABOUT HERE

In addition, smartphone surveys collect information while individuals are going about their everyday routines, as opposed to interview or laboratory settings. As Figure 4 displays, the respondent's interview answers underestimate feelings of happiness and overestimate anger, sadness, and stress as compared to his smartphone survey answers. Interestingly, the direction of these differences is similarly observed across the full sample of smartphone participants, where initial interview answers indicate lower levels of happiness and higher levels of sadness, stress, and anger compared to real-time, smartphone answers collected throughout the study (see Table 2). These differences are statistically significant (happy CI: -8.74 to -0.11; sad CI: 14.57 to 23.68; stressed CI: 2.22 to 11.25; and angry CI: 22.78 to 32.14), with some measures (e.g., sadness and anger) exhibiting large differences. I suggest that these differences result from the administration of smartphone surveys in everyday contexts, but it is also possible that participants' emotions change over the study period compared to their feelings reported in the initial interview. A comparison of answers reported throughout the study for the interview participants provides some suggestive

evidence against the latter explanation. Compared to the smartphone group, interview participants exhibit fewer differences between their answers during the initial interview and subsequent follow-ups. As Table 2 displays, happiness is the only emotion that is significantly different (CI: -17.23 to -3.37) among the interview group.

TABLE 2 ABOUT HERE

What are the implications of missing data in smartphone studies?

The frequent collection of detailed data is a major advantage of smartphone studies; at the same time, however, this approach often results in higher levels of missing data, particularly for self-report measures. Smartphone literature has generally discussed missing data as random and periodic, resulting from unforeseen technological issues, such as software bugs and depleted batteries, or participants accidentally forgetting their phones (Raento et al. 2009). Although there are fewer battery issues as technology improves, hard-to-access and mobile groups may have more challenges keeping their phones adequately charged. For instance, an NSRP participant's phone was stolen when he left it charging in the living room of a friend's house. Although this happened only once in the study, missing data due to other issues, such as intentional non-compliance was a concern from the beginning of the project. For example, individuals who violate parole requirements by traveling out of the state might not take their phones with them, resulting in erroneous conclusions about geographic mobility. These concerns may have been premature, as participants sent a relatively high

percent of location estimates (87 percent) and the data reveal that some participants traveled out of state with their phones.

As described in the NSRP methods section, the smartphone application included functions that allowed participants to turn off at will the collection of call logs, locations, and surveys. Analyzing these status changes allowed me to assess the extent and patterning of missing data due to intentional non-compliance. Figure 6 describes the times and days that participants turned off call log, location, and survey features. One might expect that participants would disable functions during weekends or evenings when they wanted privacy; however, participants were equally likely to turn off features during the day and during the week. In fact, very few status changes were made on Sunday. In total, 63 of the 135 participants (47 percent) disabled at least one function at some point during the study. The distribution across participants is highly skewed, with most participants disabling a few functions and a handful of participants frequently changing statuses.[11] Notwithstanding these few participants, missing data due to status changes accounted for a relatively small number of estimates (7 percent) for the function that was most often disabled (location).

FIGURE 6 ABOUT HERE

How do smartphone designs affect attitudes, behaviors, and other outcomes?

[11] One participant turned off his phone's functions 57 times over the study period. This individual participated in the project over the entire three months but did not participate in the final interview, so I was unable to ask him about his reasons for disabling functions.

In the NSRP, smartphone participants received phones, data plans, and frequent surveys. All of these features may change attitudes and behaviors, a phenomenon known as researcher effects or "Hawthorne effects." The provision of a new phone may change participant habits and routines for weeks or even months, depending on the novelty of the smartphone model, the tasks required for participation, and participant skill level (Bodker et al. 2010; Raento et al. 2009). For individuals returning from prison, these changes may be less consequential since acquiring a new phone is often a normal part of reentry. However, the provision of a smartphone, as opposed to a basic mobile phone, and a paid data plan may have changed phone usage patterns or encouraged greater communication. The frequent smartphone surveys may also create Hawthorne biases, by asking participants to reflect on their prior experiences and future expectations. Although questions administered in interview studies may also affect behavior, the frequency of smartphone questions could result in more consequential changes (Runyan et al. 2013).

In the NSRP, participants were asked in the final interview whether they thought the project changed how they searched for work. As Table 3 displays, the majority of smartphone participants (65 percent) stated that their participation positively changed how they searched for work, and nearly half of those stated that simply filling out surveys motivated them to search. Participants discussed the need to put something positive on the surveys, which encouraged them to look for work. As one participant stated, "[The

project] helped me be determined to find a job and the things with the surveys helped me by asking me the questions. When it comes, I can see whether I can get me an interview or fill out applications because I know a survey is coming up. It kept me on my feet, it kept me aware." Others explained that the surveys offered them a method to document and think about their progress. According to one participant, "[The] surveys made me refresh my day and I tried to make mental notes about where I was at and what my plan was—it helped me keep on top of myself."

TABLE 3 ABOUT HERE

Despite participant's statements, however, it is unclear whether the smartphone design uniquely affected respondents and changed outcomes in meaningful ways. First, a similar percent of interview participants (67 percent) stated that the project changed how they search for work, suggesting that researcher effects are present in both methods. Second, there is some indication, although circumscribed,[12] that smartphone individuals searched for work more days compared to interview participants (mean proportion of days searching: 0.16 compared to 0.09, p-value=0.007); however, the additional search effort did not pay off in increased work. Even if smartphone surveys change behaviors on the margins, therefore, they may not impact outcomes that depend on other factors, such as an employer deciding to hire an applicant. Clearly this is a complex issue that would

[12] It is possible that the smartphone and interview reporting methods account for the differences in days searching, where the real-time, smartphone measures are better able to capture irregular search patterns compared to retrospective reports in interviews.

benefit from further research. Still, the NSRP findings indicate that the majority of smartphone participants believed that their participation in the study changed how they conducted their job search, but interview participants also expressed similar beliefs.

Smartphone interventions. Although unintentional Hawthorne effects are potential challenges for researchers, these same processes can be positively leveraged as experimental interventions (Boulos et al. 2011; Eonta et al. 2011; Swendeman and Rotheram-Borus 2010). In the NSRP half of the smartphone participants were randomly assigned to a peer-based text-messaging forum that connected participants to each other. Findings from the experiment suggest that the peer forum provided a venue for information and social support. On average, participants sent 1.24 texts per day to the rest of the group; however, conversation usually occurred in sporadic bursts of exchanges. The most common text messages from participants were about job openings and leads. Individuals also provided encouragement and motivation to other participants, who had posted updates on their job search.

Although the main intention of the peer forum was to expand a participant's social network by connecting him to other jobseekers, assignment to the forum resulted in a smaller number of other phone contacts (35 versus 45, $p<0.05$) and less time on the phone communicating with each contact (88 minutes per contact versus 123 minutes per contact, $p < 0.10$; see Table 4). These findings indicate that participants appear to

have redirected their communication patterns towards the peer forum, and that interaction with the forum took the place of other phone interaction that would have occurred. This notion aligns well with communications research, which finds that individuals have thresholds for time spent interacting with others (Miritello, Lara, et al. 2013). As Table 4 displays, participants in the peer forum also reported modestly higher levels of emotional wellbeing, although these differences were small and not significantly different. They also spent a marginally greater proportion of days searching and working, but again, these differences were quite modest and not significant. Although the findings are based on a small sample of individuals assigned to the treatment group, they illustrate the potential benefits of social or peer-based smartphone interventions.

TABLE 4 ABOUT HERE

III. DISCUSSION

In this paper, I used the NSRP to illustrate some of the advantages and potential challenges of using smartphones with hard-to-reach, highly mobile, and less technologically skilled groups. Perhaps one of the main advantages was that participants seemed to prefer the use of smartphones, as demonstrated by their higher initial take-up rate and their statements about the convenience of smartphone surveys. For groups that are typically hard-to-reach, this is a clear advantage compared to interview or survey methods. Smartphones also facilitate the collection of detailed behavioral measures that are often not possible to obtain with other methods, such as measures

of everyday geographic mobility and social networks. Moreover, they enable the collection of frequent self-report answers, which is a particular benefit for researchers studying groups, topics, or contexts that are characterized by irregular or changeable experiences. For researchers considering smartphone projects, however, the potential "Hawthorne effects" of frequent surveys, as well as the provision of phones and data plans, should be assessed within the scope and aims of the specific project. As the NSRP found, participants believed that the project provided benefits during their job search and that their job search changed as a result of their participation. At the same time, however, participants in the interview group also voiced similar beliefs. Researchers might consider capitalizing on researcher effects by incorporating smartphone-based interventions or experimental designs to test theories of social behavior; these types of smartphone-based interventions are increasingly prominent in other disciplines, particularly health.

For researchers seeking to use smartphone designs with hard-to-reach, resource-poor, or less technologically skilled groups, I discuss below several issues that are particularly relevant to consider. Other issues, such as alternative methods of participant recruitment and efficient smartphone survey formats are addressed elsewhere, in the context of specific projects (Gaumer et al. 2014; Goldberg et al. 2014; Raento et al. 2009) or review articles (Buskirk and Andres 2013; Schober et al. 2014).

Strategies to gain participant trust and protect privacy

As discussed in the participant sampling and recruitment section above, there were many reasons for individuals to be skeptical or hesitant to participate in a smartphone-based study, particularly with the lead researcher based at the parole office. In addition to these participant concerns, smartphone designs involve distinct data privacy and security issues. Smartphone information is collected at frequent intervals, and this does not simply mean that there is more data compared to traditional methods. Rather, the format of detailed information increases the likelihood of identification (Ohm 2009). The risk is particularly high when information from outside the study is matched to the data; however, identification can also occur because participant patterns are unique. For example, there may be only a handful of people who travel the same route on particular days and times. I believe that several strategies helped to address concerns of privacy and security, and helped to counteract initial suspicion or reluctance on the part of participants, leading to NSRP's high participation rate.

Eligible individuals were asked to participate in a group meeting to discuss the project, including the types of data that would be collected and the methods used to secure the data. These meetings encouraged detailed discussion about the project, and they provided me the opportunity to describe the functions that we specifically included in the smartphone application to help protect privacy, such as the status functions and the encryption method for phone numbers. Apart from adjustments specific to the smartphone application, we also ensured that the data were encrypted

throughout all stages of the process—from storage on the smartphones to transmittal to researchers. Moreover, encrypted data on the phones were erased after transmittal to the server. The website and server used for transmittal were secured with several layers of protection, including strong user passwords and a SSL (Secure Sockets Layer) protocol. Information on the website was removed at frequent intervals throughout the study and transferred to a stand-alone server, which was maintained by the university. We also obtained a Certificate of Confidentiality from the federal government to safeguard against forced disclosure. All of these strategies illustrated how seriously the NSRP took data privacy and security, and the group meeting provided a platform for me to convey these approaches to potential participants.

In devising these protocols, I found it helpful to consult with computer science colleagues about current security practices and ways to best safeguard sensitive data. Conventional sources of confidentiality guidelines (such as Institutional Review Boards) might not be fully aware of the potential risks of disclosure unique to smartphone data or the current technological standards for security; however, this is likely changing as smartphones and their related privacy challenges become more ubiquitous.

Methods to address heterogeneous technological skills of participants

Another primary issue that I anticipated before the start of the NSRP was participants' varying technological skill levels. In the NSRP, 53 percent

of participants had never previously owned a smartphone; only two percent had never owned a mobile phone. Although I used some strategies to mitigate skill-related problems, several issues arose throughout the study that could have been better addressed preemptively. As the participant sampling and recruitment section described above, I offered optional smartphone training sessions to participants at the start of the study. These training sessions reviewed basic functions, including making and receiving phone calls, sending text messages, and downloading applications. Participants also learned how to use the voice-to-text translation button, which enabled them to record responses to survey questions or text messages without using the touchscreen keyboard. The sessions also set up participant Google accounts, which are necessary for Android phones and had the added benefit of creating email accounts for the participants who did not yet have one.

These were important topics to cover in the training sessions, but there are several additional issues that I would include in any future smartphone training. First, I would discuss the use of passwords for Google accounts, the devices themselves, and other smartphone applications. I would encourage people to write down their passwords in a separate notebook or to make sure that they remember whatever codes they use. This may seem obvious, but participants commonly forgot their passwords, believed that I could retrieve them, or thought that passwords across applications were interchangeable. Second, I would emphasize that Android charging ports are delicate and that

charging cables can only be inserted one way. Although not frequent, the most common technological issue throughout the study was damaged or broken charging ports on the phones, which required replacement and could have easily been avoided with these types of warnings. Finally, depending on the anticipated technology skills of participants, I would consider making the training sessions mandatory rather than optional. Some individuals believed that they did not need the training, but I ended up conveying to them most of the lessons from the training in subsequent one-on-one meetings or calls. Although these suggestions may all seem fairly minor, technological support questions and issues from participants are common and can be time-consuming to address on an aggregate scale; preventing issues from arising through mandatory training sessions may help reduce this burden.

Questions to consider when assessing phones and data plans

In the NSRP, I provided phones and data plans to participants. Although costly, there are several advantages to this approach for resource-poor groups. Providing phones and data plans ensure that participants have reliable phone access and that the smartphone application operates as expected on the device's operating system. Purchasing phones through no-contract, month-to-month providers may seem like the most obvious approach, since project designs often conflict with the service terms of contract plans, month-to-month phones and plans are cheaper, and poor participants are better able to assume responsibility for the plans after the

study. However, NSRP pilot tests indicated that the technological capabilities of no-contract devices were substandard to the requirements of the application. The no-contract provider also offered limited customer support, which was particularly important when a project involves many participants, when phones malfunction and need to be replaced, and when the project depends on access to the same phone model throughout the study period.

In designing the NSRP study, one of the primary concerns was that participants would accidentally or intentionally lose their phones or that their devices would be stolen. To mitigate this concern, the project's consent form stated that missing devices would not be replaced and that stolen devices might result in a police report. Of the 135 smartphone participants, only three people (2 percent) reported their phones stolen during the study period. One person recovered his phone by contacting the perpetrator and paying for it, another person bought a new phone of the same model to continue his participation, and the third person was unable to recover his phone and participated via interviews for the remaining months. A related concern was that participants would enroll in the project for the sole purpose of obtaining a phone and would leave the study immediately after receiving the device. This concern appears to have been misplaced, since participants often stated to me that they thought the plans were more valuable than the devices themselves. This may be because the NSRP used an older Android model, as opposed to a top-of-the-line smartphone. One participant did leave the study after the first day; however, it is not clear that his original

intention was to obtain the phone without further participation. Overall, missing and stolen devices were relatively minor issues in the NSRP.

Other strategies and recommendations

For the NSRP, I developed my own smartphone application, in collaboration with a computer science class at my university (see footnote 1). This choice made sense for the study design; for example, I wanted to send surveys based on observed behaviors, such as when a participant received a call or text message from a new phone number. To my knowledge, other survey applications still do not have this functionality. Since the NSRP distributed phones to participants, we needed to ensure that the smartphone application was compatible with the particular model and operating system, but we did not need to test the application on the vast variety of other phone models and systems. For researchers that are primarily interested in collecting data via surveys, rather than observational data, I suggest using an already-developed, mobile-compatible web-based survey that can be used across a variety of phone models.

Researchers also might consider combining smartphone methods with other survey approaches to improve data quality and participation rates. For example, previous research has found that survey methods that draw on reciprocity norms, that increase perceived control, and that incorporate novelty improve overall participation rates, as well as the rate of individual questions completed (Pickett et al. 2013). Smartphone survey designs could easily integrate this survey choice method as a way to further improve data

quality and increase participation rates.

Finally, it is important to emphasize that the automated functions in smartphone studies do not preclude the need for ongoing researcher support throughout the entire data collection period. This may be particularly true of studies that have a long data collection window or that are working with groups with diverse technological skills. As mentioned above, participants raised technology questions and issues throughout the study, and these were time-consuming to address in the aggregate. Moreover, a research assistant monitored all incoming data on a weekly basis, to check for unanticipated technology bugs or other unexpected malfunctions. Computer science students who created the smartphone application were also on-hand throughout the data collection phase, to provide additional assistance in case technological issues arose that the main research team could not address. Communication with the phone plan provider was also unexpectedly time consuming. All of these tasks throughout the smartphone data collection field period required dedicated researcher time.

IV. CONCLUSION

With care, sociologists should readily adopt new technologies when warranted by the research question and population under study. Traditional research methods are limited by a multitude of biases and errors that smartphones can potentially help remedy. Not only can smartphones improve the participation rates of hard-to-reach groups and the accuracy of self-report measures, but they can also expand the types of research

questions that can be studied. For example, smartphone data can map social networks to better understand the frequency, type, and duration of weak and strong ties (Karsai, Perra, and Vespignani 2013; Mirisaee et al. 2010; Onnela et al. 2007). Smartphone data can illuminate segregated spatial patterns of individuals, perhaps distinguishing by race or class, as they move through their daily lives (Palmer et al. 2013), and research on neighborhoods and spatial exposure can directly measure the geographic contexts of individuals throughout the day and over time (Browning and Soller 2014; Palmer et al. 2013). Smartphones thus enable us to "catch the uniformities of dynamic process" of human and social behavior; 65 years ago, Talcott Parsons famously regretted this simply was not feasible for social science researchers (1951:21). The high-frequency format of smartphone data has opened up a new world of research possibilities.

Despite these many benefits, smartphones are also nascent social science tools and questions remain about the viability of interpreting smartphone data as human experience. The NSRP is also one of the few smartphone projects that focused on a traditionally hard-to-reach and highly mobile group, and it is not clear how well the findings and recommendations described here generalize to other disadvantaged study populations. However, the potential advantages highlighted in this paper, suggest that smartphone designs may be especially well suited to hard-to-reach, resource-poor, and mobile groups.

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FIGURE 1: The participation rate among smartphone and interview groups

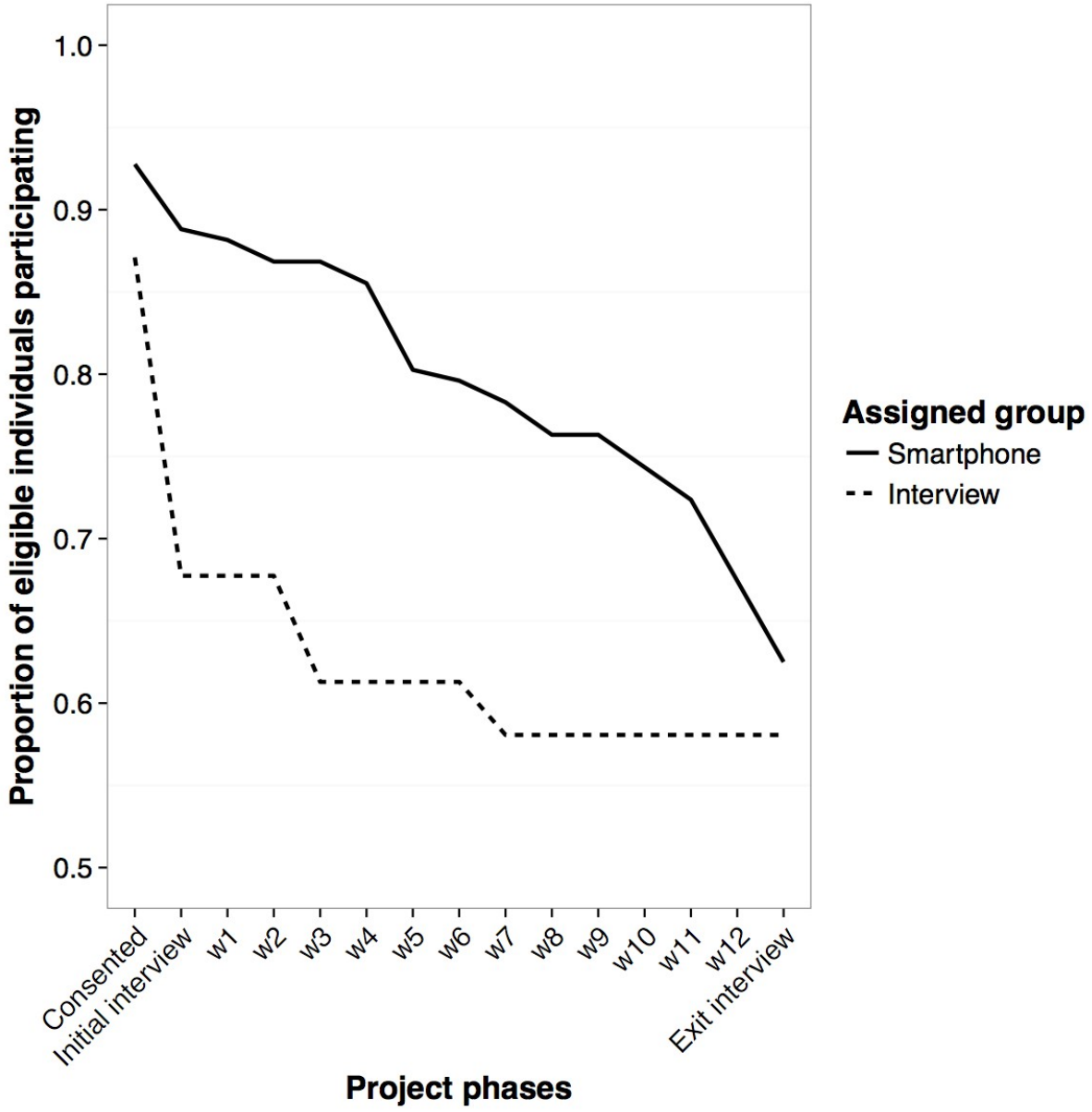


FIGURE 2: Smartphone survey completion rates by participant, n=135

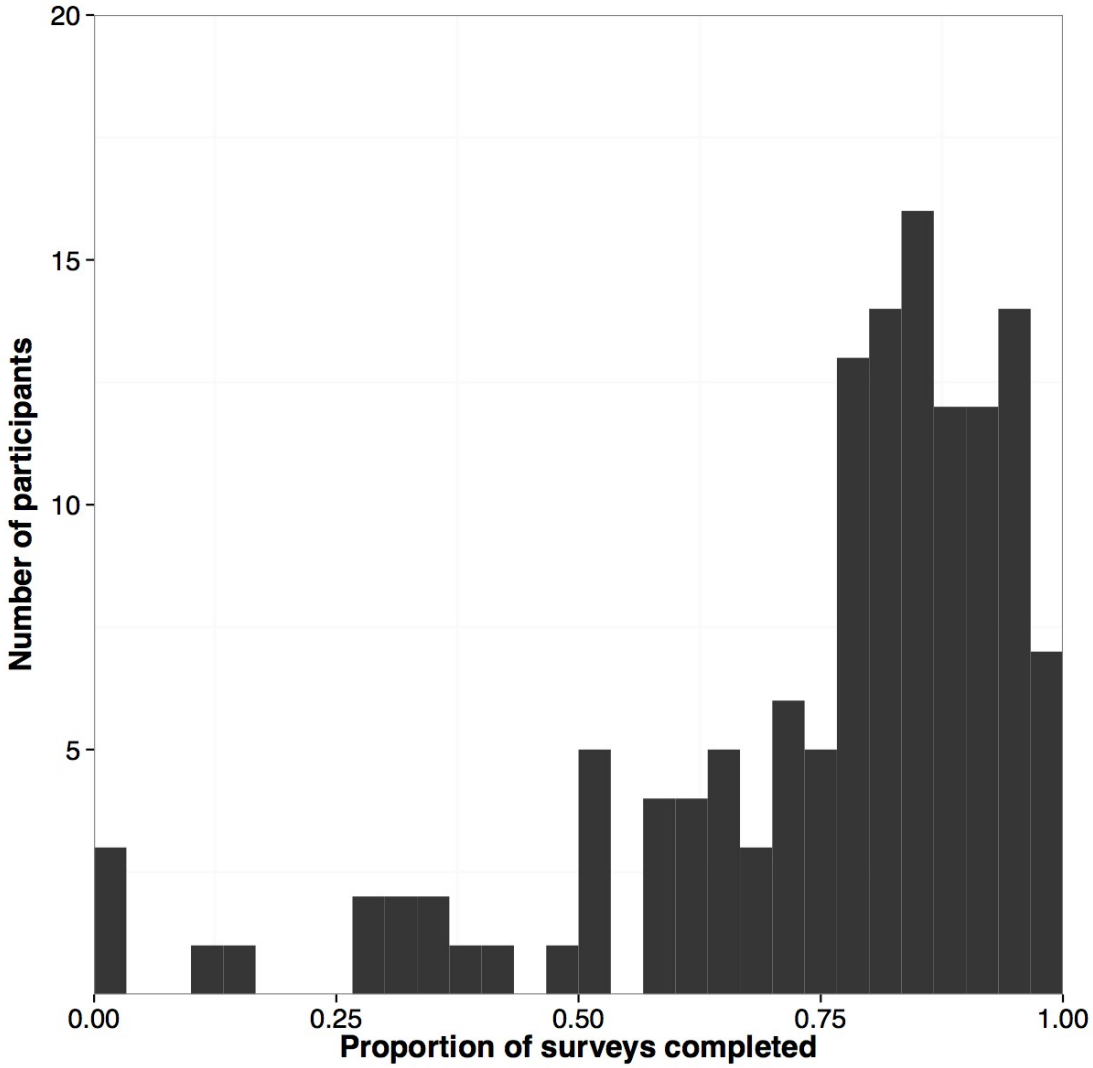
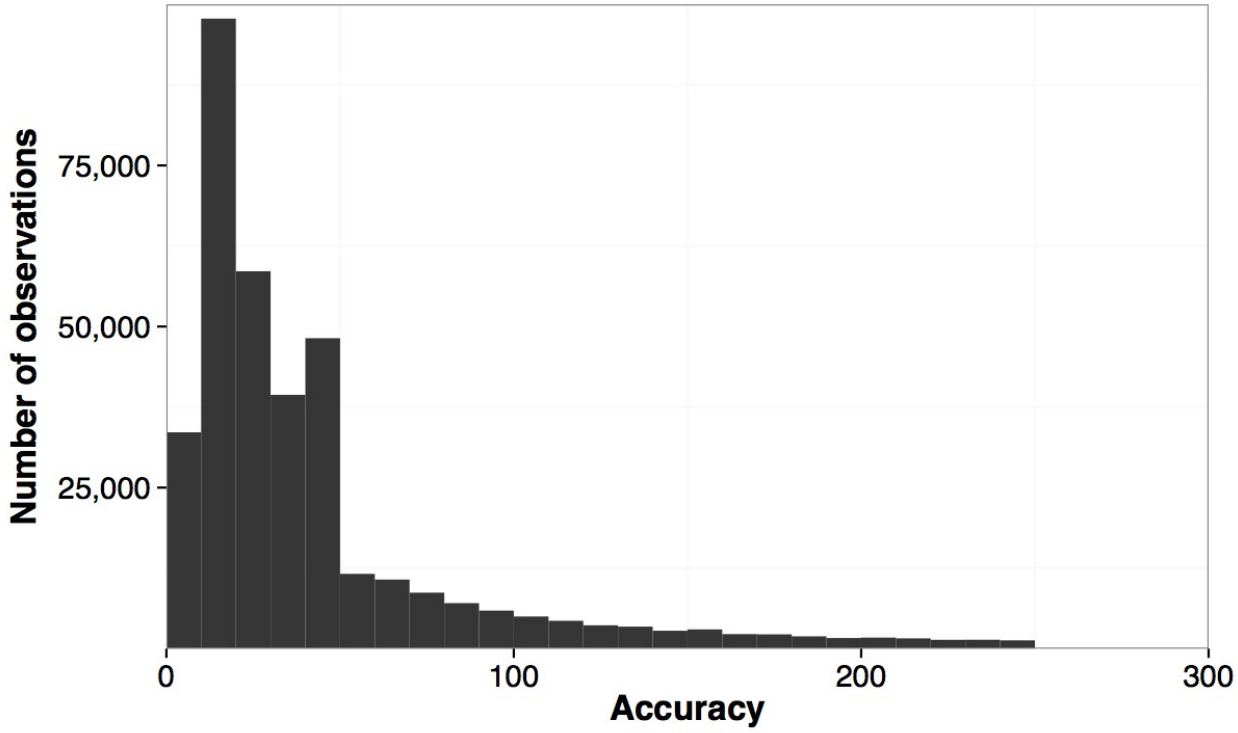
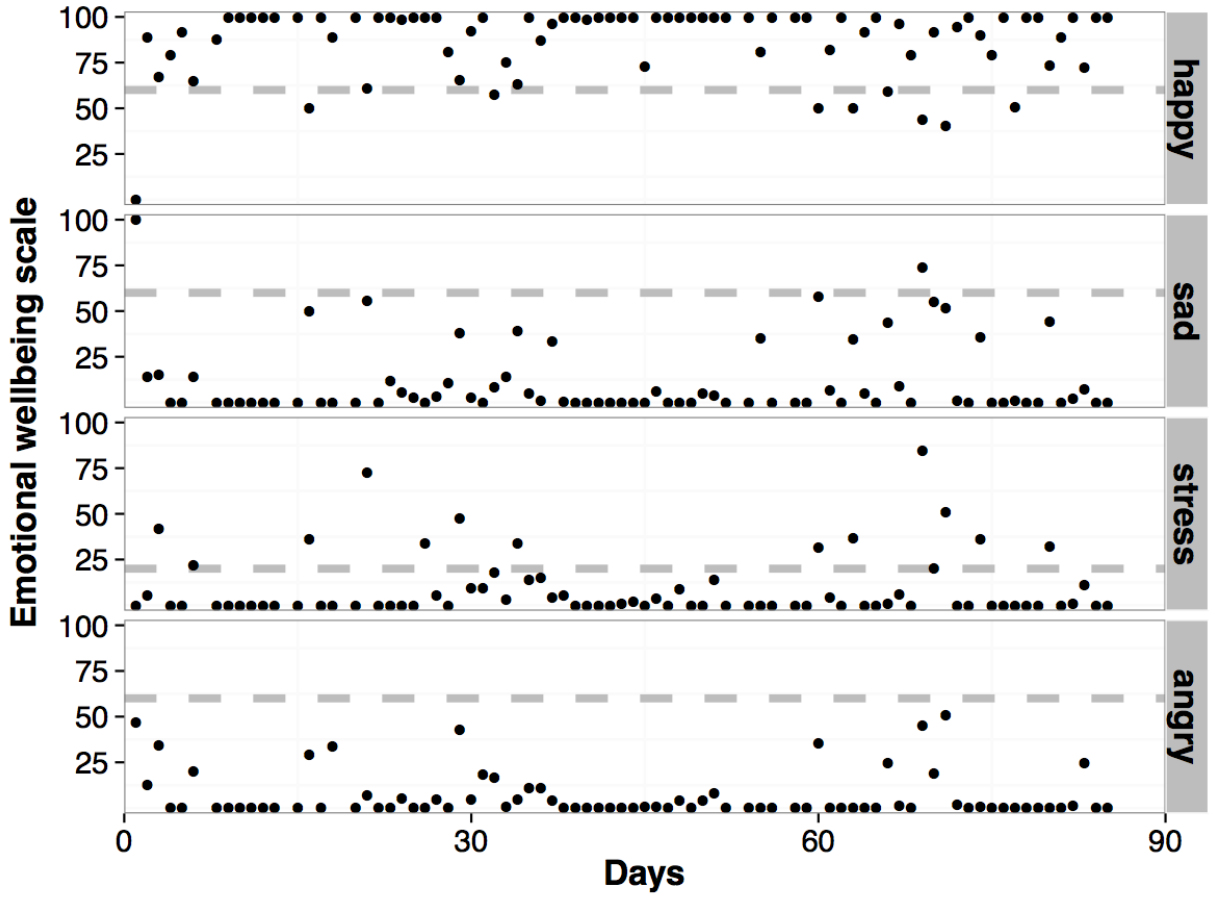


FIGURE 3: Distribution of accuracy estimates for location observations, n=359,167



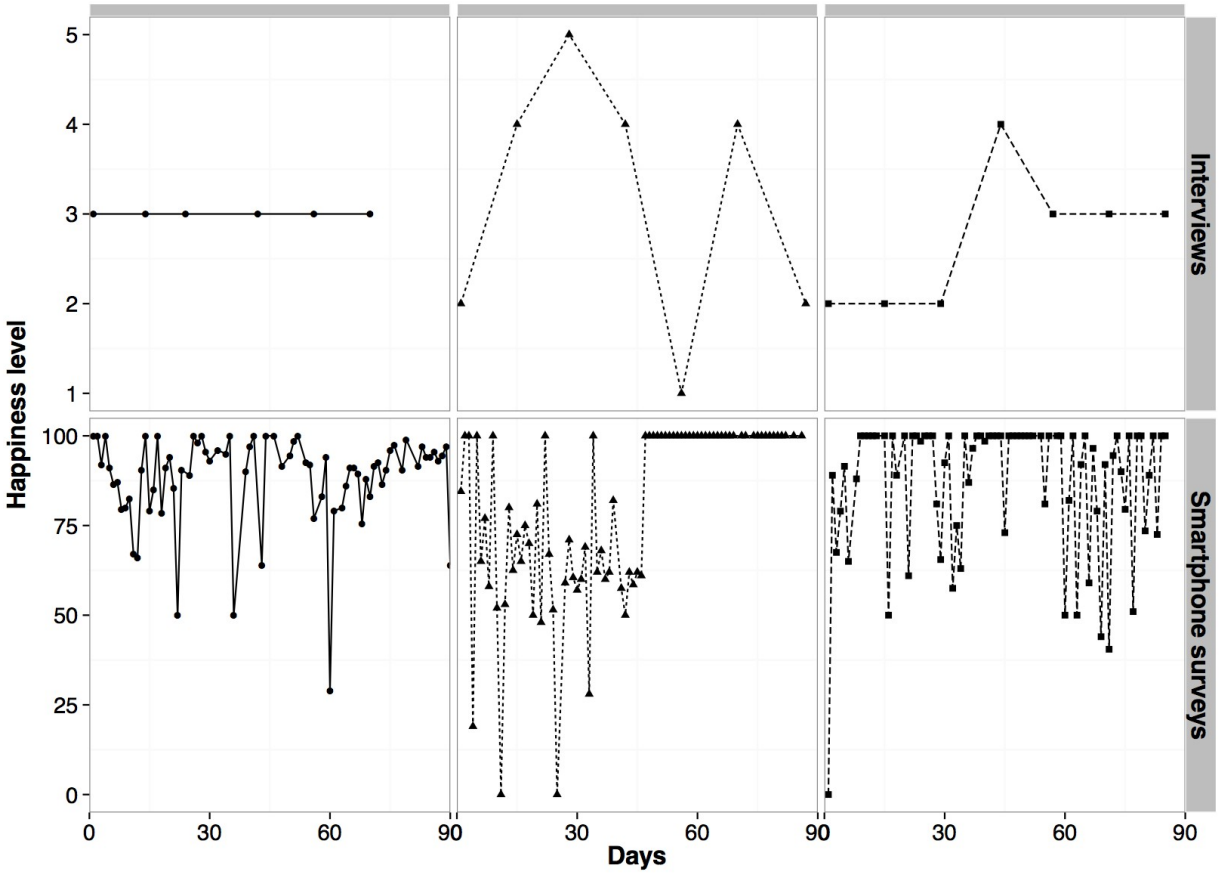
Note: Accuracy refers to the number of meters that fall within the 95 percent confidence interval for the point estimate

FIGURE 4: Emotional wellbeing reports, at initial interview and via smartphone surveys for one participant



Notes: The points reflect survey answers received from one participant throughout the study period. The gray dashed lines represent the level of emotional wellbeing reported at the initial interview.

FIGURE 5: Reports of happiness from interviews every other week and daily smartphone surveys



Notes: The figures describe data from three randomly chosen interview participants and three randomly chosen smartphone participants. Interview participants were asked to rate how happy they felt on a 5-point scale. Smartphone participants were asked to rate their happiness by selecting a point on a 0 to 100 point scale on their phone. The smartphone data provide fine-grained reports that reveal highs and lows of wellbeing, as well longer term trends of happiness.

FIGURE 6: Disabled data collection functions by participants, by hour of day and day of the week

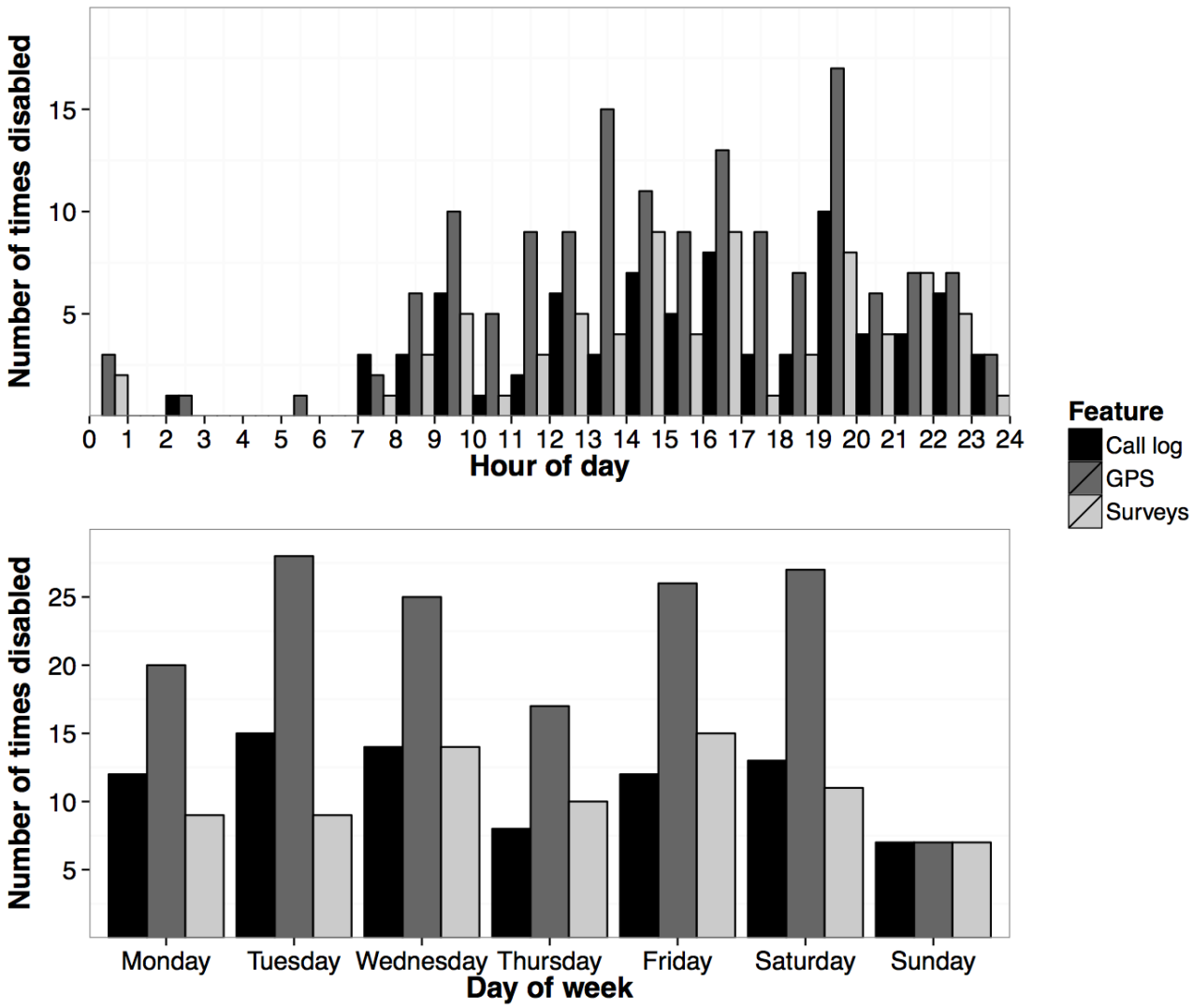


TABLE 1: Participant preferences: smartphone surveys or biweekly interviews

	Preferred method	
	N	%
Smartphone surveys	63	66%
Interviews	20	21%
Don't know	12	13%

Note: Smartphone participants who completed the final interview (n=95) were asked this question.

	Smartphone participants					Interview participants			
	Initial interview		Smartphone survey			Initial interview		Biweekly interview	
	Mean	SD	Mean	SD		Mean	SD	Mean	SD
Happy	62.3	19.0	66.9	21.0	*	58.1	14.0	68.6	1
	7	9	6	1		0	1	7	
Sad	41.7	23.7	22.2	20.0	**	47.6	27.1	40.8	1
	8	5	2	8	*	2	9	7	
Stressed	34.8	19.6	28.1	23.9		36.1	19.6	35.9	1
	1	9	9	2	**	9	2	6	
Angry	48.7	25.1	20.9	20.1	**	54.2	24.6	46.5	2
	4	1	0	9	*	9	1	1	

Notes: *p<0.05, **p<0.01, ***p<0.001; significance levels are based on two-tailed paired tests, and refer to differences between initial interview and smartphone survey answers for smartphone participants, and between initial interview and interview answers for interview participants.

TABLE 2: Emotional wellbeing measures for smartphone and interview participants

TABLE 3: Do you think your participation in the project change how you search for work?

	Smartphone participants		Interview participants	
	N	%	N	%
Yes				
Positively	62	65%	12	67%
Negatively	1	1%	0	0%
No	32	34%	6	33%

Notes: answers refer to individuals that completed the final interview (n=113)

TABLE 4: Outcomes for peer-based and individual groups

	Peer-based group		Individual group		
	Mean	SD	Mean	SD	
Size of phone call network	34.53	31.84	45.31	31.01	*
Duration of calls per contact (minutes)	87.52	98.16	123.09	134.65	
Happy	72.95	22.05	69.12	22.53	
Sad	18.67	19.14	23.71	21.57	
Stressed	25.21	23.30	28.57	24.97	
Angry	17.84	19.28	21.64	20.49	
Searching (percent of days)	21.90	19.92	20.98	17.35	
Working (percent of days)	17.05	21.15	15.77	21.79	

Notes: *p<0.05, **p<0.01, ***p<0.001; significance levels are based on

two-tailed paired t-tests, outcomes refer to peer-based group (n=68) and individual group (n=67)