Opportunities and Challenges for Leveraging Smartphone Technology in Field Studies: A Pilot Study in New York City

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Overview

The increased saturation of technology in everyday life has opened new opportunities for collecting objective data to supplement more traditional survey methods. This is particularly valuable for assessing outcomes where self-report is unreliable or where data requirements increase respondent burden beyond what is practicable. Smartphone technology offers a unique opportunity to collect data on geographic mobility, social interaction, and daily activities while increasing data quality and reducing respondent burden. These type of measurements may be particularly valuable for defining exposure (length of time and frequency) to different residential, work, and school environments and thus help to refine theories of contextual influence on a wide range of individual outcomes.

Despite many exploratory studies that utilize different techniques for leveraging this technology, challenges persist. Technical limitations in battery life and precision in geo-locating may limit the validity of objective data collected and reduce compliance. In this pilot study, we examined the potential for using smartphones to capture physical mobility and activity among working adults living in a dense urban environment. GPS readings are compared to self-report daily activity logs, respondent-defined residential neighborhood boundaries, and secondary data on the built environment to test participation and compliance rates, as well as document technical challenges. Exploratory analysis tests how these data may be used to generate measures of life space diameter and level/amount of exposure to the residential environment, defined according to resident mapping of what they consider to be the neighborhood in which they live. Recommendations for future research are discussed.

Background

According to the Pew Internet and American Life project, 91% of adults and 78% of teens own a cell phone, including 37% of teens that own a smartphone (Madden et al. 2013). Market saturation has increased across all income and age groups (cite). Technology has improved and become more affordable over time, making smartphones a more practical option for many field studies. Yet, concerns about privacy are prevalent. Recent research on awareness and perception of Location-Based Services (LBS), such as apps that use your current location to offer services, weather reports, or directions, shows 52% of users expressed “strong concern” over sharing their location with other people or organizations (Microsoft 2010).

Previous studies have used GPS and accelerometer data to measure the activity space of individuals (Zenk et al. 2011), physical activity among children (Wheeler et al. 2010, Cooper et al. 2010), associations between exposure to various types of commercial activity such as fast food chains and diet (Zenk et al. 2010), and differences in home and non-home environments (Hurvitz et al. 2012), among others. Most work to date has noted technical limitations, including accelerated battery depletion, missing data from signal loss, and accuracy of GPS locating (Wan and Lin 2013, Kerr et al. 2011). Participant adherence is also a recognized issue, which is frequently indistinguishable from technical failures unless combined with accelerometer data (see reviews by Krenn et al. 2011 and Kerr et al. 2011).

Data and Methods

Twenty-five adult participants were recruited from a single affordable housing complex in Brooklyn, New York in March through June, 2013. Data were collected in three phases: a baseline survey, a nine-day measurement period in which participants were asked to carry a smartphone and maintain a daily activity diary, and a close-out survey. Participants that withdrew during the measurement period were asked if they would complete an alternative self-administered questionnaire that asked about reasons for non-participation or withdrawal from the study. All interviews were conducted in English. Overall, 21% consented to participate; of those, 96% completed the nine-day measurement phase (one participant withdrew during the study).

Smartphones were provided by the study and were enabled with iEpi, a specialized application that would sample Global Positioning System (GPS) data at specific intervals and record these data on the phone. The application also captured movement of the phone as a proxy for physical activity using sampled data from the built in accelerometer. Data from the smartphones were retrieved and analyzed after the end of the close-out interview at the study's computer lab at the University of Saskatchewan. The participants were randomly divided into two groups: in the first group, iEpi sampled GPS and accelerometer data continuously for two minute every five minutes; in the second group, data were sampled for three minutes every fifteen minutes. This enabled the research team to evaluate trade-offs in battery life of the smartphones relative to more granular GPS and activity data.

Table 1.
Study Population Characteristics

Median age		31
Race/Ethnicity		
	White, non-Hispanic	32%
	Black, non-Hispanic	4%
	Hispanic	48%
	Asian	0%
	Other	8%
	Not Reported	8%
Education		
	Less than HS	0%
	HS Graduate / GED	12%
	Some college / Associate's	10%
	4-Year College or beyond	44%
	Not Reported	4%
Married		28%
Have 1+ Child		52%
Currently Employed		76%
	With More than 1 Job	20%
n		**25**

Surveys collected basic demographic information and solicited information on potential challenges to compliance. Daily activity logs were used to compare against GPS and accelerometer data based on time of day and repeat locations/activities. Self-defined neighborhood maps were used to define the buffer around the respondent's home and analyze differences in physical activity and exposure within and outside of the residential community.

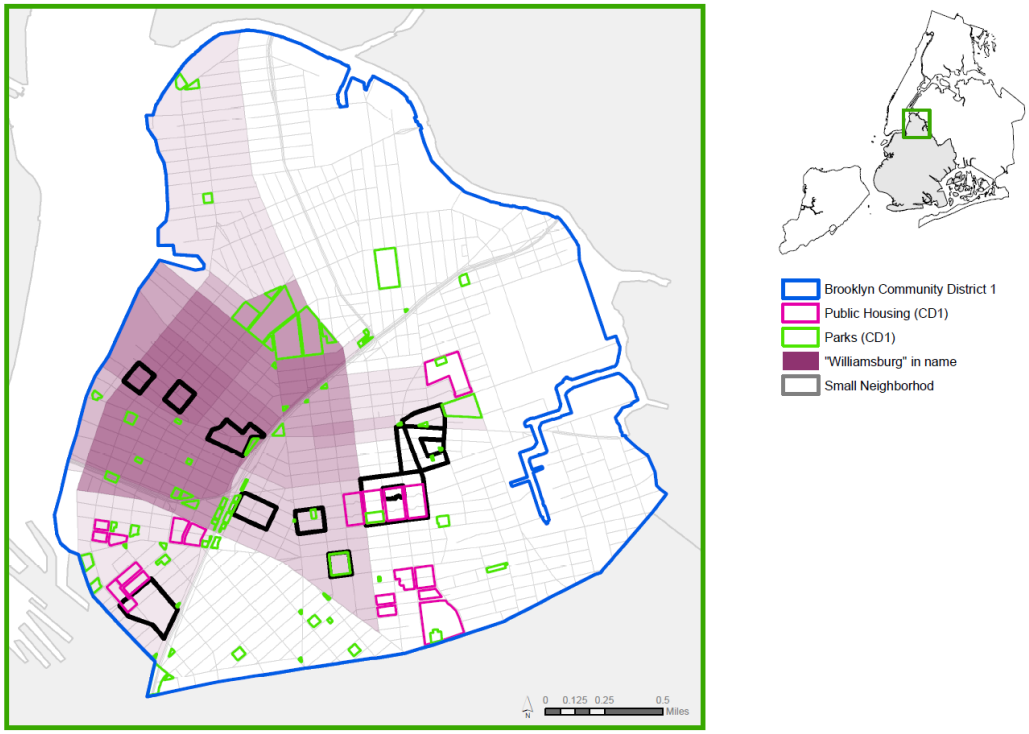
Findings

Analysis of the first eight participants yielded more than 63 person days of recording time and produced 18.5 million records, including accelerometer and GPS readings. Figure 1 shows the path of six participants over the study period, with the home address of all participants indicated with the arrow. These data show respondents travelling far outside of their immediate residential neighborhood. Because this pilot recruited individuals that all live in the same building, we are able to examine similarities and differences in travel paths while controlling for home environmental characteristics and transportation accessibility. We find wide variation in the length of time spent in the residential environment, overall distance travelled, and level of variability from day to day.

Figure 1. GPS Data on Participants Geographic Mobility Over Nine Day Period (n=6)

Figure 2 shows an aggregate of self-defined neighborhood boundaries provided by residents of the same neighborhood as the pilot site respondents. The map roughly corresponds to the white box in Figure 1 and shows the extent to which daily activities within the neighborhood roughly correspond to a perceived community area.

Figure 2. Self-defined Neighborhood Boundary (n=50)



Despite the volume of data collected, technical challenges were common. Table 2 summarizes the technical and practical issues experienced during the field period. The most prevalent issue identified by respondents was forgetting to carry the phone with them (60%), followed by battery or charging problems (44%). Few reported anxiety about carry the smartphone (4%); however, the low overall response rate (20%) may indicate that individuals with privacy concerns chose not to participate.

Table 2. Reported Problems / Issues with Carrying Smartphone over 9-Day Period

	Yes	No	Not Reported
Technical/Practical Challenges			
Problems carrying phone	28%	64%	8%
Charging/Battery life problem	44%	36%	20%
Forgot/left phone at least once	60%	32%	8%
Discomfort carrying phone	12%	76%	12%
Anxiety about carrying phone	4%	88%	8%
Others asked about phone	16%	76%	8%

Conclusions

Smartphones have become more cost effective and technology has continued to improve. They offer a potential means of collecting objective measures of both physical activity and mobility with minimal respondent burden. This pilot corroborated that battery life and protocol adherence are the primary sources of data loss. Future research should focus on developing new compliance strategies and incentive structures that will ensure greater compliance. Additional strategies for minimizing anxiety about privacy may also increase response rates.

Exploratory analysis shows that individuals are exposed to a substantially larger area than the residential neighborhood. This underscores the need to deepen our conceptualization of how context influences an array of outcomes; however, these findings also show that the daily round within the neighborhood largely occurs within the area delineated by respondent own report. If validated across neighborhoods, this may suggest that GPS technology could be used to not only quantify life-space diameter (exposure), but also define more organic neighborhood boundaries for the population being studied.