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Mapping Multi-Day GPS Data: A Cartographic Study in NYC

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Abstract

Multi-day GPS data is increasingly being used in research—including in the field of spatial epidemiology. We present several maps as ways to present multi-day GPS data. Data come from the NYC Low-Income Housing, Neighborhoods and Health Study (*n*=120). Participants wore a QStarz BT-Q1000XT GPS device for about a week (mean: 7.44, SD= 2.15). Our maps show various ways to visualize multi-day GPS data; these data are presented by overall GPS data, by weekday/weekend and by day of the week. We discuss implications for each of the maps.

Keywords

maps; cartography; neighborhoods; global positioning system; mobility; spatial epidemiology

1. Introduction

Global Positioning System (GPS) data is the preferred method to map and understand people's spatial mobility. As such, multi-day GPS data is increasingly being used in research —including in the field of spatial epidemiology. Data on individual level GPS has rapidly proliferated with the advent of GPS enabled smart-phones, and the cost associated with obtaining and processing these data have come down considerably. Substantively, GPS data is beginning to be used to overcome limitations of cross sectional data analyzed using Geographic Information Systems (GIS)—including spatial misclassification (Duncan, Kawachi et al. 2014). However, researchers and practitioners apply different methods for visualizing and mapping multi-day GPS data. Oftentimes, surprisingly researches in the field of spatial epidemiology do not visualize the GPS data collected and analyzed, because their goal is to evaluate relationships between GPS-derived activity spaces and health outcomes. We note though that researches have utilized GIS-based geovisualisation techniques to explore human activity-travel patterns (Kwan, 2002; Kwan, 2007), including special 3-D displays and algorithms tailored to variables in the urban environment confronting women to display space–time paths during the day (Kwan, 2002). GPS data are often presented in a map of GPS data, but visualization techniques are less often used to inform the reader of spatial patterns in the data. More often GPS data are simply quantified in a table—perhaps due to publication size limitations. However, these inherently spatial data can help researchers to identify unique phenomena when they are displayed visually. The

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visualization often allows for trends that were otherwise not apparent to appear which can then be tested for significance with various spatial statistics methodologies (Pfeiffer, Robinson et al. 2008). In this study, we present several maps of ways to present multi-day GPS data to encourage researchers to map and visualize such data and explore these data visually in multiple ways.

2. GPS Data Collection

Data come from the NYC Low-Income Housing, Neighborhoods and Health Study (*n*=120) (Duncan et al., 2014). Recruitment was conducted through various community-based approaches, including distributing flyers outside of three selected public housing developments in three different Manhattan neighborhoods and outside of one public housing development in Queens. Participants were considered eligible for participation in the study if they: reported living in low-income housing (e.g. public housing) in New York City; were 18 years of age or older, could speak and read English, self-reported not pregnant, self-reported no restrictions to usual physical activity, and were willing to wear a Global Positioning Systems (GPS) device for a week. The majority of the participants reported living in public housing (80%).

GPS data were collected between June and July 2014. We used QStarz's Super 51-CH Performance Bluetooth GPS Travel Recorder (BT-Q1000XT, Qstarz International Co., Ltd., Taipei, Taiwan), which has been used in many previous research studies (Christian 2012, Robinson and Oreskovic 2013, Yen, Leung et al. 2013, Dessing, de Vries et al. 2014, Epstein, Tyburski et al. 2014). Also consistent with many other studies (Zenk, Schulz et al. 2011, Hurvitz and Moudon 2012, Yen, Leung et al. 2013, Dessing, de Vries et al. 2014, Yan, Tracie et al. 2014), GPS tracking of the sample was conducted for a week. During the study orientation and baseline assessment participants were instructed to place the small (roughly 1” by 2”) GPS device on their belt (using the manufacturer-provided case) or in their pocket. Participants also were instructed to charge the GPS device nightly. While our preference was for participants to keep the device in their pocket, when distributing the GPS device, we told women it was okay to put the unit in their purses as long as their purses would stay on them at all times. Participants were asked to wear the GPS devices at all times (except when sleeping, swimming or showering). We also asked participants to complete a travel diary, which consisted of a series of yes-no questions that asks: “Did you charge the GPS monitor today?” and “Did you carry the GPS monitor with you today?” It was meant to help the participant remember to charge the unit and carry it with him or her throughout the week. We set the GPS device to log in 30-second intervals prior to distribution. The GPS device (battery fully charged and with a unique GPS serial number) was given to participants in a large zip lock bag, which also contained a mini USB charging cord for the GPS device, a USB wall adapter for charging, a manufacturer-provided GPS belt holder (if requested), a pamphlet containing background information on GPS and the travel diary. Notably, in several cases, participants had the opportunity to wear the GPS device for more than 7 days because their GPS return day was more than 7 days (due to logistical issues; e.g. one GPS return day [following the 7 day GPS protocol] was on a holiday, so we extended the protocol) (mean: 7.44, SD= 2.15).

Informed consent was obtained from all participants prior to collection of data. The Institutional Review Board at New York University School of Medicine reviewed and approved the research protocol.

3. Conclusions

In conclusion, there are many ways to visualize multi-day GPS data. Here we present GPS data in a variety of maps overlaid upon data from the city of New York's Open Data Initiative. In particular, in this study, for one participant, we visualized the aggregate total of GPS data as a density of points to illustrate not only GPS locations, but also duration spent in various location, we also visualize data by day of the week, and data by weekday versus weekend. While this current work represents a visualization and not formal data analysis, of interest are the differing mobility patterns between week and weekend days as represented in the main map and inset maps. Visualizing data in this way can help to formulate hypothesis about mobility patterns, and how individuals move through the built environment that may be of interest to public health researchers and practitioners. Of interest for instance was the weekday versus weekend inset, which perhaps can be explained as traveling further during the workday and closer by on weekends. We recognize that there are additional mapping options including mapping significant clusters of GPS points (Vazquez-Prokopec, Stoddard et al. 2009) as well as performing further analysis on rasterized data and displaying and identifying key locations visited as indicated by GPS data (Xie and Yan 2008). In addition, there are time activity maps (Seto, Knapp et al. 2007) and one could map all participants (Seto, Sousa-Figueiredo et al. 2012). Therefore, maps presented should align with the goals of the study or project. We encourage researchers and practitioners to map and visualize GPS data in multiple ways.

Software

GPS participant data was downloaded using the Qstarz proprietary software and stored as .gpx files. The GPS data was then processed with several scripts built using the python programming language, and ArcGIS Models (Python Software Foundation. Python Language Reference, version 2.7. Available at: http://www.python.org) and ArcGIS version 10.2 (ESRI, Redlands, CA). GPS data was first converted from the open source .gpx file format into ESRI layers within a geodatabase, and then unique files were created for each participant and for various timestamps (day, week, weekday, weekend, and date).

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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