

Evaluating Feasibility and Utility of Smartphone-based GPS Activity Metrics in Cognitively Unimpaired Adults

Albert Pham¹, Sreya Dhanam¹, Ray Fregly¹, Winnie Kwang², Kaitlin B. Casaletto¹, Joel H. Kramer¹, R Scott Mackin³, Michael W. Weiner^{1,2,3,4}, Rachel L. Nosheny^{3,4}, Adam L Boxer¹, Adam M. Staffaroni¹ *, & Emily W. Paolillo¹ *

¹Department of Neurology, Edward and Pearl Fein Memory and Aging Center, Weill Institute for Neurosciences, University of California, San Francisco; ²Department of Radiology and Biomedical Imaging, University of California, San Francisco; ³Department of Psychiatry and Behavioral Sciences, University of California, San Francisco; ⁴Brain Health Registry, University of California, San Francisco

*co-senior authors

Contact: linh.pham@ucsf.edu

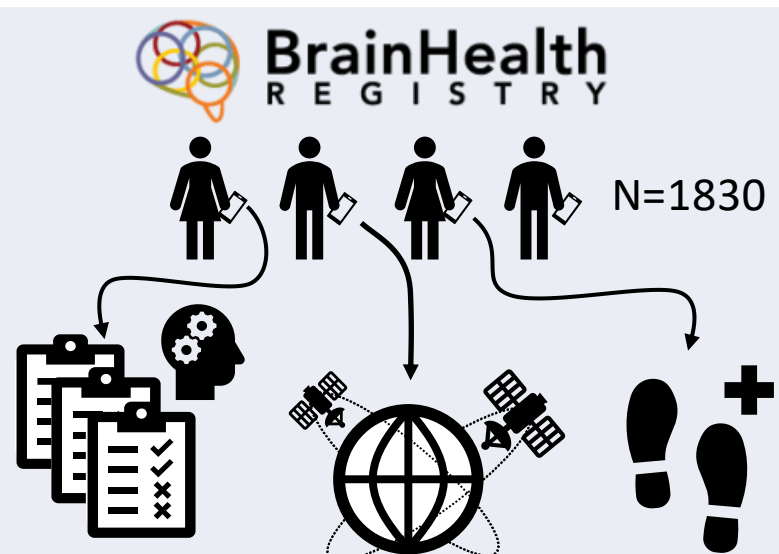
Background

- Mobility typically decreases with age and may be sensitive to cognitive aging.
- Passively collected GPS data from personal smartphones have potential to monitor real-world age-related cognitive and functional change.

Study Aims

- 1) Determine feasibility and validity of smartphone-collected GPS activity featurization.
- 2) Associate GPS activity with cognitive functioning in cognitively unimpaired adults.

Methods



Cognitive test scores, GPS activity, and step counts are collected via the Datacubed mobile app from unimpaired U.S. adults enrolled in BHR.

Participants without high GPS data completeness are excluded.

GPS data are processed with the *Trackintel*¹ package to calculate daily mobility metrics.

Pearson correlations are performed. Follow-up regression analyses adjust for age, sex, and education.

GPS activity metrics

Per day, GPS position fixes are summarized as staypoints, i.e. coordinates + start & end times.

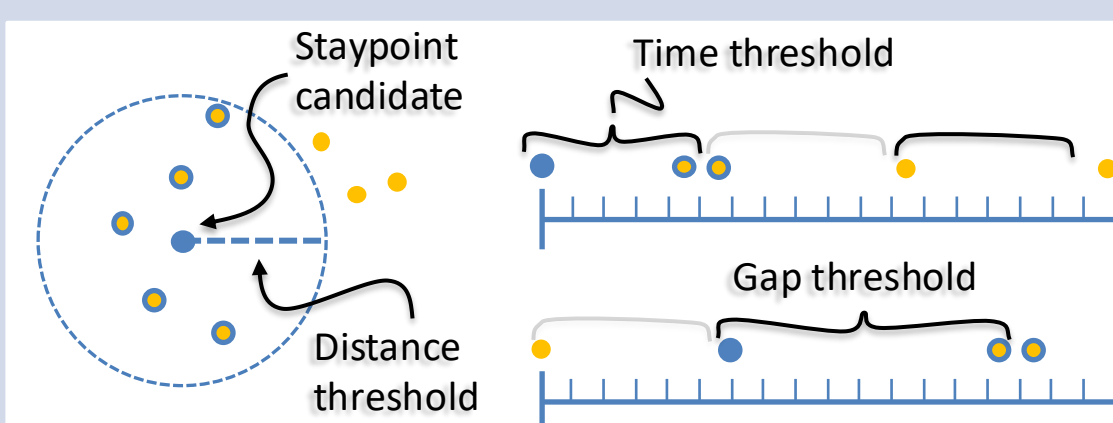


Figure 1. Staypoint construction by sliding window aggregation is parameterized by space, time, and data missingness thresholds.

- Radius of gyration: radius of centroid centered at staypoint center of mass weighted by duration
- Jump length: distance between staypoints
- Purpose: highest total duration staypoint is labeled *Home*, otherwise *Non-home*.

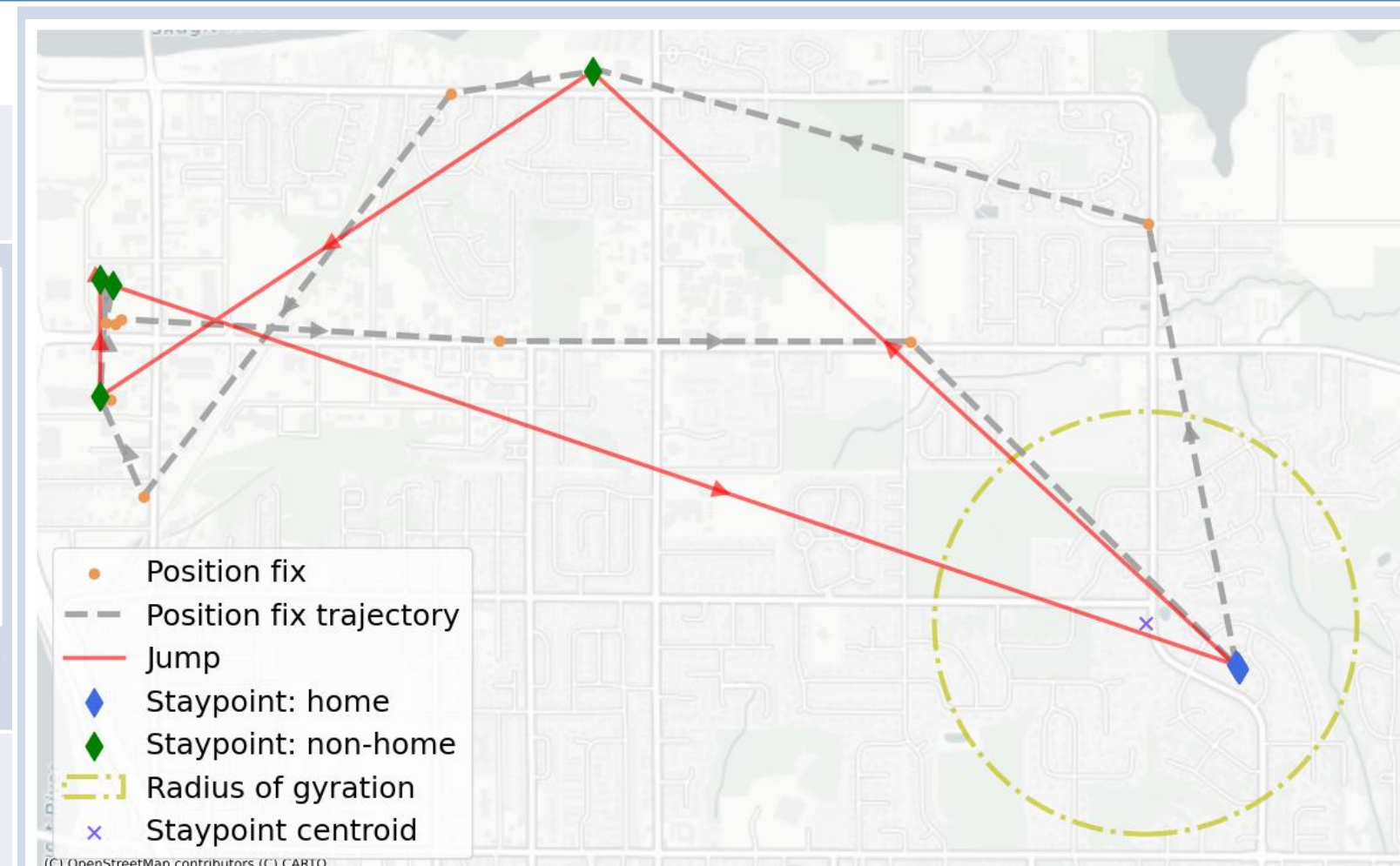
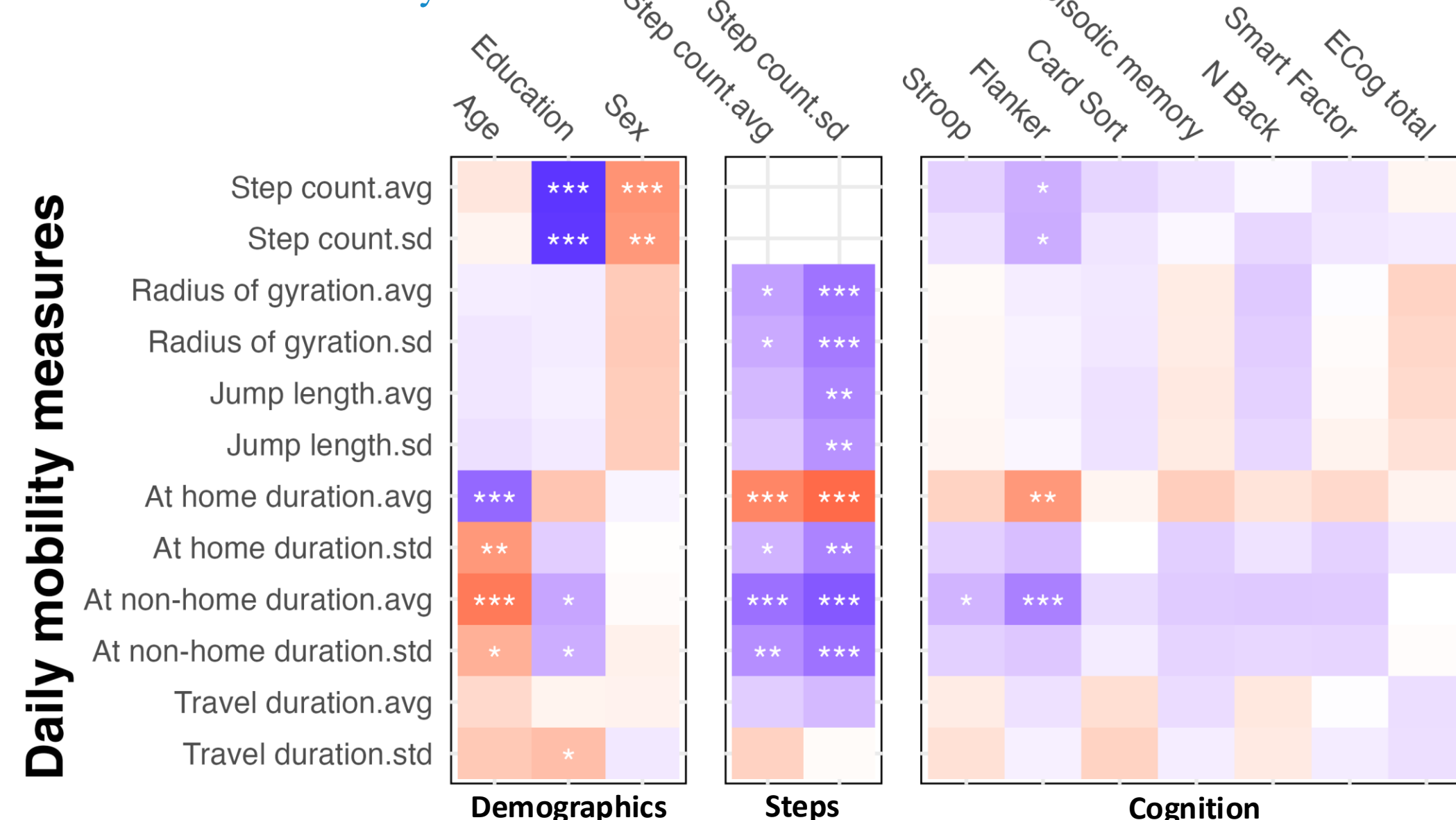


Figure 2. A day of GPS activity and its mobility metrics.

Associative analysis



Mobility and demographics

Age significantly correlates with time spent at home. Education and male sex positively associates with step count.

Mobility and step counts

Significant associations of mobility metrics with age and step count support construct validity.

Mobility and cognition

Averaged location durations correlate with executive functioning; however, associations are not independent of demographics.

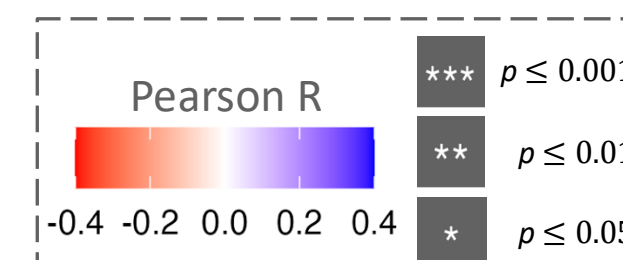


Table 1. Participant characteristics	BHR cohort (N = 1830)	Analysis sample (N = 238; 13%)
Age	64.02 (11.60)	61.95 (11.69)
Gender (male)	1233 (32.8%)	108 (46.3%)
Education	16.24 (2.3)	16.26 (2.3)
Race (Non-Hispanic white)	1534 (83.1%)	197 (84.5%)
Device type (Android)	586 (31.1%)	237 (99.5%)
GPS activity collected (days)	19.58 (37.97)	12.95 (17.33)

Results

- Greater age related to longer average ($r=0.26$, $p<0.01$) and less variable ($r=-0.21$, $p<0.01$) time at home, and shorter average ($r=-0.27$, $p<0.01$) and less variable ($r=-0.16$, $p<0.05$) time at non-home locations.
- Step counts significantly correlated with 14/20 GPS metrics in expected directions (r range= $[0.13]$ to $[0.29]$, $ps<0.05$).
- Higher average time at non-home locations associated with better app-based executive functioning (Flanker: $r=0.21$; Stroop: $r=0.12$; $ps<0.05$). Additionally, higher average time at home related to worse Flanker performance ($r=-0.21$, $p<0.01$).
- **Mobility associations with cognition do not retain significance after adjusting for demographics**

Conclusions

- Further work is needed to develop additional mobility measures that are independently sensitive to cognitive function.
- Future validation of lower GPS data completeness thresholds may expand cohort applicability.

¹ Martin, H., Hong, Y., Wiedemann, N., Bucher, D., & Raubal, M. (2023). Trackintel: An open-source Python library for human mobility analysis. Computers, Environment and Urban Systems, 101, 101938.