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Spatial knowledge acquisition in mobile map-assisted navigation: a real-world longitudinal study

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Abstract:
Hand-held mobile map applications relying on Global Navigation Satellite System (GNSS) services have become the preferred wayfinding and navigation support over the last decades. Mobile map apps provide pedestrian urban navigators with abundant geographic information. Navigators can assess their current location in real-time, zoom, pan, and query the map during navigation. This has profoundly impacted our daily mobility routines. Navigation occurs concurrently with spatial learning, that is, navigators continuously acquire visual-spatial information from the surrounding environment and from their mobile maps during navigation. Navigators encode this information into memory and ultimately construct a mental representation of the traversed environment. Recalling and decoding spatial knowledge can assist navigators in self-localization, locating and finding relevant features in their surroundings, and getting to new destinations (Downs & Stea, 2011). Previous studies have extensively examined pedestrian spatial learning in terms of its behavioral stages (Ishikawa & Montello, 2006; Kim & Bock, 2021) and how this process is supported by neural systems in the brain (Epstein et al., 2017; Peer et al., 2021). However, how *map-assisted* pedestrian spatial knowledge develops over time is still an open research question. Little is known about how evolving environmental familiarity impacts map-assisted navigators' spatial learning processes. Having these unsolved issues in mind, we proposed this empirical study to address the following two research questions:

1) What is the process of spatial knowledge acquisition in mobile map-assisted pedestrian navigation and what role does the mobile map play in this process?

2) How do changes in navigators' map use behavior, visual attention, and related brain potentials occur in response to increased environmental familiarity?

We designed a longitudinal pedestrian navigation experiment following a within-subject design. In order to achieve better ecological validity, we extend the experimental laboratory to the real-world. Participants will navigate two routes in an unfamiliar neighborhood three times within a week. Each time we will record a diverse range of data streams simultaneously. This includes participants' interactions with the mobile map, their gaze behavior using a mobile eye tracker, their brain activity using mobile high-density electroencephalograph (EEG) recordings, and the assessment of acquired spatial knowledge through pencil-paper tests.

The novel empirical findings of our ongoing study will shed more light on the perceptual, cognitive, and neural mechanisms involved in mobile map-assisted spatial learning during navigation in urban environments. By investigating this dynamic process specifically for changing environmental familiarity, our study has the potential to theoretically and empirically inform the design and development of future, adaptive navigation assistance, adaptive in real-time to navigators' varying geographic information needs dependent on their environmental familiarity.

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