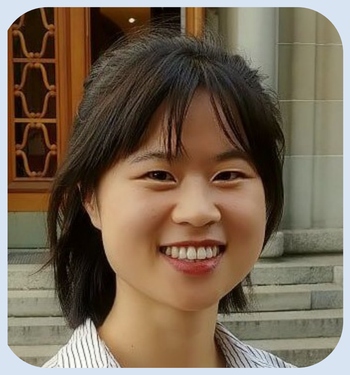
The effect of landmark density in mobile maps on spatial learning



Bingjie Cheng, Ian T. Ruginski, Sara I. Fabrikant

Department of Geography, University of Zurich, Switzerland

Digital Society Initiative, University of Zurich, Switzerland

bingjie.cheng@geo.uzh.ch

GIVA@UZH

Introduction

- **Landmarks** help navigators to determine their current location, remember key decision points on routes and to navigate to planned destinations.
- Despite the crucial role of landmarks in navigation, very few mobile navigation systems refer to landmarks when **providing wayfinding directions.**
- Learning performance drops when the number of items exceeds **limited cognitive capacity.**
- The current study examined the effect of **three different levels of landmark densities (3 vs. 5 vs. 7 landmarks)** on a mobile map on **spatial learning**.

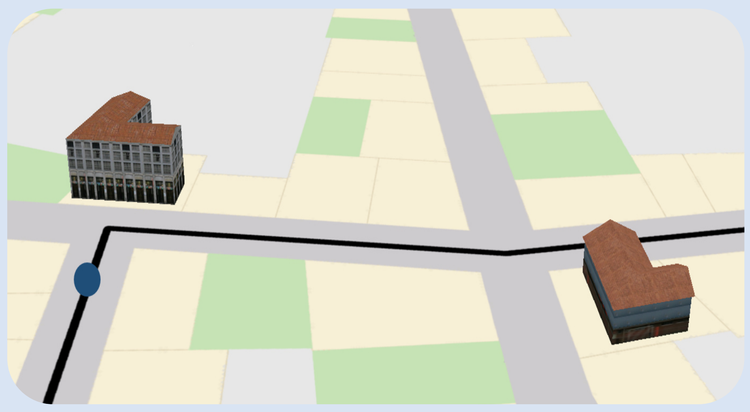
Hypotheses

- Spatial learning performance **increases** when the number of landmarks increases **from three to five.**
- Spatial learning performance **drops** when the number of landmarks increases **from five to seven,** due to limited working memory capacity**.**

Methods

- **Forty-eight adults** (f=24, 18-36 yrs.) completed the study with the three **within-participants** landmark density conditions.
- **Procedure:** Participants were asked to navigate as quickly as possible to a specific destination in three different virtual cities, and learn the landmarks along the route that were displayed on the maps. After navigating in each city, participants' spatial knowledge was tested using a landmark recognition task, a route direction task, and a Judgments of Relative Direction (JRDs) task.

First-person perspective view of participants in a virtual city



A track-up map providing a navigator's current location (blue dot), the route to be followed (black line), and the task-relevant 3D landmarks.

Results

Multi-level regression analyses were conducted to compare spatial learning performance between the landmark conditions. The results reveal support for our hypotheses:

- Landmark recognition (Fig A) and route direction memory (Fig B) **improve** when the number of presented landmarks increases **from three to five** (p = 0.017, p = 0.001)**.**
- Learning performance does **not increase further** with **seven** landmarks (p = 0.689, p = 0.334).
- No significant effect of the number of landmarks on JRDs (p > 0.8). JRD performance is generally poor in the three conditions.

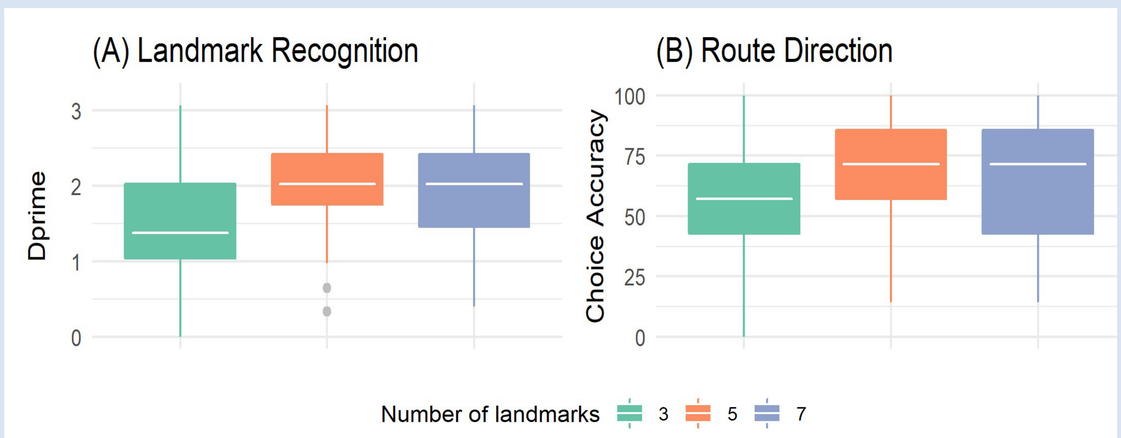


Figure A depicts the relationship between number of landmarks and Dprime. Dprime is calculated as the difference between the Z scores of the hit rate (recognition of seen landmarks) and that of the false alarm rate (recognition of not seen landmarks).

Figure B depicts the relationship between the number of landmarks and route direction choice accuracy in percent.

Summary & Outlook

- The **effectiveness of landmarks** displayed on maps depends on their number, and the **best performance** is achieved with **five landmarks.**
- **Mobile map design** should also consider the wayfinders' **spatial learning outcomes**. **Display of cognitively-supportive landmark density** can be one solution.
- **Individual differences** in working memory capacity and spatial abilities may **moderate** the relationship of spatial learning with landmarks. The further analyses are still in ongoing.
- The results may further inform **personalized mobile map design** based on individuals' spatial abilities and working memory capacity.

University of Zurich[UZH]

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