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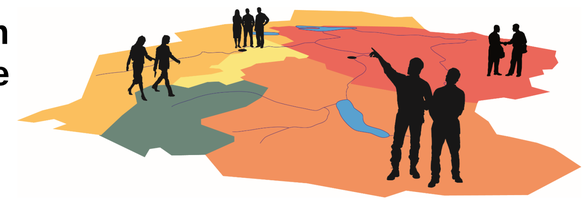
University Research Priority Program
Language and Space



Phylogeographic Methods under Varying Migration Scenarios

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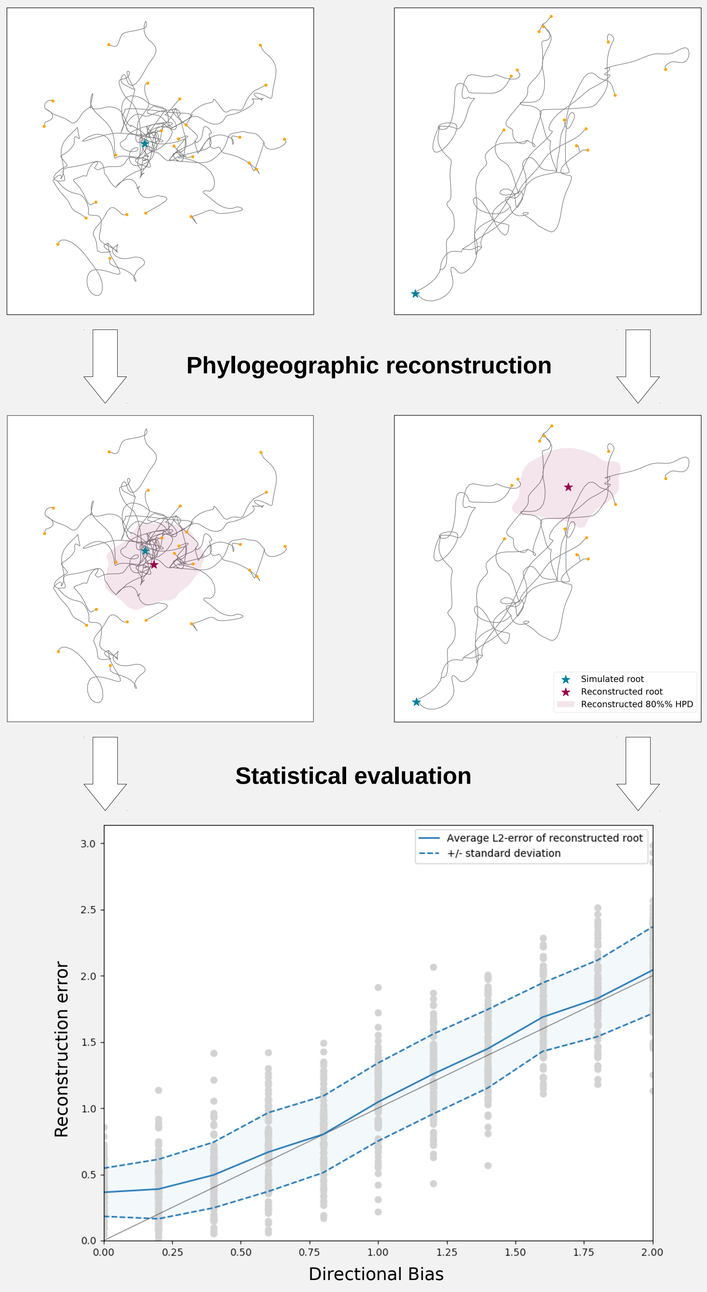


Background

Phylogeography has been used to propose origins and expansions of major language families [1,2].

Directed Migrations: Over the course of history, humans repeatedly followed directed migrations over significant distances (e.g. the settling of the Americas, the Austronesian expansion [3] or the Bantu expansion [2]). Phylogeography assumes an undirected diffusion process behind the data. This raises the question:

Do phylogeographic methods work in scenarios of directed movement?

Simulation based evaluation

Simulation: We simulate phylogenetic splitting and spatial dispersal in directionally biased and unbiased scenarios.

Reconstruction: We attempt to reconstruct the simulated homeland in a phylogeographic analysis.

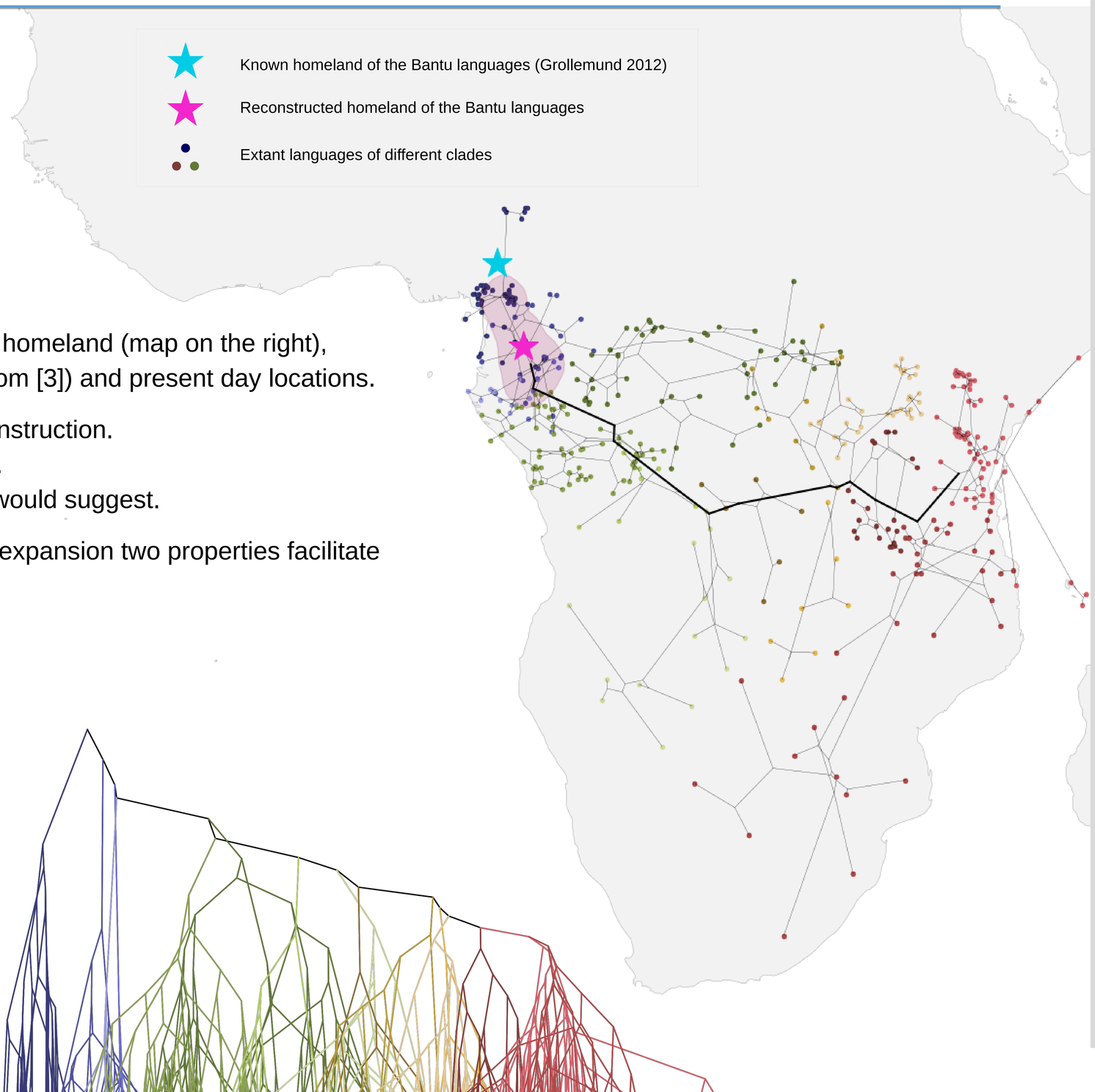
Evaluation: We statistically evaluate the quality of the reconstructions in the different scenarios. That is, we compare how far the reconstructed homeland is from the simulated one

Results

In the undirected diffusion scenario phylogeographic methods successfully reconstruct the simulated root. With increasing directional bias in the migrations the reconstruction error increases drastically (see figure to the left).

Case study: The Bantu languages

Setting: About 500 languages which spread from Cameroon towards the south-east (map on the right). This directed south-east expansion seems like a natural example to test how the findings above translate to real cases of language spread.



Analysis: We use phylogeography to reconstruct the homeland (map on the right), based on the language family tree (below, topology from [3]) and present day locations.

Results: We observe the following results in the reconstruction.
- As expected, there is an error in the reconstruction.
- However, the error is smaller than the simulations would suggest.

Synthesis: We suggest that in the case of the Bantu expansion two properties facilitate the reconstruction:

- Only partially directed migrations: Some societies stay sedentary (see map on the right).

- Imbalanced tree topology: Early splits of sedentary societies give information about the homeland (see tree at the bottom).

These factors can mitigate the effect, but generally directed movements lead to errors in phylogeographic reconstructions.

[1] Grollemund, Rebecca, et al. "Bantu expansion shows that habitat alters the route and pace of human dispersals." PNAS 112.43 (2015)

[2] Bouckaert, Remco, et al. "Mapping the origins and expansion of the Indo-European language family." Science 337.6097 (2012)

[3] Gray, Russell D., Alexei J. Drummond, Simon J. Greenhill. "Language phylogenies reveal expansion pulses and pauses in Pacific settlement." science 323.5913 (2009)

[4] Lemey, Philippe, et al. "Phylogeography takes a relaxed random walk in continuous space and time." Molecular biology and evolution 27.8 (2010)