

# Geo-Language Games: An Agent-Based Model of the Role of Terrain in Language Diversity

Rachel Hendery, Liam Magee

Digital Humanities Research Group, University of Western Sydney, Parramatta, Australia



DIGITAL HUMANITIES  
Research Group

## Introduction

- ▶ Origins of linguistic diversity are a matter of much debate
- ▶ For example, PNG has:
  - ▷ 0.1% of the world's population
  - ▷ 13% of the world's languages
- ▶ Many factors have been proposed to account for diversity (e.g. Pawley 2007; Currie & Mace 2009; Lupyán & Dale 2010; Greenhill 2014)
- ▶ It has been suggested terrain may play a role (e.g. Marck 1986, 2000), but this is rarely included in modern models
- ▶ Here we:
  - ▷ argue that GIS & ABMs offer useful ways to understand role of geography as well as other factors in language change
  - ▷ compare *NetLogo* to custom WebGL 3D visualisations

## Model Running in NetLogo

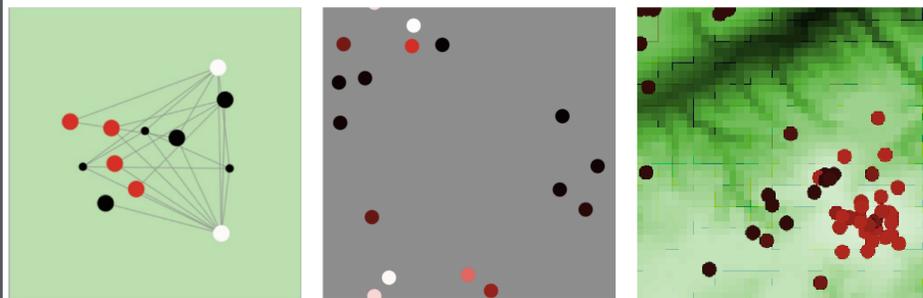


Figure 1: No agent movement; interaction governed by social network

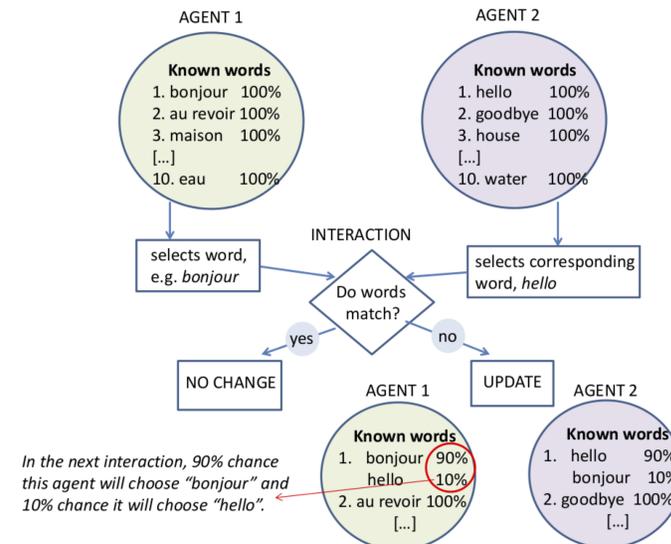
Figure 2: Movement is random; interaction with nearby agents

Figure 3: Terrain constraints on movement; interaction with nearby agents

## General Model

- ▶ Agents are:
  - ▷ Motile: semi-random movement, constrained by preference for like terrain (limited movement up or down)
  - ▷ Linguistic: agents have a constrained lexicon of 10 items
  - ▷ Influential: agents can vary their lexicon under influence of neighbouring agents
  - ▷ Transmissive: agents pass on lexicographic information to their offspring
- ▶ Simulation includes:
  - ▷ Sample terrain, including a valley and hillside
  - ▷ Two notional language variants (agents' lexicons can feature items from both)
- ▶ Scalar parameters for:
  - ▷ Initial language balance
  - ▷ Rate of influence
  - ▷ Rate of emigration
  - ▷ Transmissive mode - both or a single parent

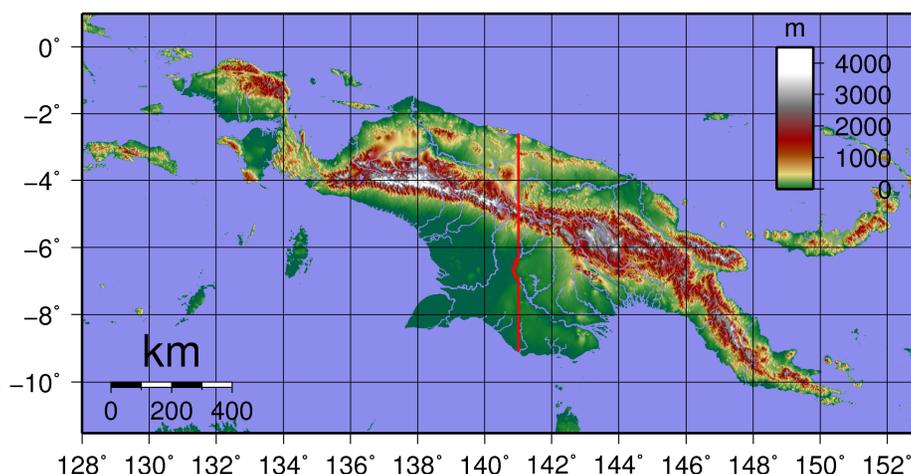
## Language Change: A Simple Lexical Replacement Model



## Descriptive Results

- ▶ With sufficiently low or high initial language imbalance, one language comes to dominate
- ▶ At language balance at close to 50%, linguistic diversity is retained
- ▶ Dialects with a mixed-origin lexicon can develop in hard-to-reach locations with heterogenous initial populations
- ▶ "Ethnocentrism"-type (Axelrod & Hammond 2003) clustering patterns emerge, partially shaped by topography
- ▶ Suggests higher "cost" of movement (e.g. here to higher or lower rather than same elevation) is a plausible deterrent to contact-induced language change
  - ▷ Irregular topography can help explain preservation of linguistic diversity, even in relatively dense geographies

## Terrain in New Guinea



## NetLogo vs WebGL

- ▶ *NetLogo*
  - ▷ Easier to program
  - ▷ Mature framework for input parameters and output analysis
- ▶ *WebGL* easier to embed in HTML
  - ▷ Easier to program
  - ▷ 3D modelling, shaders help "see" agent effects
  - ▷ Fast, scalable (GPU for rendering)
  - ▷ New libraries (*three.js*, *underscore.js*, *jStat*) simplify visualisation and analysis
- ▶ Observations
  - ▷ Feature-for-feature translation between Logo and JavaScript plausible
  - ▷ Future: possible automation (similar to *Unity 5* / *UnrealEngine 4*)
  - ▷ *WebGL*-enabled ABMs attractive for teaching (e.g. embedding in *BlackBoard*)

## Model Running in WebGL

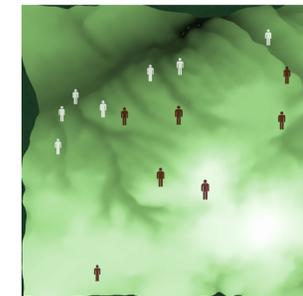


Figure 4: Figure 3 in 3D

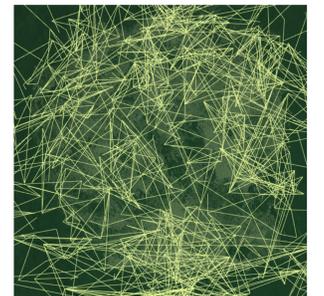


Figure 5: Emergent networks



Figure 6: "View from the ground"; pseudo-realistic lighting

## Further Refinements

- ▶ Model extended with various further factors:
  - ▷ Economic, cultural and other social exchanges
  - ▷ Exogenous events - colonisation, technology
  - ▷ Perceptions of language as a "marker" of culture
  - ▷ Variation on intermarriage effects
- ▶ More complex language model, beyond the lexicon.
- ▶ Experiment with different operationalisations of "successful" communication.

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