An Ising-like Model for Language Evolution

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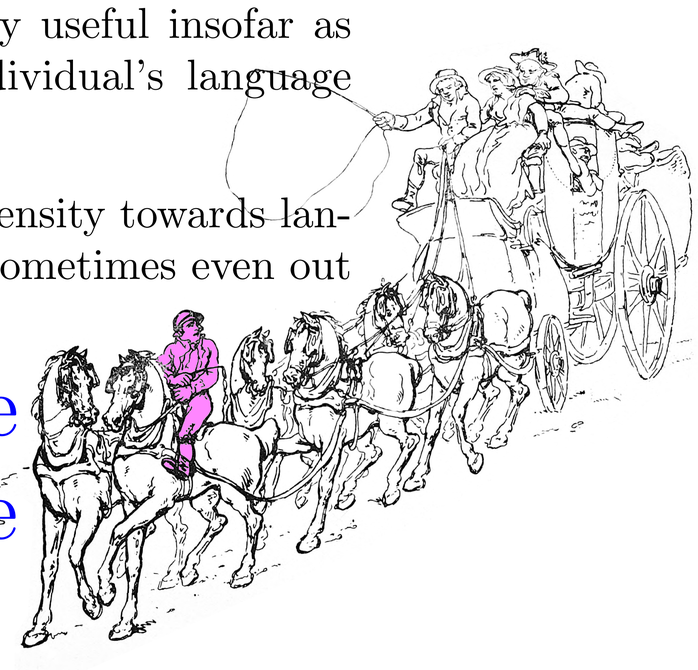
Languages evolve under the influence of contrary forces, forces:

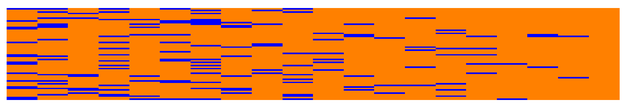
- Those that encourage convergence, languages are only useful insofar as they are understood. Under this imperative an individual's language should align with the languages of others.
- Those that encourage change, there is a contrary propensity towards language invention: an inclination to reinvent language, sometimes even out of a simple delight in the act of language creation.

regional words for 'woodlouse'



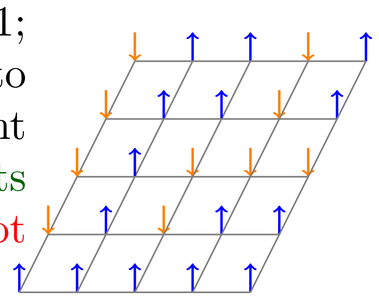
our postillion has been struck by lightning

Our aim here is to propose simple models that include these two forces!



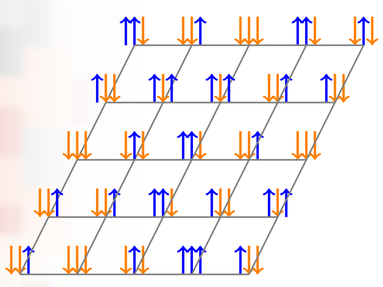
Here we propose an Ising model

In an Ising model the nodes of a graph have a value of plus or minus one, $s = \pm 1$; this value is called the *spin* of the node. The Ising model is used in physics to model magnetization. In physics the overall energy of the system is important and this energy is minimized by aligning the spins of a node with those of its neighbors in the graph. It is a thermodynamic model and so the nodes do not always change their states in a way that reduces this energy.



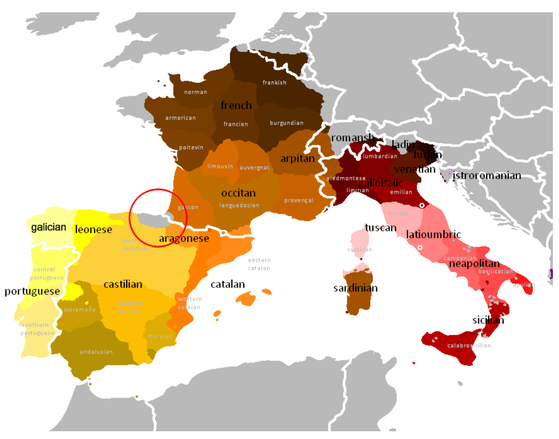
$dE = \frac{2}{n} s_x \sum_y s_y$

accept if $dE < 0$
or
with probability
$p = \exp(-dE/T)$



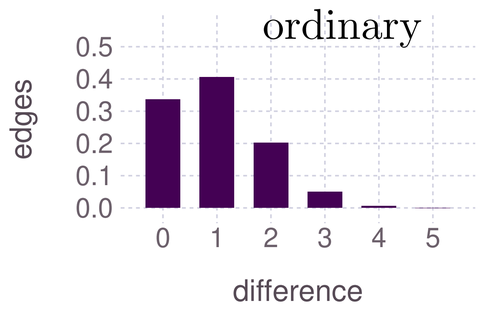
In this way, the Ising model models the key aspect of language evolution noted above. There is a competition between alignment and randomness, so the simplest model is a two-dimensional Ising model whose nodes correspond perhaps to individual speakers or villages. However, this would only allow for two languages, the "up-language" and the "down-language". To address this shortcoming, the individual spin is replaced with a length L vector of spins.

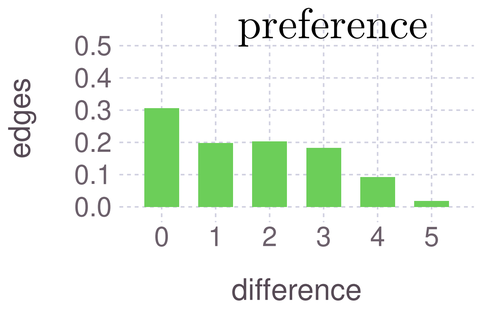
However, there is a problem. An olden-days traveler could walk from Lisbon to Naples without crossing a language boundary: people living near each other were always able to communicate. This is a property of the L-state Ising model. However, language continua are common but not universal; if the traveler varied their route, the Basque country would be a language boundary.



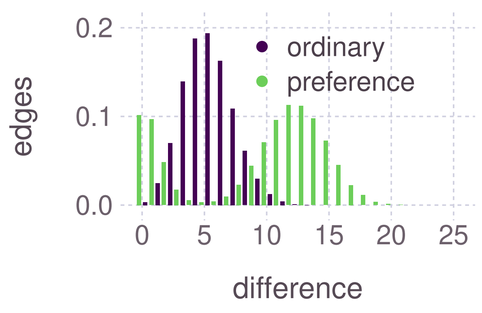
In my preference model each node only interacts with its most similar neighbour.

The preference model succeeds in allowing langauge boundaries.





Number of different spins between neighbours ($L = 5$)



The number of differences between neighbours with $L = 25$.

github.com/evoising/alife2023.