The nonequilibrium dynamics of new-dialect formation

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with

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Language Change

- Consider *linguistic variables* - "two (or more) ways of saying the same thing".
  - ⋆ SOV vs SVO word order.
  - ⋆ Different vowel sounds.
- We are interested in the situation where an *innovation* (hitherto unheard variant) propagates across a whole community and becomes the *convention* for that community.

What factors lead to successful propagation?
What are the dynamics of the process of change?

Some Observations of Macroscopic Behaviour

Formation of NZ English

- Wave of British immigration from mid C19th.
- Origins of immigrants known, hence can estimate initial condition for variants[1].
- Also have *sound recordings* and *genealogies* of first settler's *children* from 1946-8, few of whom sound like modern New Zealanders.
- Trudgill's thesis[2]: coarse demographic properties of the immigrants govern the resulting modern NZ English standard.

[1] Gordon *et al*, "New Zealand English: Its Origins and Evolution" (2004, Cambridge UP)
[2] Trudgill, "New Dialect Formation: The Inevitability of Colonial Englishes" (2004, Edinburgh UP)

Majority Rule

Feature	Ancestors
H Retention	Irish, Scottish, Northumbrian, West Country, East Anglian (~75%)
Absence of Glide Cluster Reduction	Scottish, Irish, N. English
Absence of START backing	Predominant in Britain
Weak vowel merger	Ireland, W. Country, N. England (~32%)
Short front vowels	S.E. English, Irish, Scottish (~60%)
Diphthong shift	Widespread in Britain (~75%)
Rounded LOT vowel	Predominant in Britain (~53%)
/a:/ in DANCE	S.E English, East Anglian (~52%)

Trudgill says: majority variant **always** wins out (as opposed to that which 'belongs' to the social elite)

(Except '*always*' is an overstatement! Trudgill cites as explanations bias towards unmarked vowels, changes that had already started).

Process of Dialect Formation

1. *Immigrants* speak with the dialect of their origin (England, Scotland, Ireland C19th) and hardly change.
2. *First native generation* has no community convention, so acquire mixture of variants around them.
3. *Second native generation* take the majority variants available and make them dominant.

NB: This is an **idealisation**, but one recognises **nonequilibrium dynamics**.

Other Examples

- Families with deaf children in Nicaragua devised *ad-hoc sign languages*. When brought together at a national deaf school, the children's languages became more *abstract* and *grammaticalized*.
- Speakers of two different languages come together and communicate initially using a *pidgin* which evolves into a *stable* language called a *creole*.

In these cases it has been observed that **stability** is typically attained in **one or two generations**

Some Observations of Microscopic Behaviour

Innovation

- Recognise *non-innovative* (conventional) use: even *competent* speakers exhibit *entrenchment*.
- *Functional* accounts of language in use [Jakobson (1971)] provide mechanisms for innovation:
  - ★ Referential - communication of information.
  - ★ Poetic - creativity and expressivity.
  - ★ Phatic - conformance to social norms.
- In any case a *fundamental indeterminacy* - no two situations are exactly alike, nor do speakers construe a situation the same way [Croft (2005) in press].

Propagation

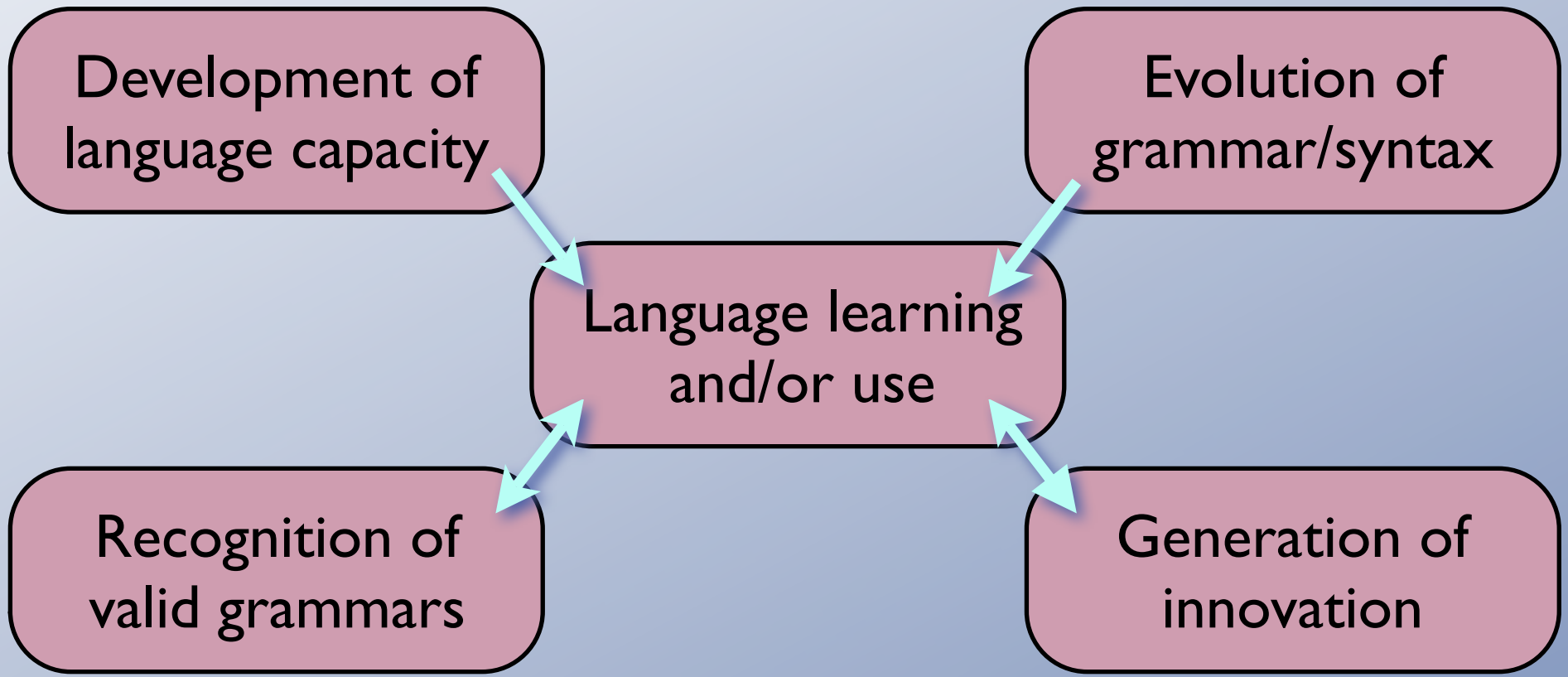
- Sociolinguists (Labov, Milroy, Trudgill, ...) recognise a number of acts biasing the production (and thus success) of certain variants:
  - ★ self identity
  - ★ accommodation
  - ★ prestige
  - ★ covert prestige

Croft: Variants have no *inherent* fitness for a particular purpose; rather they are left to acquire social value.

Evolution, evolution, evolution...

Biological evolution

(Adaptation, fitness landscapes, hill-climbing...)



Cultural evolution

(What are the relevant concepts?)

Building a Model

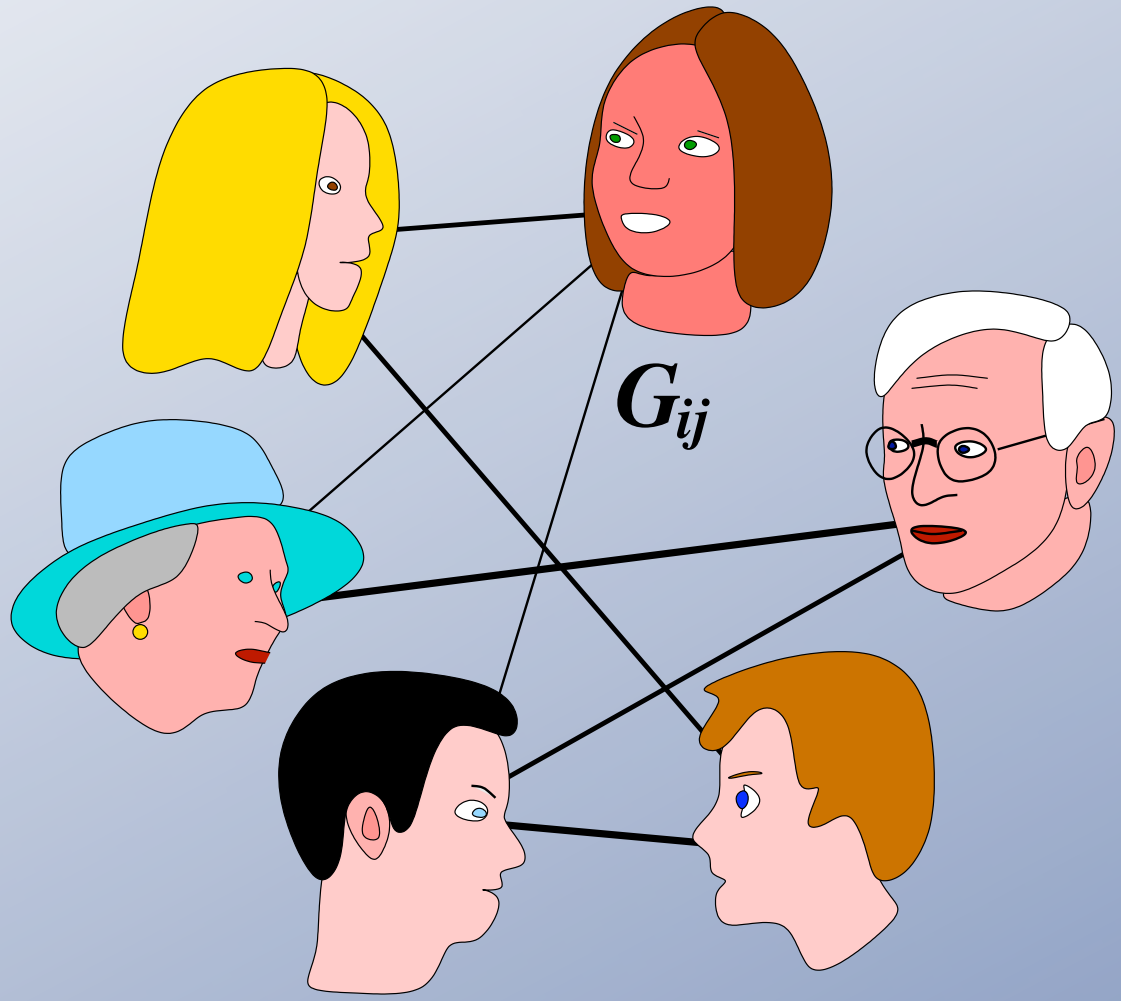
Basic Framework

At the very least, a model must contain:

- a speech community and interactions between speakers;
- at least one linguistic variable;
- a rule for producing variants according to some *grammar*; and
- a rule for *updating* the grammar as a consequence of hearing others' utterances.

Physics approach: do the simplest possible thing.

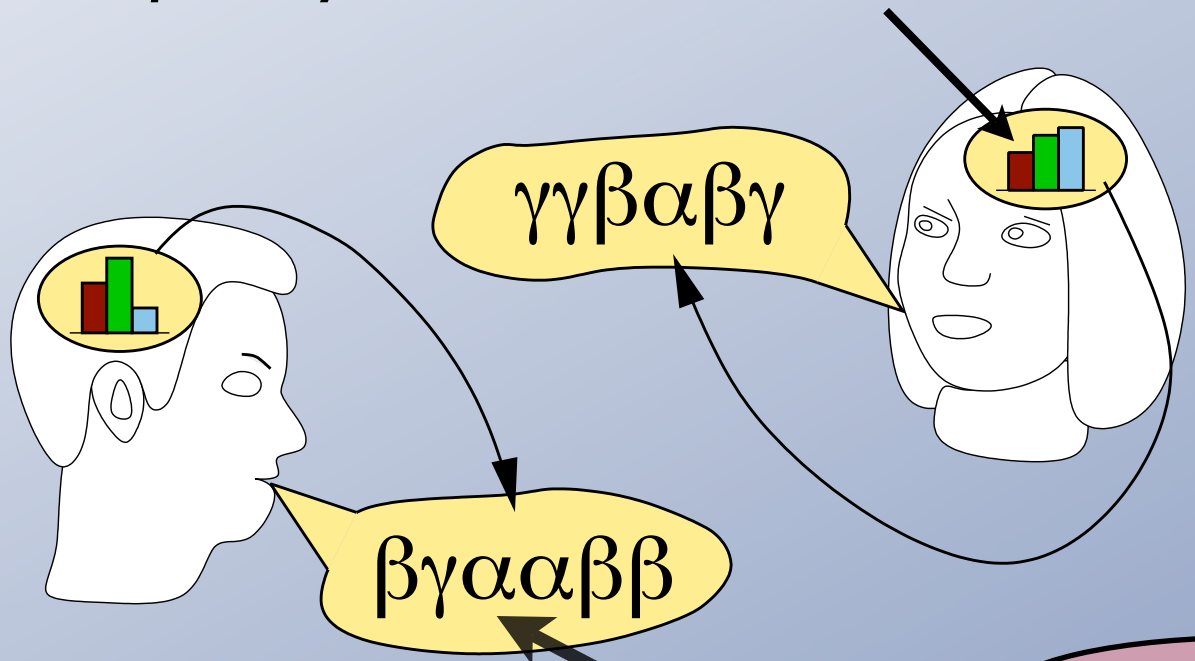
The Speech Community



G_{ij} gives the frequency with which speakers *i* and *j* interact

Using the Grammar

Single variable, label the variants *1,2,3,...*
Grammar is *frequency* of the variant, x_i ; $x_1+x_2+x_3+...=1$

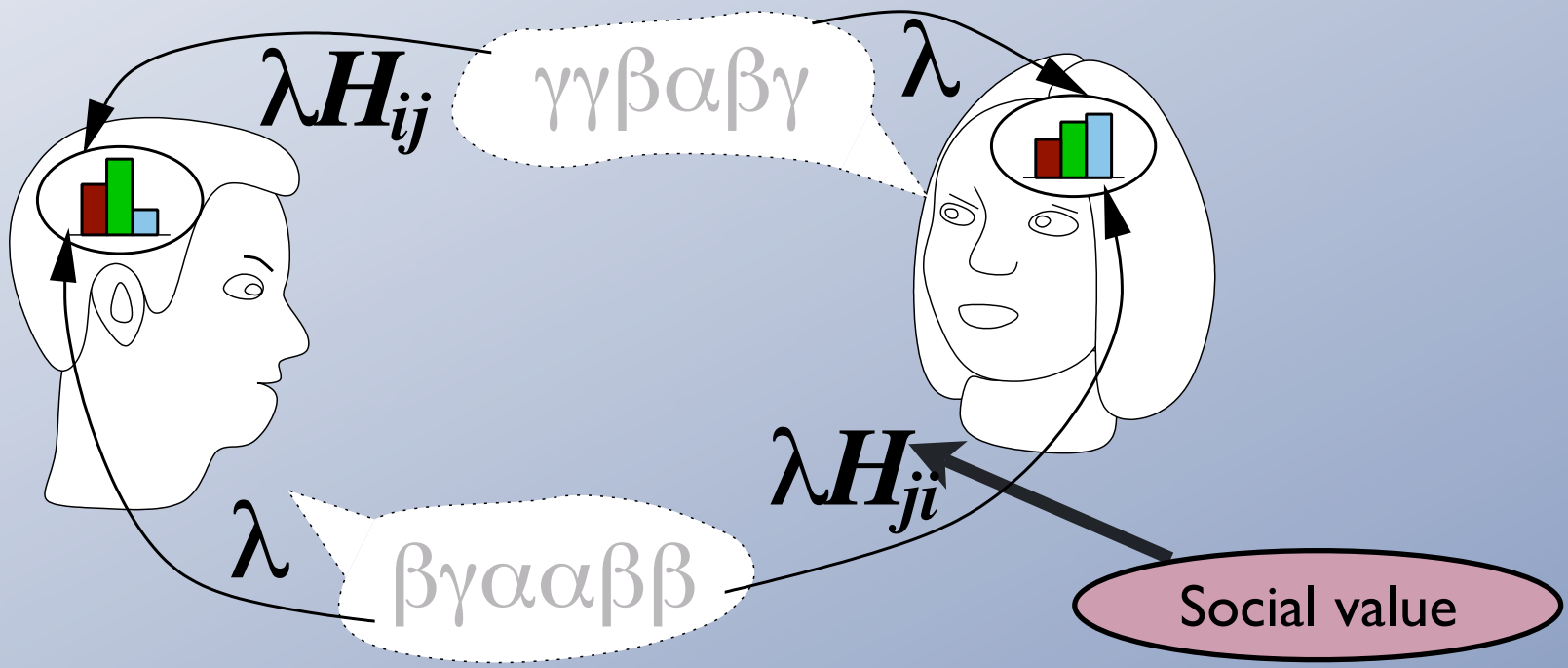


Variation

Unbiased production model - *utterances* α, β, γ, ...
produced with *probability* x_i

Building the Grammar

Each speaker produces a certain number of *tokens* in each interaction.

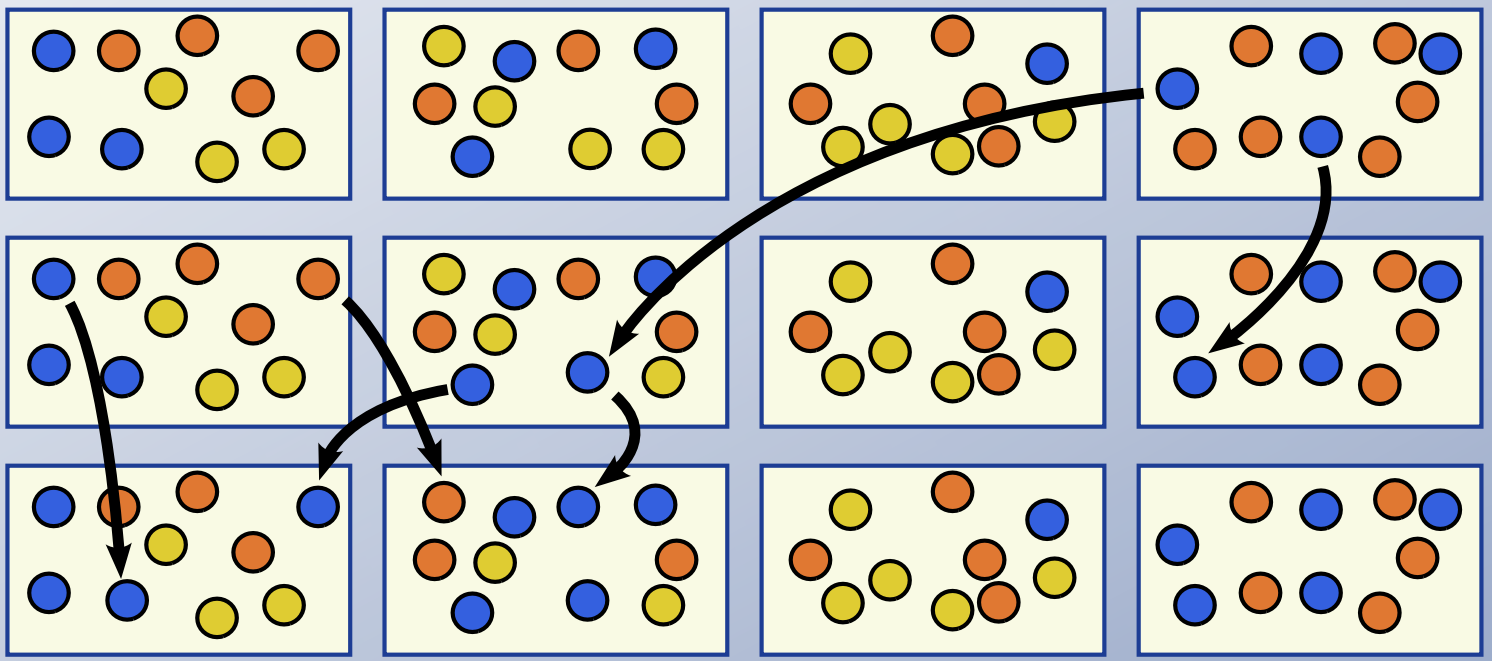


Each hearer then constructs a new grammar which is a *weighted sum* of the existing grammar, his own tokens and the other speaker's tokens.

Analysis of the Model I: Forward-Time Description

Genetic Drift

Interpret the grammar as a *store* of tokens.



Every man is an *island*: tokens are *asexually reproducing* individuals on an island; can *migrate* and go *extinct* or *fix*.

Classic, well-studied systems introduced by population geneticists in the 1930s (Fisher, Wright, Haldane...)

Forward Master Equation

- If one has a single speaker (island), the distribution of the number of mutants changes over one generation as

$$P(n, t+1) = \sum_m \binom{N}{n} \left(\frac{m}{N}\right)^n \left(1 - \frac{m}{N}\right)^{N-n} P(m, t)$$

- Mean change in mutant number is zero (each individual has a single offspring on average).

- Mean square change per generation is

$$\langle (n-m)^2 \rangle = N \left(\frac{m}{N}\right) \left(1 - \frac{m}{N}\right)$$

Stochastic Majority Rule?

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H Retention	Irish, Scottish, Northumbrian, West Country, East Anglian (~75%)
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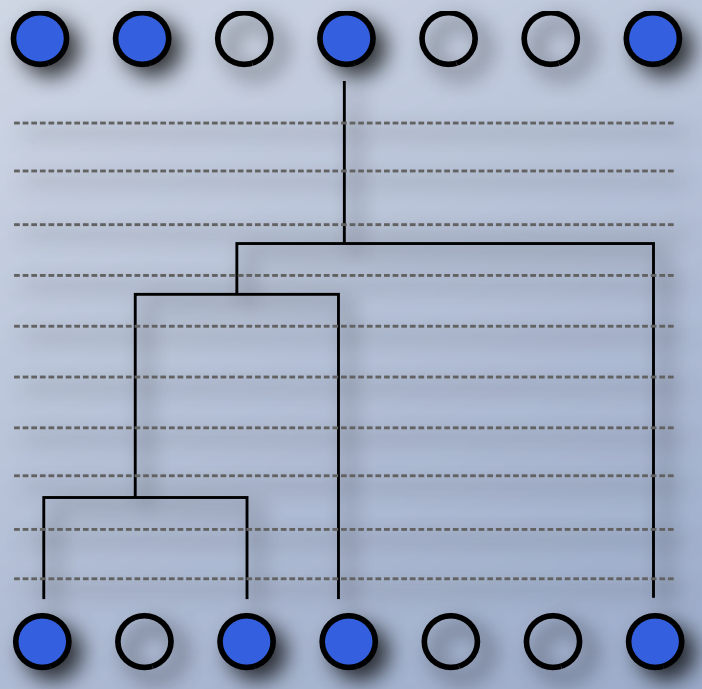
- Trudgill says: majority variant *always* wins out... (except when it doesn't: e.g., because of a bias towards unmarked vowels, changes that had already started).
- Genetic drift says: initial frequency is *probability* of survival.

Need more sophisticated analysis

Analysis of the Model II: Backward-Time Description

The Coalescent

- When following the forward process, you track individuals who leave no descendents in the final population.



- Much more efficient to track the ancestry of the present day population.

Change Under Drift

- Typically, an *inhomogeneous* initial condition relaxes "quickly" to a state where every speaker has a similar grammar with all variants present in their initial proportions.

  Remark: Sensible behaviour obtained only for specific range of H

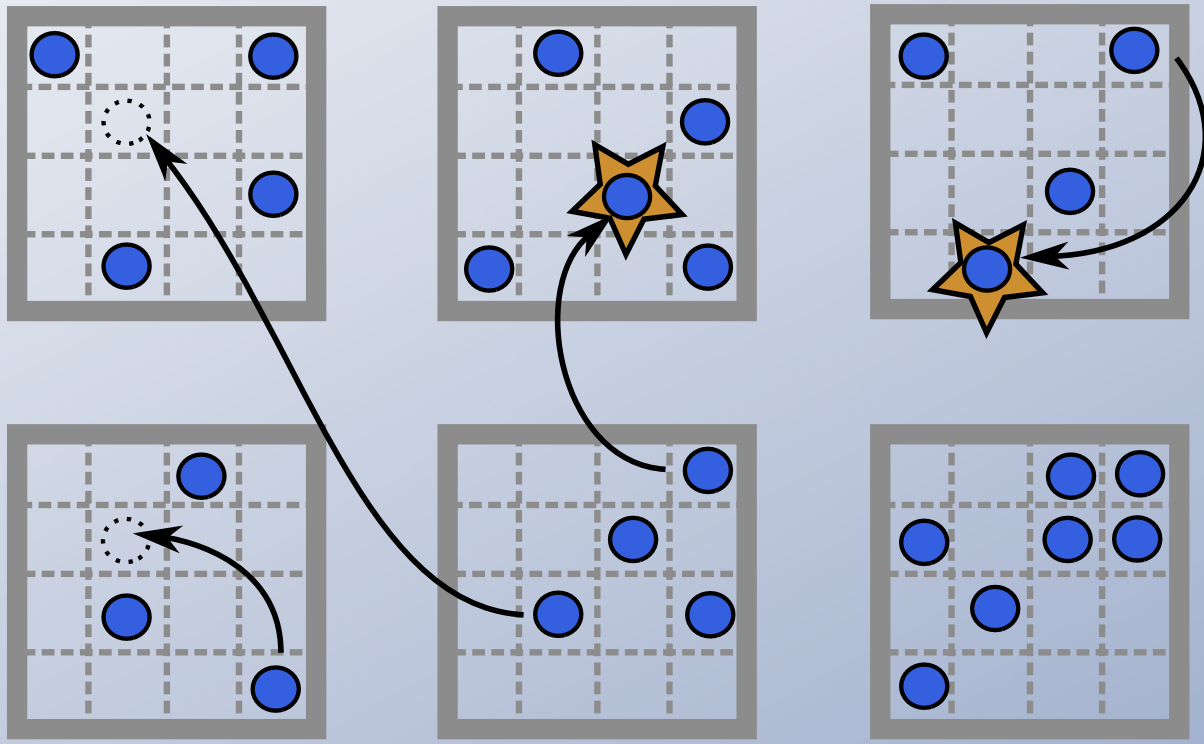
- This state persists for a time proportional to the number of speakers in a *flat* society.

  Remark: Unreasonable for a population of, say, 100,000 speakers.

- In a flat community of 100 speakers, each exposed to 10^9 instances of a variant per lifetime, require a "memory" of about 2 days of usage for fixation to occur in a generation.

  Remark: We do not know how to interpret this result.

Nonequilibrium Dynamics



- Have a **particle coalescence dynamics** where a finite number of sites contain a bounded number of particles that may make long-range hops.
- Physicists tend to like infinite systems, short-range dynamics, regular lattices...

Future work

- Our *belief* is that genetic drift is insufficient to describe all the features of, say, the New Zealand English data but it's proving tricky to reject it out of hand: further tests are required.
- Need to *understand* the actual data better.
- Need to put the model on more *realistic* network structures (gives new models of interest to nonequilibrium statistical physicists).
- Need to understand the role of different *generations* of speakers.
- Probably require *localising* effect to compete against the spreading from drift if stable dialects in different sub-communities are to arise (do we get a phase transition?).