

What can mathematical models tell us about mechanisms of propagation in language change?

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Evolutionary dynamics of language



Speakers **replicate** linguistic variables in interactions

Variation may be generated in token production

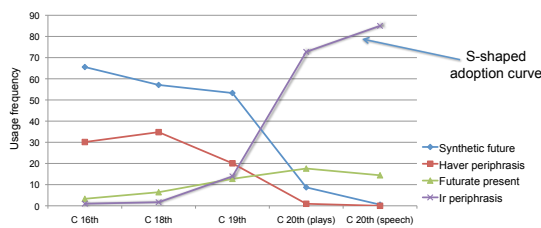
Some variants may be replicated more frequently than others: this is **selection**

We adopt the view of language change as a two-step process

innovation – propagation

(Croft 2000)

Propagation of innovations



Brazilian Portuguese Future (Poplack and Malvar 2007)

S curves in language change

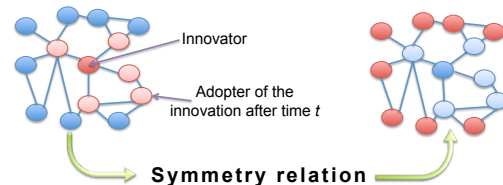
- Smooth, directional 'slow-quick-slow' growth pattern (not necessarily logistic)
- "The S-curve ... is now established as a kind of template for change" (Chambers 2002:361)
- A few examples
 - English periphrastic *do* (Ellegård 1953)
 - English *are* vs *be*; subject *you* vs *ye*; multiple negation vs single negation... (Nevalainen 2000; Nevalainen and Raumolin-Brunberg 2003 ch 14)
 - French embracing *ne VERB pas* (Grieve-Smith 2009:143)
 - Quotatives in Toronto English (Tagliamonte and D'Arcy 2007:205)
- Not all changes are S curves
 - some are incomplete, others reverse themselves
 - different patterns may be seen when there is no existing convention

Qualitatively distinct mechanisms for language change

A typology

Replicator selection

- Sturtevant-inspired mechanism
 - "Linguistic change [through] the association of particular forms of speaking with ... social groups" (Labov 2001:24)



Replicator selection

- Asymmetry in the variants
 - Variant A spreads in a different way to variant B
- Examples
 - Prestige, hypercorrection (Labov 1972)
 - Acts of identity (LePage and Tabouret-Keller 1985)
 - Roles of speakers in creolization (Mufwene 2008)

Interactor selection

- Bloomfield-inspired mechanism
 - “Language change may simply reflect changes in interlocutor frequencies” (Labov 2001:191)

Neutral interactor selection

- Innovation spreads from speaker *i* to speaker *j* with same probability as reverse
- Both speakers in an interaction respond to variation in the same way
- Examples
 - Deterministic theory for new-dialect formation (Trudgill 2004)
 - Potentially some social network theories (Milroy and Milroy 1985)

Weighted interactor selection

- Asymmetry between speakers
- Examples
 - Other social network theories (Milroy and Milroy 1985)
 - Diffusion of innovations (Rogers 1995)
 - Community partitioned into five ‘adopter categories’
 - Leaders-and-followers model (Labov 2001:356)

Summary of typology

	Mechanism	Variants (replicators)	Speakers (interactors)	Interaction frequencies
Progressively weaker selection ↓	Replicator selection	Asymmetric		
	Weighted interactor selection		Asymmetric	
	Neutral interactor selection		Symmetric	Unequal
	Neutral evolution	Symmetric	Symmetric	Equal

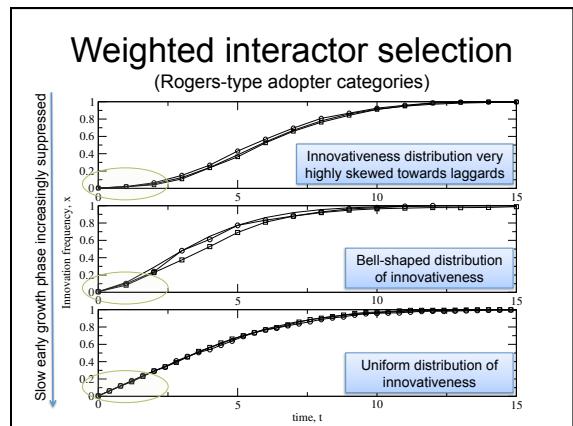
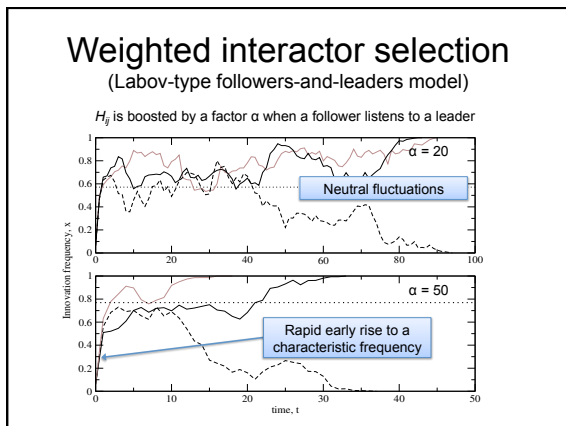
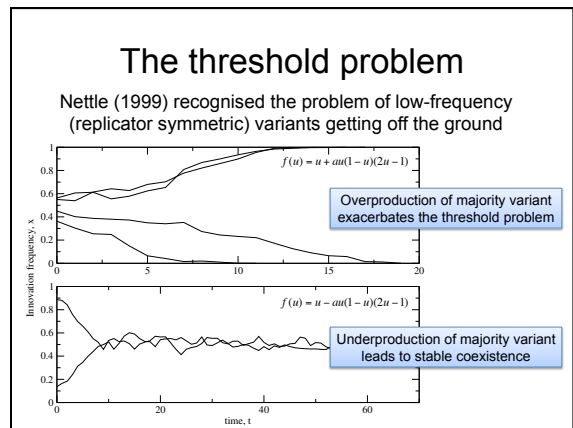
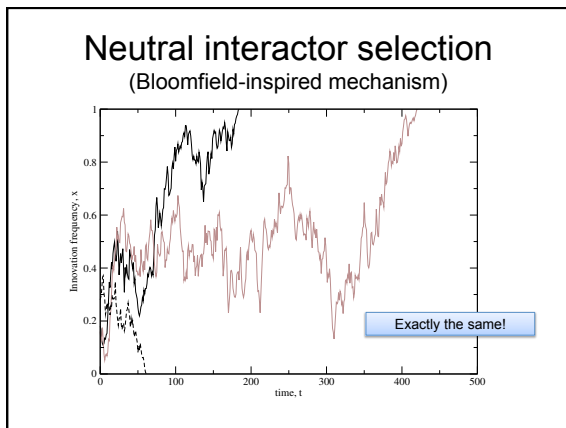
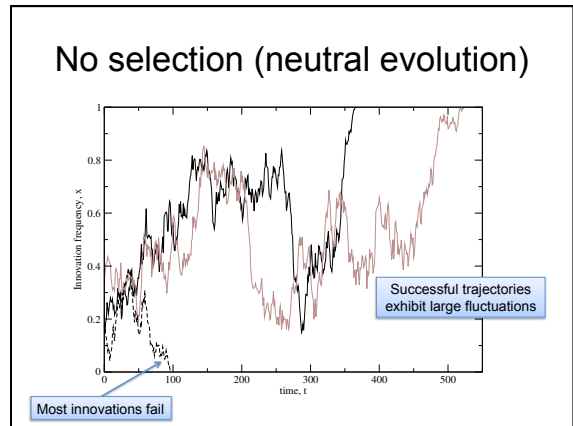
Which selection mechanisms allow for an S curve?

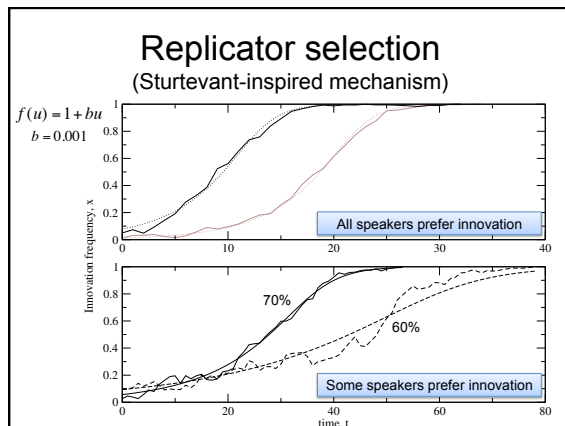
Address this question with mathematical models

Utterance Selection Model

Extends model of Baxter, Blythe, Croft and McKane (2006)

0. A speaker i uses the innovation with relative frequency x_i
1. Speakers interact with probability G_{ij} per timestep
2. Speakers produce T tokens each, independently and probabilistically according to their frequencies x_i
3. Speakers alter their frequencies x_i according to the number of innovative tokens n_i produced
4. Renormalise frequencies and go back to 1

$$x_i' \propto x_i + \lambda \left[H_{ij} f\left(\frac{n_i}{T}\right) + H_{ij} f\left(\frac{n_j}{T}\right) \right]$$




Beyond one specific model

- Have investigated much wider set of conditions than those shown here
 - E.g. more than two speakers per interaction, different implementations of selection mechanisms
- Results from other models in the literature also consistent with our main findings

To obtain an S curve need to impose an asymmetry between the convention and innovation either through asymmetric social structure, or through preference for the innovation

General argument?

Assume a simplistic 'homogeneity' principle

Replicator symmetry

Community mean usage frequency $F(1-x) = -F(x)$
 $F(\frac{1}{2}) = 0$

$\frac{dx}{dt} = F(x)$

Interactor symmetry

If the path from speaker i to j is followed with the same probability as the path from j to i , the identity of innovator does not affect the usage frequency curve

Require a **directional structure** in the speech community to get a **sustained directional change** in usage frequencies

Summary

- Formulated a systematic typology of selection mechanisms for language change
- Focussed on mechanisms that admit the frequently-reported S curve growth
- Necessitates fundamental asymmetry in the system – possibly between speakers, more likely between variants (replicators)
- What is the origin of replicator asymmetry? How is it established in, e.g., language-contact situations?

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