Mathematical Models of Word Order Change in Middle English

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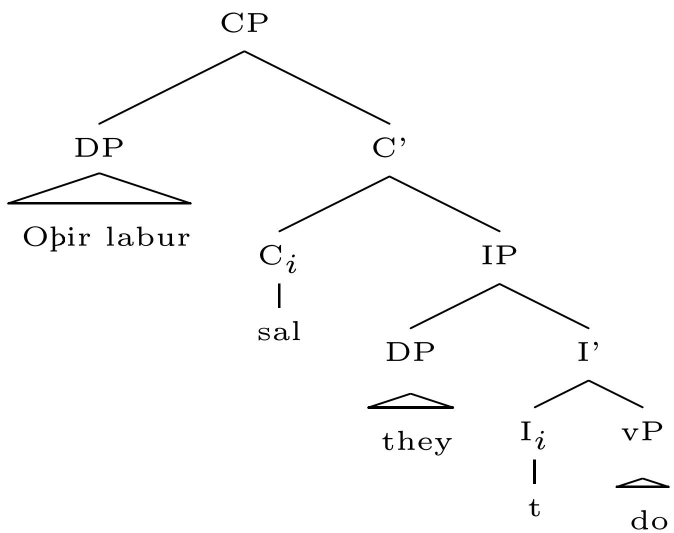
Explanations of syntactic change & reanalysis

- Three Hard Questions:
  - Description of language before
  - Description of ambiguous, unambiguous, reanalyzed forms
  - Description of language after
- Three Very Hard Questions:
  - Why did the change occur once feasible?
  - Why did it happen at the time it did?
  - Why didn't some other potential change happen?

Verb-second in northern Middle English

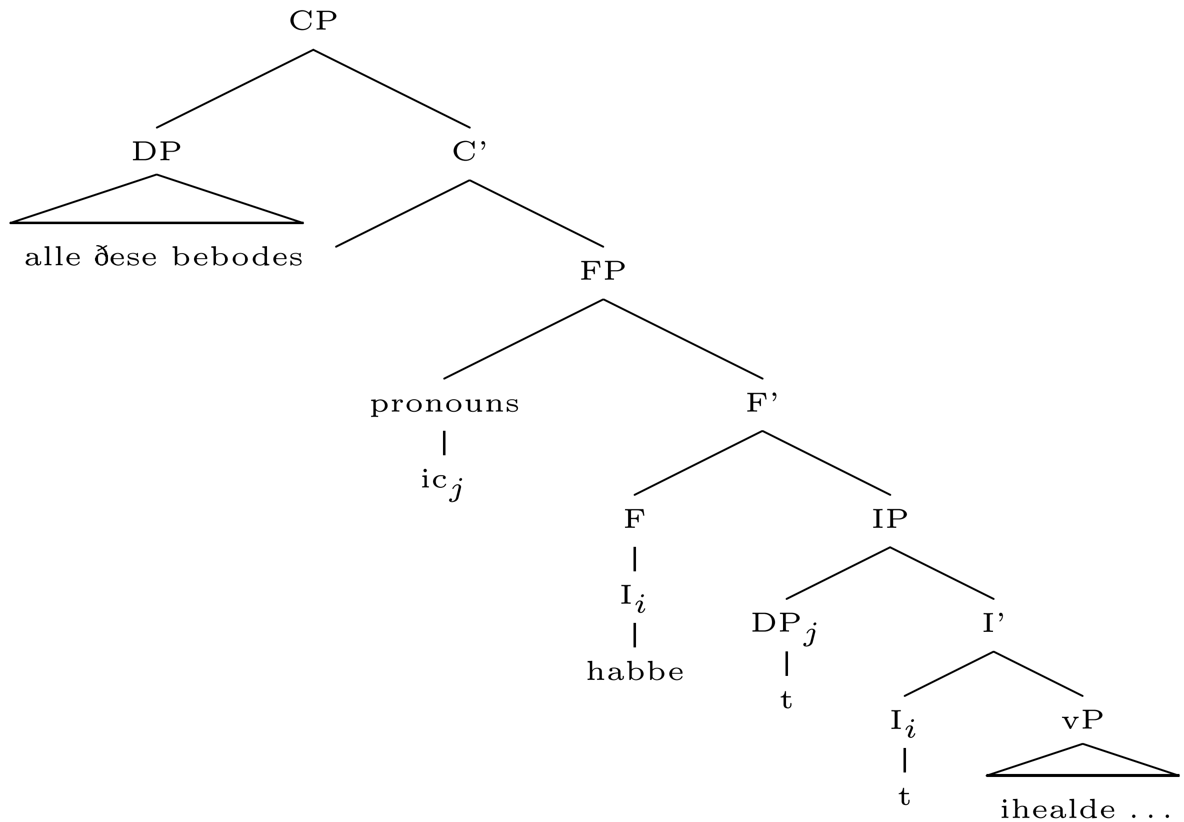


(1) '[Oþir labur] *sal* they do'

(*The Rule of St. Benet*, Fischer et al. [2000, p. 131])

CP-type verb-second, pronouns are full words

Verb-second in southern Middle English



(2) '[alle ðese bebodes] ic *habbe* ihealde fram childhade'

(*Vices & Virtues*, Fischer et al. [2000, p. 130])

FP-type verb-second, pronouns are special

Three hard questions

- Before: South SVO+FPv2+pronoun slot, North SVO+CPv2
- Northern, Southern, Modern: Subject Vf ...
  Northern, Southern: XP Vf Subject ...
  Southern: XP Pronoun Vf Subject ...
- After: Modern SVO

Cue sentences for NME

XP Vf Subject . . .

- Assume children determine quickly that NME has underlying SVO
- Cue sentences: Those which can only be parsed with SVO+CPv2
- Learning hypothesis: Northern children acquire a verb-second grammar only if they hear enough sentences of this form. Proposed by Lightfoot [1999].
- Contact with southern ME leads to fewer cue sentences

First model: Grammar and learning

- Two grammars, G_1 and G_2, but G_1 is marked (requires substaintial evidence to acquire) and G_2 is the default
- People speak either G_1 or G_2, no diglossia
  (We'll come back to this...)
- Learning: Children hear n sentences total; choose G_1 if m or more of them are cues, else choose G_2
- Speakers of G_1 produce cue sentences at rate $p_1 \approx 30\%$
  Speakers of G_2 produce cue sentences at rate $p_2 < 5\%$

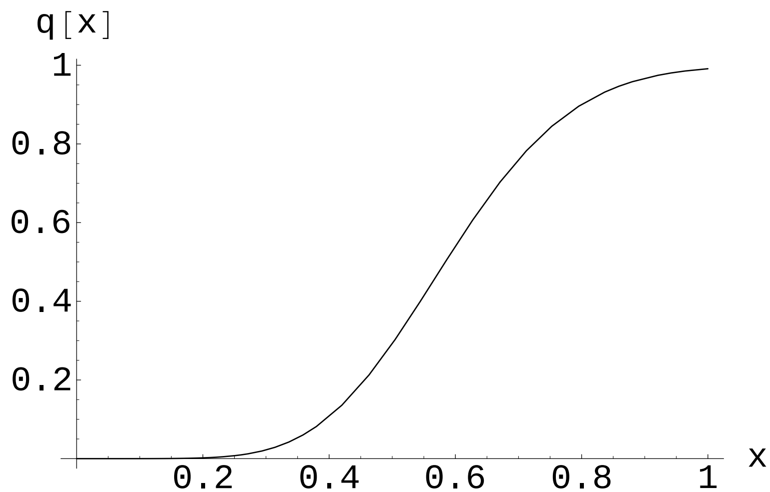
First model: Population structure

- Two regions, North and South; children learn only from neighbors
- x_N = fraction of northerners speaking G_1
- x_S = fraction of southerners speaking G_1
- Mixing parameters α and β: Measure rate at which people move from one region to the other

Mathematical notation

$$q(x) = \mathbb{P}\{\text{child picks } G_1\}$$

$$= \sum_{j=m}^{n} \binom{n}{j} \gamma^j \gamma^{n-j}$$



$\gamma = p_1 x + p_2(1 - x)$

$x =$ fraction speaking G_1

$n = \#$ sample sentences $= 100$

$m = \min \#$ cue $= 20$

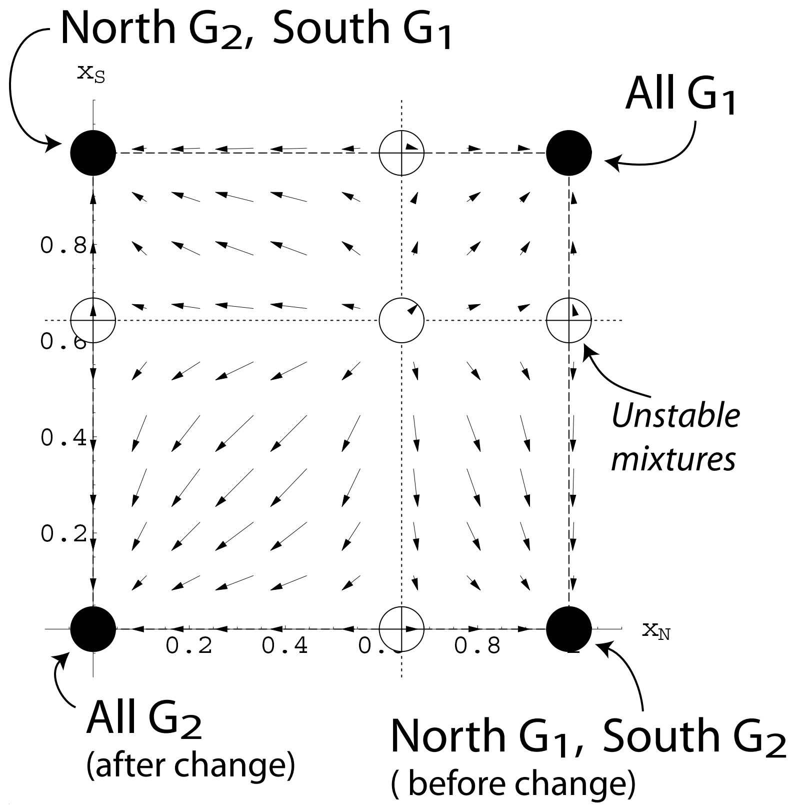
$p_1 =$ cue freq for $G_1 = 0.3$

$p_2 =$ cue freq for $G_2 = 0.05$

$$\dot{x}_N = q(x_N) - x_N + \alpha(x_S - x_N)$$

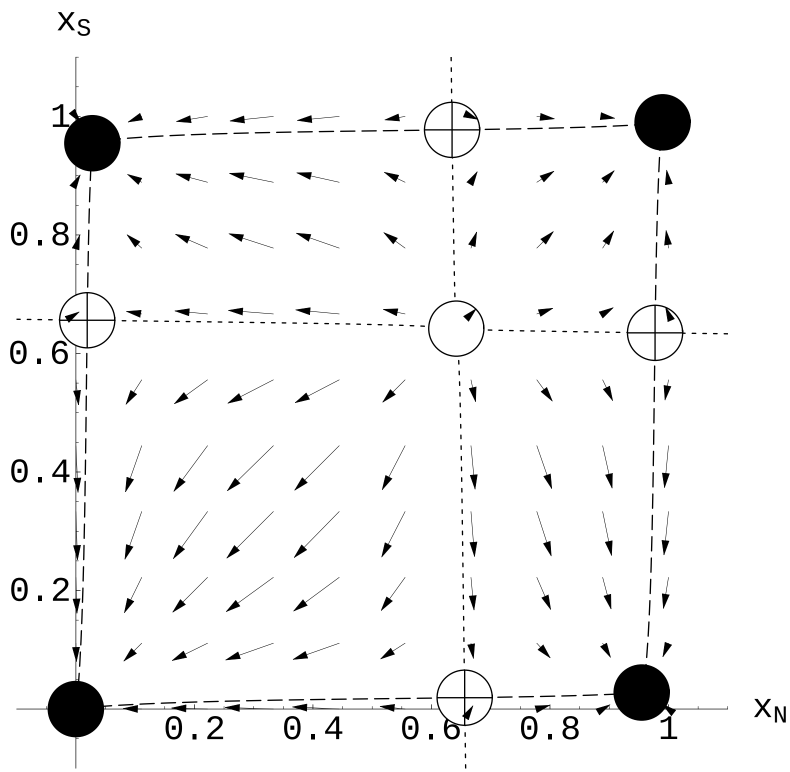
$$\dot{x}_S = q(x_S) - x_S + \beta(x_N - x_S)$$

Phase portrait for isolated regions



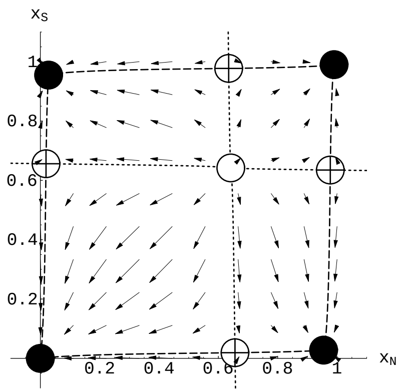
$$\alpha = \beta = 0$$

Phase portrait: small mixing

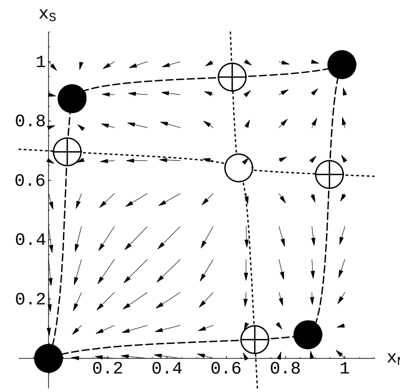


$$\alpha = \beta = 0.03$$

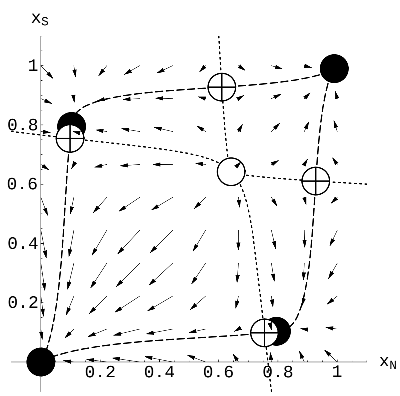
Phase portrait: more and more mixing



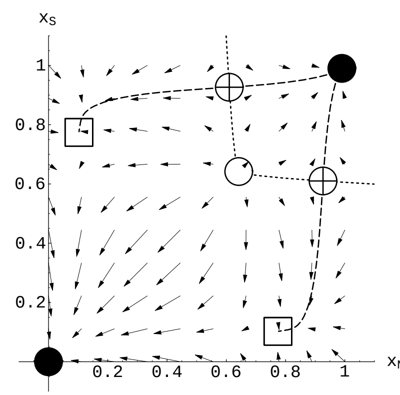
$\alpha = \beta = 0.03$



$\alpha = \beta = 0.1$

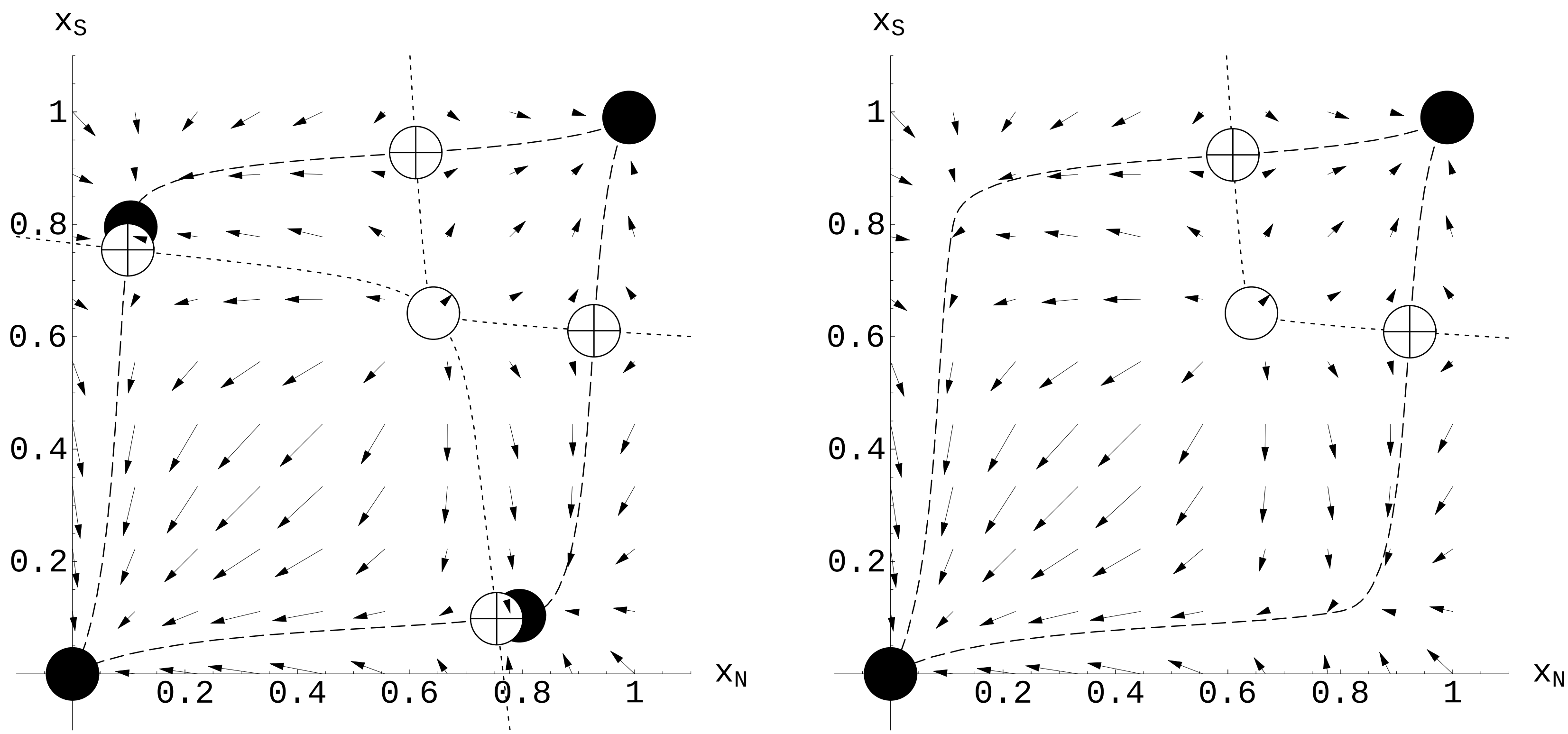


$\alpha = \beta = 0.15$



$\alpha = \beta = 0.152985\ldots$

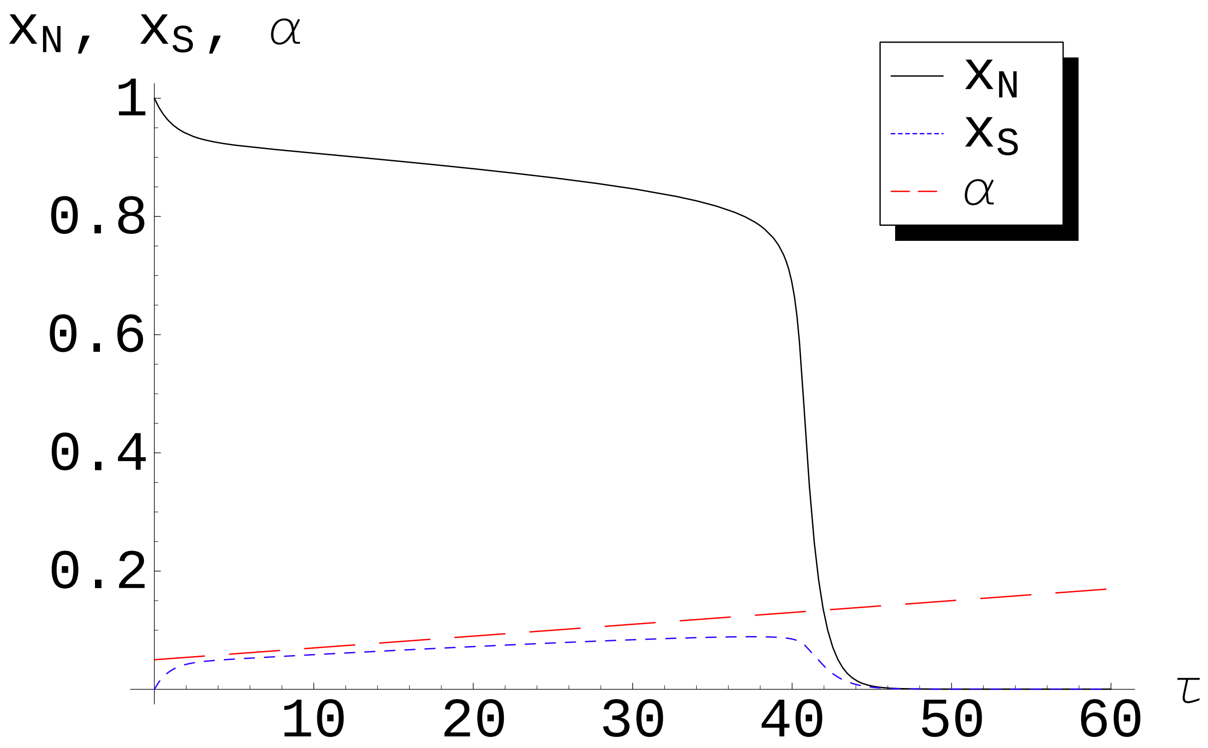
Phase portrait: bifurcation



Before

After

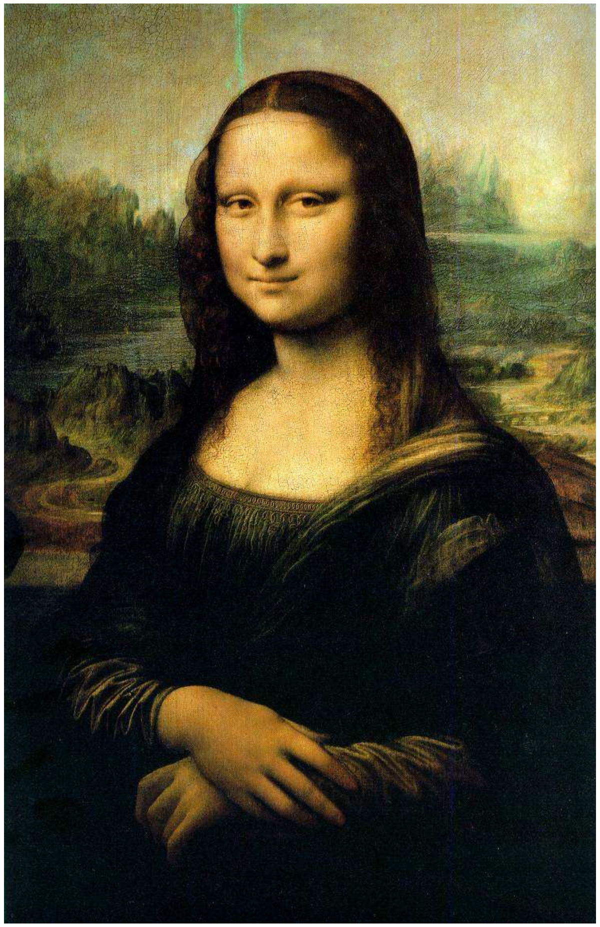
Time traces



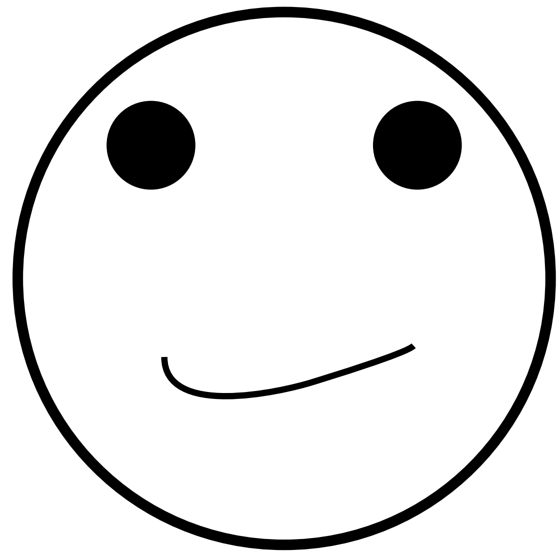
Horizontal axis: Time (rescaled units, not years)

Vertical axis: Fraction of population speaking G_1

Using $\alpha = \beta$, both increasing linearly in time



The goal



The model so far

Needed improvements

- Allow diglossia
- Allow more grammars (SVO+v2, SVO+v2+pronoun slot, vanilla SVO, various kinds of v2, etc.)
- Connect to manuscript data

Second model: a simulation

In collaboration with Anthony Kroch

- Agent based, not a continuous approximation
- Minimalist grammar [Adger, 2003]
- Detailed learning algorithm [Yang, 2002]
- Literacy

References

David Adger. *Core Syntax: A minimalist approach.* Oxford University Press, Oxford, 2003.

Olga Fischer, Ans van Kemenade, Willem Koopman, and Wim van der Wurff. *The Syntax of Early English.* Cambridge University Press, 2000.

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Charles D. Yang. *Knowledge and Learning in Natural Language.* Oxford University Press, Oxford, 2002.