Three compatible models of S-curves in language change

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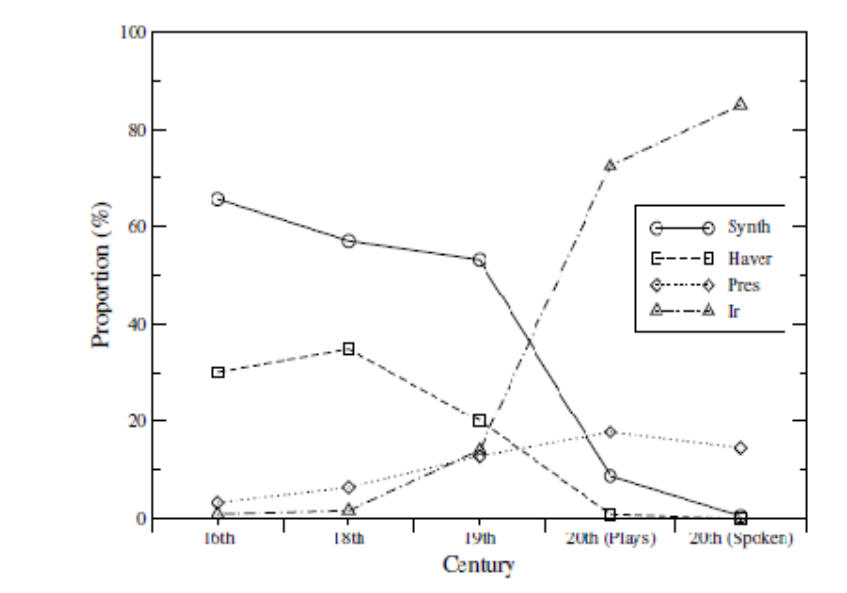
Outline

- How changes propagate
- Instrumentalism and pluralism
- Three theories/models
  - Logistic
  - Competition
  - Utterance selection
- Data
- Results

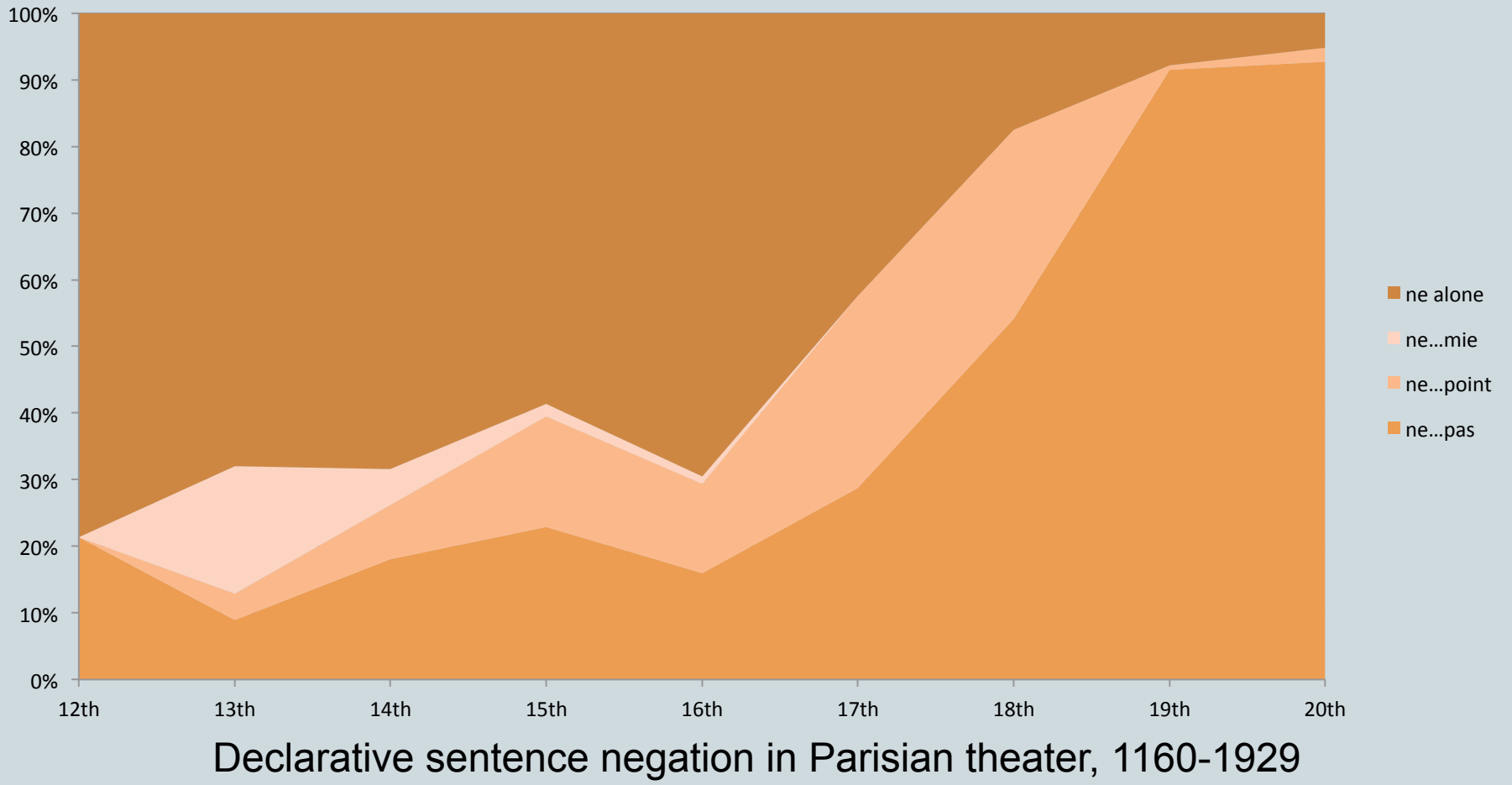
How changes propagate



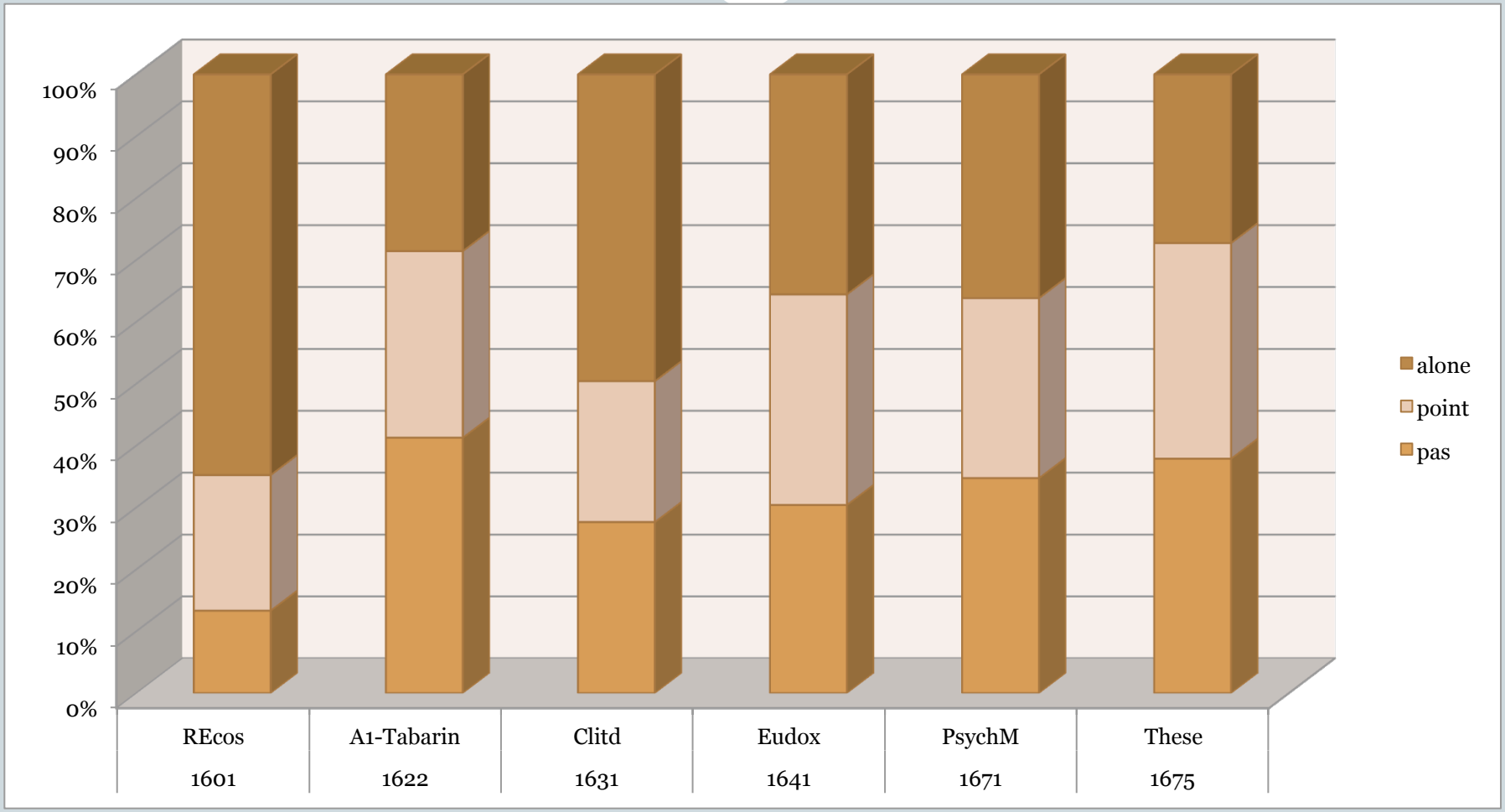
Future tense markers in Brazilian Portuguese (Poplack & Malvar 2007:14, via Blythe and Croft 2012)

- Slow, quick, slow
- Replacement of one form (or more) by another
- Better represented as a stacked area chart

Another S-curve



Variation within plays, and within characters



Dimensions of propagation (Bailey 1973)

- Through the lexicon
- Through situations
- Through space
- Through social groups

Instrumentalism and pluralism

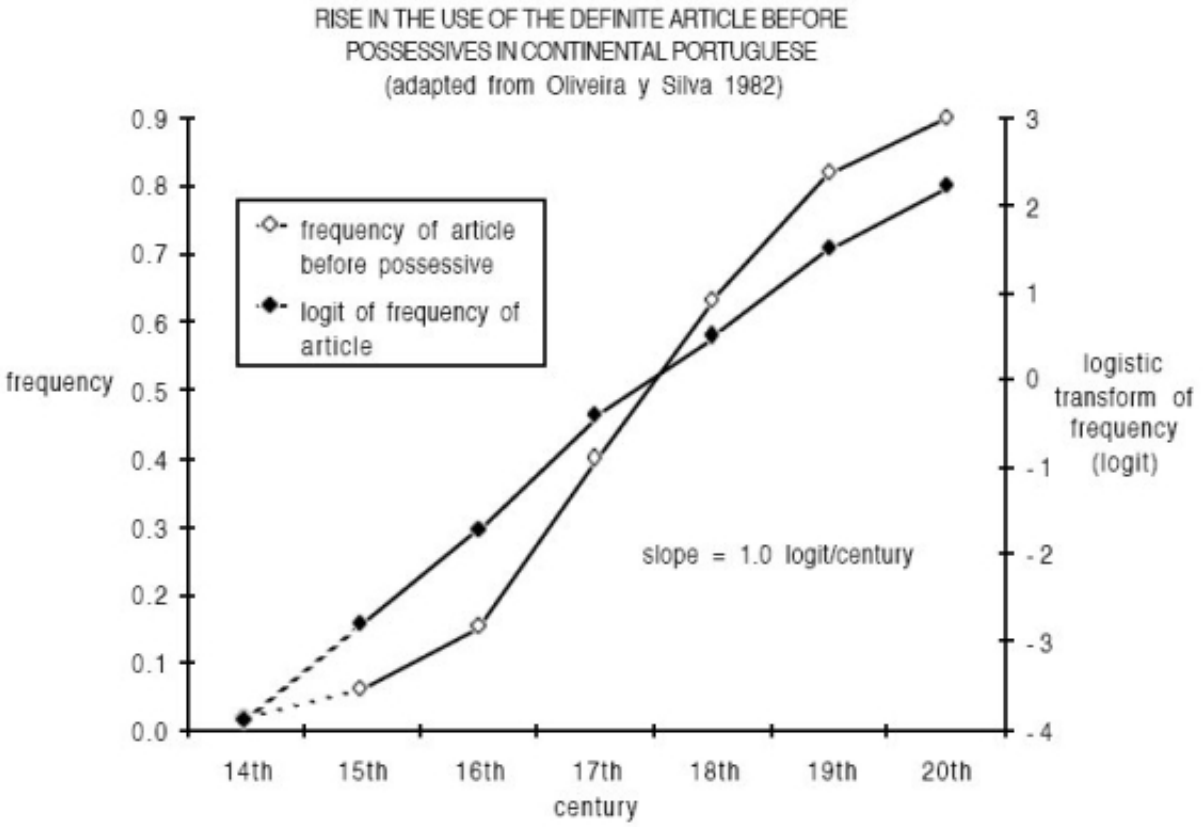
- “Construed as statements that are either true or false, the two theories are on the face of it mutually incompatible. But construed as techniques […], the theories are simply different though complementary instruments, each of which is an effective intellectual tool for dealing with a special range of questions.” – Nagel (1961)

Three models to explain S-curves

- Basic logistic model
  - Kroch 1989
  - From Verhulst 1838
- Competition model
  - Grieve-Smith 2009
  - From Lotka 1925 and Volterra 1926
- Utterance selection model
  - Blythe and Croft 2012
  - From Hull 1988

"incremental linguistic change seems often to reflect competition among alternative licensing principles for entire grammatical subsystems"

$$\frac{dx}{dt} = rx\left(\frac{1-x}{k}\right)$$



Logistic model (Kroch 1989)

The mathematics behind the logistic

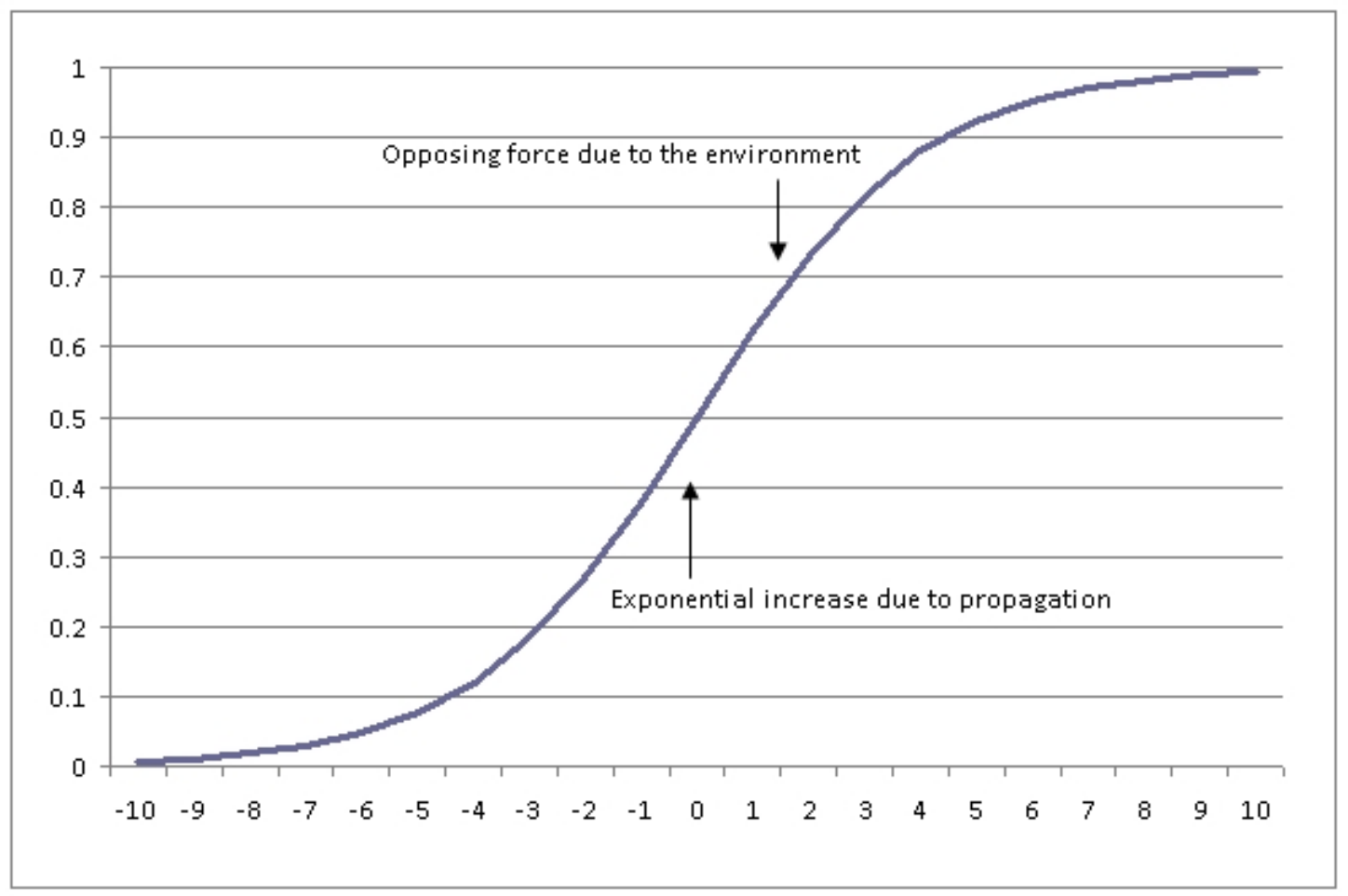
Picture: Flameng sculp (1850)

"L'accroissement virtuel de la population trouve donc une limite dans l'étendue et la fertilité du pays, et la population tend, par conséquent, de plus en plus à devenir stationnaire."

"La vitesse d'accroissement de la population est retardée **par l'augmentation même** du nombre des habitans"

– Verhulst (1838)

What are the forces producing S-curves in language?



Extension through Type Frequency

Photo: University of Oslo (2005)

"The more lexical items that are heard in a certain position in a construction, … the more likely it will be to extend to new items."

-Bybee and Thompson (2000)

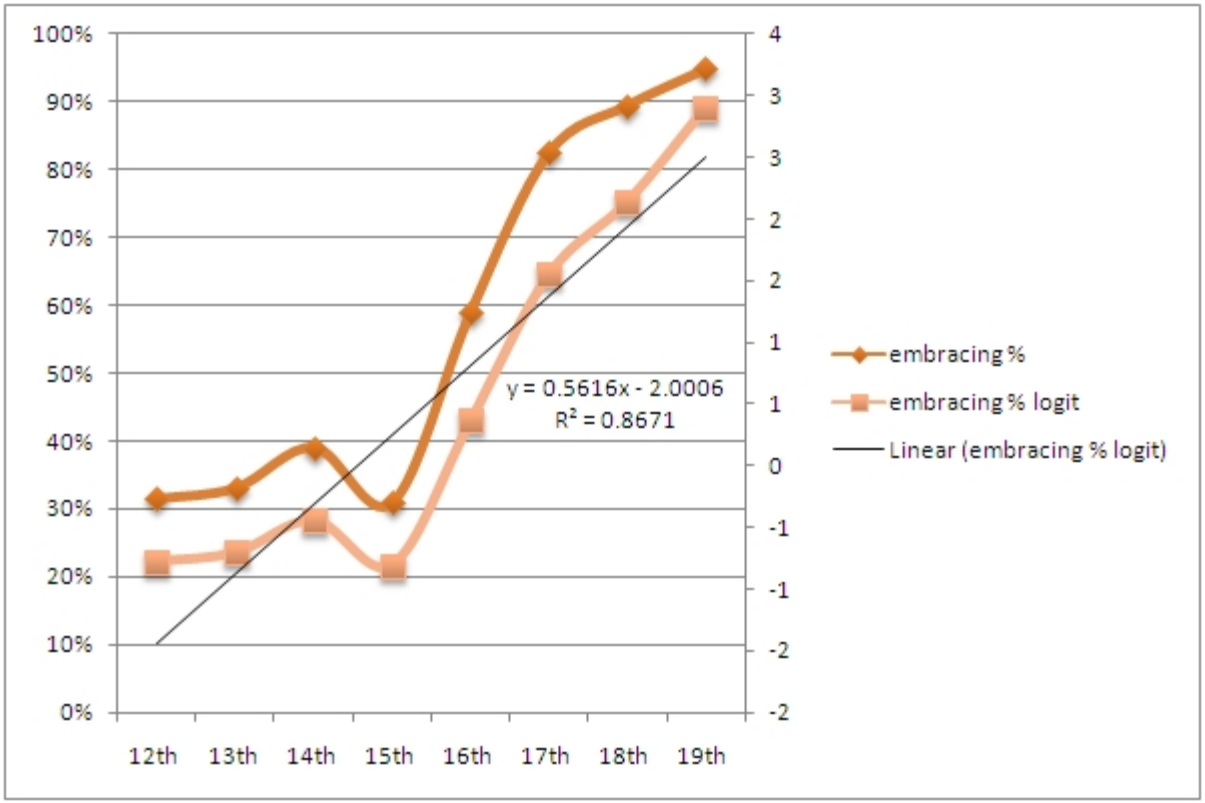
Entrenchment through Token Frequency

Photo: UC Santa Barbara

"the more a form is used, the more its representation is strengthened… Words that are strong in memory and easy to access are not likely to be replaced by new forms created with the regular pattern"

– Bybee and Thompson (2000)

Test of the logistic model (Kroch 1989, Verhulst 1838). The R^2 value of 0.867 indicates that the model explains 86.7% of the observed variation.



Proportion of tokens of declarative sentence negation with any embracing negation construction, from 1200 through 1939

The logistic doesn't explain it all

- Intended for species colonizing virgin territory
- Not for competition
- Has no applicability to declining populations
- How can we model competition?

Photo: Erhardt / Wikipedia (2006)

Modeling inter-species resource competition

Photos: Unkown

- Alfred J. Lotka (Johns Hopkins U., 1925)
- Vito Volterra (U. of Rome La Sapienza, 1926)
- Also modeled predator-prey relationships

Lotka and Volterra's insight

Original logistic formula (Verhulst, 1838):

$$\frac{dx}{dt} = rx\left(\frac{1-x}{k}\right)$$

Inter-species competition (Lotka 1925, Volterra 1926):

$$\frac{dx_i}{dt} = r_i x_i\left(\frac{K_i - \sum a_{ij} x_j}{K_i}\right)$$

competition coefficient

- **Competition coefficient**
- The effect that each member of species *i* has on each member of species *j*

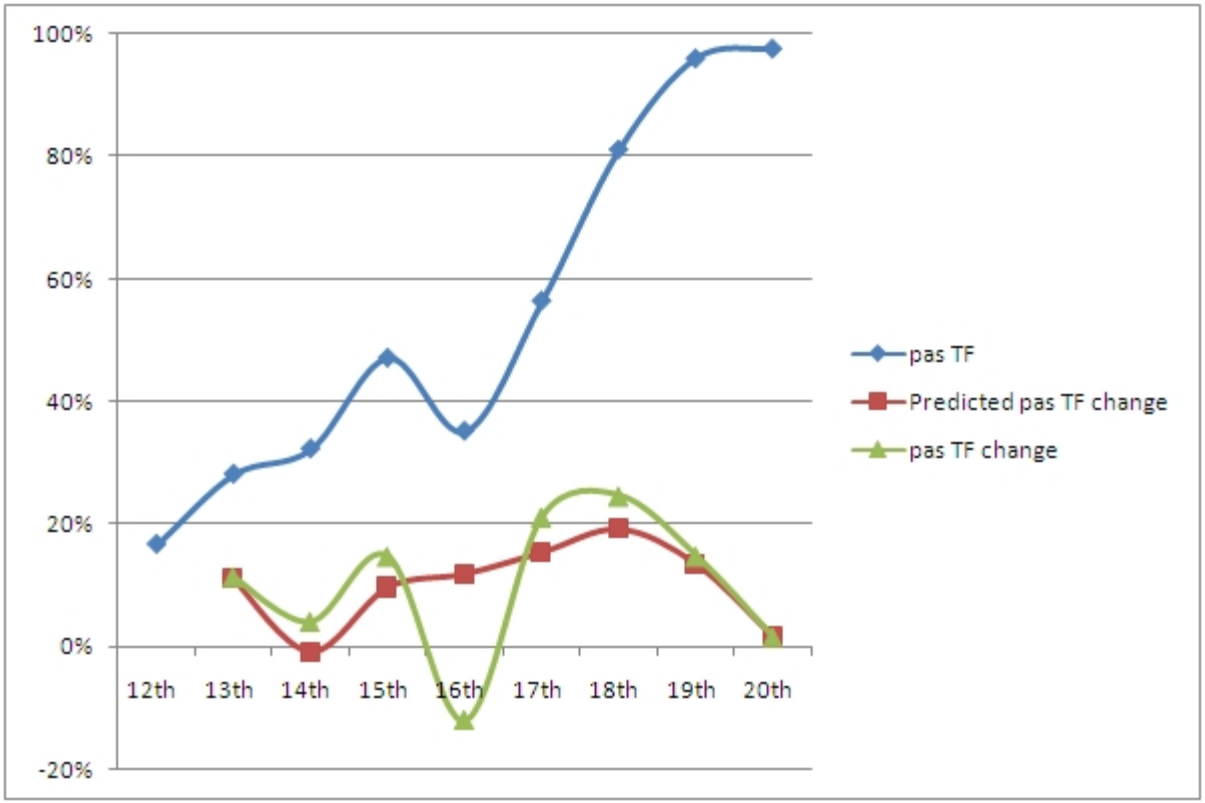
So what values of α did I use?

effect	of *ne* alone	of *ne … pas*	of *ne … point*	of *ne … mie*
on *ne* alone	1.000	1.290	1.140	1.760
on *ne … pas*	0.274	1.000	0.000	1.530
on *ne … point*	0.000	1.670	1.000	0.302
on *ne … mie*	0.451	3.870	0.000	1.000

How did these values work out?

Function	Competition	Centuries	Correlation (*r*)
Presupposition denial	*ne* … *pas* vs. *ne* … *point* vs. *ne* … *mie*	12th-16th	-0.418
Presupposition denial	*ne* … *pas* vs. *ne* … *point*	17th-19th	0.951
Predicate negation	*ne* alone vs. *ne* … *pas*	17th-20th	0.977

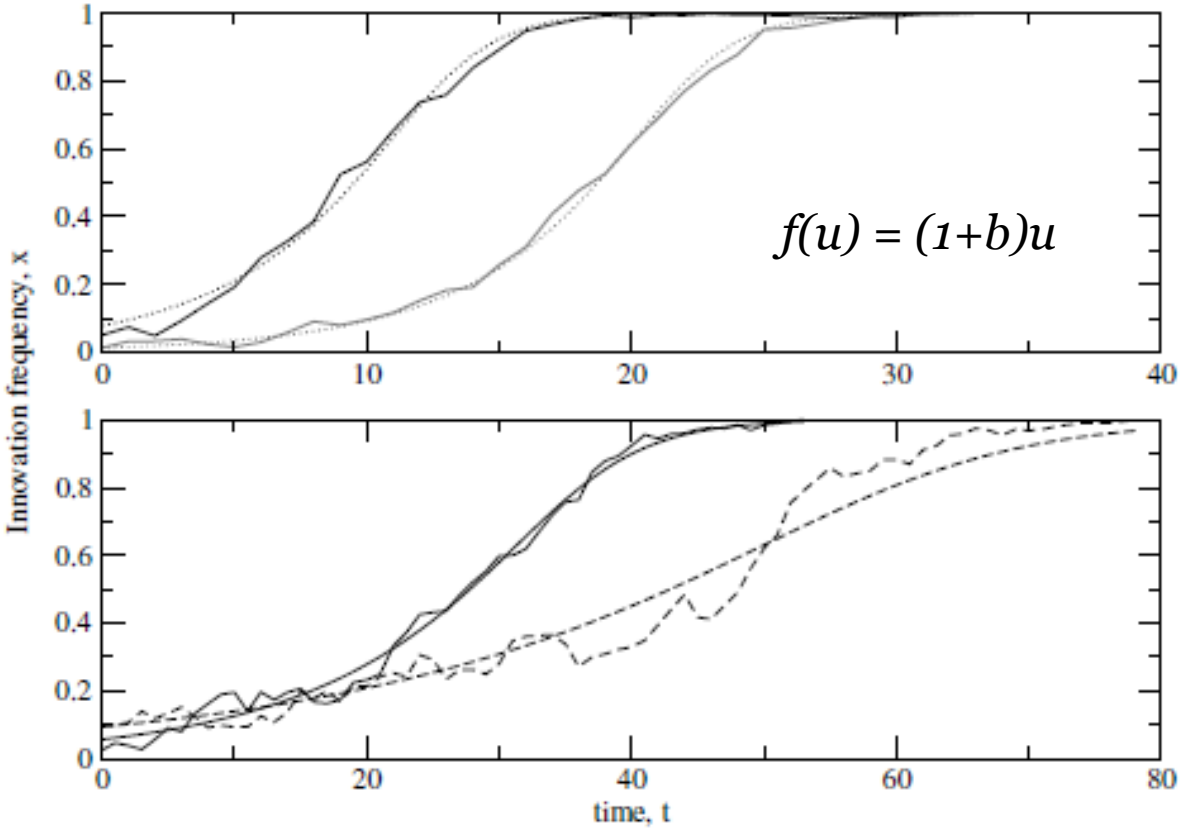
Type frequency, predicted change and measured change in type frequency of embracing *ne … pas* for main verbs, excluding high-frequency verbs and hapaxes.



Modeling the evolution of embracing *ne … pas* ($\alpha_{ij} = 1.29$)

"In this expression, *Hii* is the weight speaker i gives to her own utterances, and *Hij* to those of speaker j. Note in particular that we do not require *Hij* = *Hji*: when these weights are unequal, there is an asymmetry between the speakers *i* and *j* that is characteristic of weighted interactor selection." (p. 284)

$$y_i = H_{ii} f\left(\frac{n_i}{T}\right) + H_{ij} f\left(\frac{n_j}{T}\right)$$



Utterance selection model (Blythe and Croft 2012, hypothetical data)

The Takeaway

- The logistic model (Kroch 1989) gives us a simple view
- The competition model (Lotka (1925)-Volterra (1926) conveys more details about preference
- The utterance selection model (Blythe and Croft 2012) models interactions in a speech community
- All three can explain propagation at different levels of detail