Social structures and their influence on language change

Erice Summer School

"Statistical Physics of Social Dynamics: Opinions, Semiotic Dynamics, and Language"

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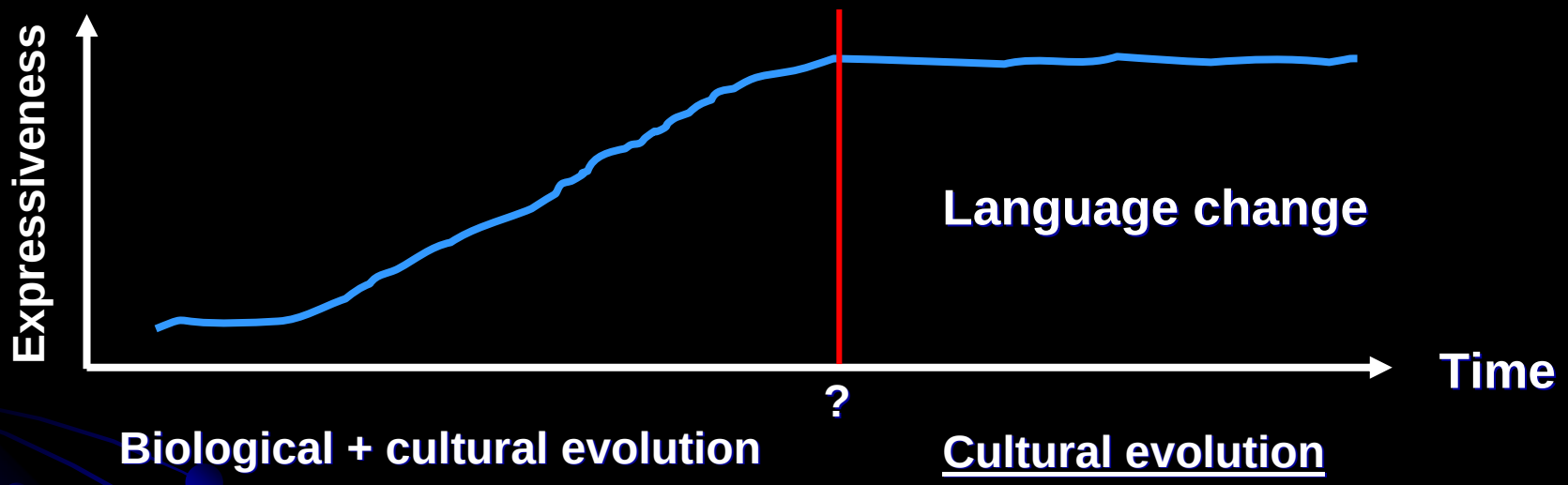
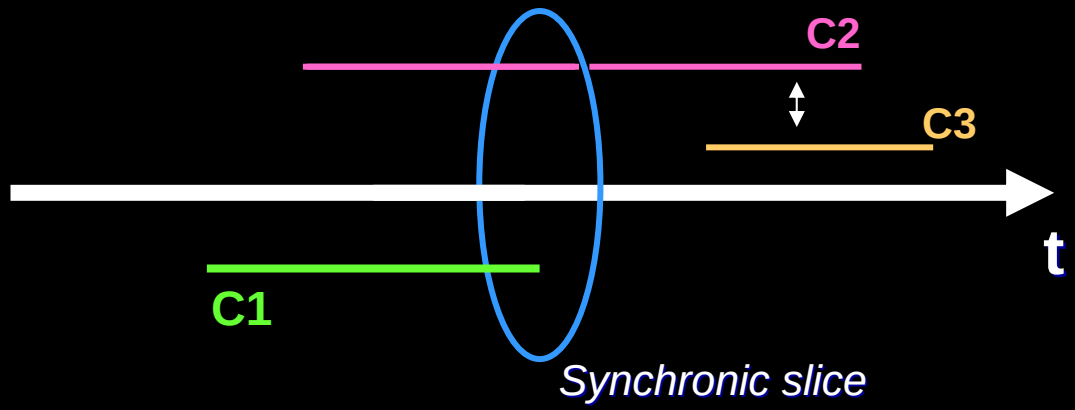
Evolution of languages, not emergence of language !



- Raise different questions, both linguistically and with respect to network theory
- How can models of opinion dynamics, complex networks etc. be of help to linguists?

Language change

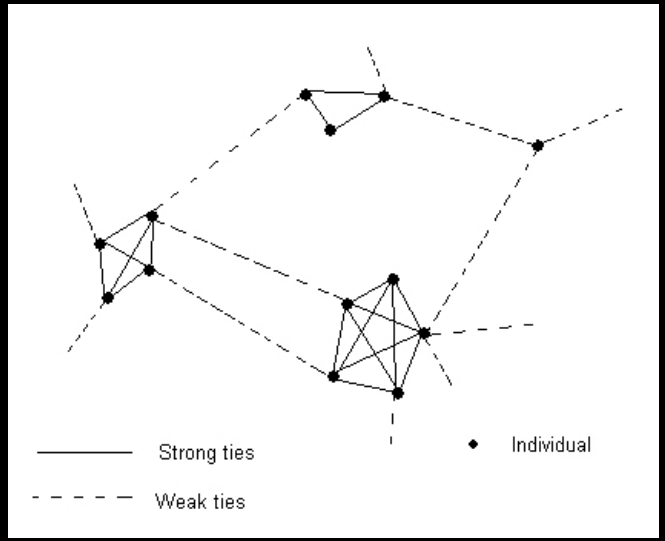
- All languages keep changing (Sapir, 1921)
  - No final stage of evolution



- Because of contradictory constraints
  - Physiological & cognitive constraints
  - *Social constraints*
    - language as a tool to assert one's identity [Labov, 1972]

Social networks & language change

- Sociolinguists have been wondering about social ties and their influence…
  - Clusters, socio-economic classes, weak vs. strong ties etc.



from [Milroy, 1992]

  - "*The leaders of linguistic change are people at the center of their social networks, who other people frequently refer to, with a wider range of social connections than others*." [Labov, 2001, p.356]

- … but… limits of micro-scale "field" analyses

What's next?

i) Consider 3 linguists' questions regarding language change

ii) Consider how network theory and its models may help investigate them

iii) Show that such issues may suggest research on networks themselves

Problem n°1: Languages of the past

Evolution of social structures during prehistory

from small & mobile groups of hunters-gatherers…

… to sedentary & larger populations

Which situation before the Holocene?

Linguistic level: faster or slower evolutions? diversity?

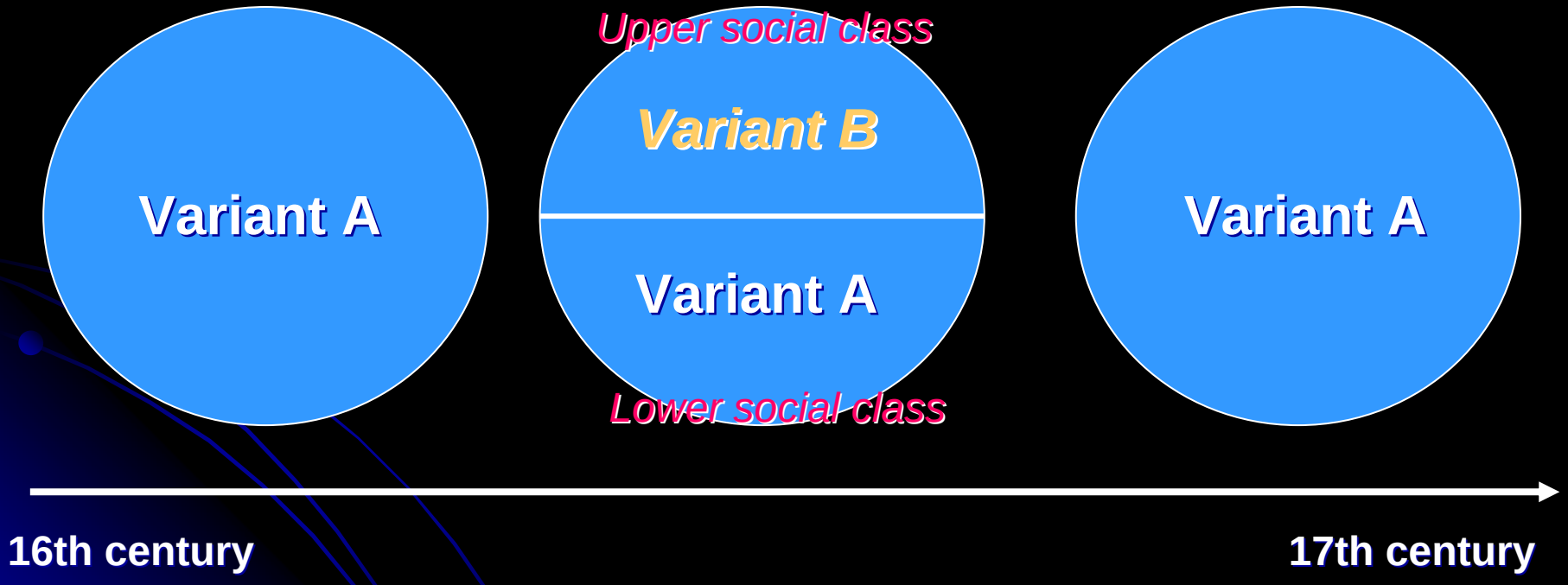
(Is it possible to reconstruct the putative ancestor of all modern languages?)

More generally: cultural interactions?

no direct evidence, few indirect cues!

Problem n°2: Reversal of merge

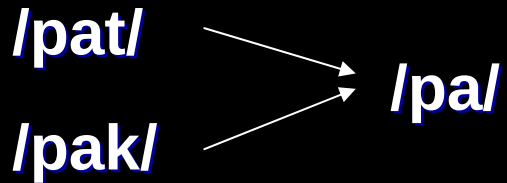
To explain a theoretically impossible evolution in Middle English, Weinrich, Herzog & Labov (1968) came up with the following sequence:



How could variant B appear, be maintained and then disappear?

Problem n°3: Changes disrupting linguistic systems

Disappearance of /p/, /t/, /k/ in final position in some Chinese "dialects" during the past (Wang & Chen, 1975)



Homophony → ambiguity → Did it impede communication?

If yes, why did this change happen? (tout-se-tient!)

If no, how did the system remain balanced?

(other *simultaneous* changes like disyllabification?)

Adopting a “sociophysical” reading

Interest in elaborate dynamics, variations, meta-stability etc.
… not so much in asymptotic states, final equilibriums etc.

How does complex network structures prevent / ease the diffusion of innovations?

Which social structures allow for dynamics involving meta-stable linguistic states?

Can an emerging variant less functional than the dominant one spread in a population?

Some finer-grained issues…

- Debates on the mechanisms creating linguistic variation
- Internal (linguistic) factors *vs.* external factors (social influence)
  - How do they *together* drive the competition between linguistic variants?
- Which model to adapt/build to relate relevant sources of variability to real observed dynamics?

Few models have been specifically developed to address the former issues

(is this a naive linguist's statement?)

=

common situations of language change

(not "abrupt" situations like language extinction or emergence)

Nettle's model (1999): overview

- 2 linguistic variants: p & q
- *Source of variation*:
  - speakers' replacement (5 life stages) & imperfect learning
- Social structure
  - Fully connected network (N=400)
  - weights decreasing with distance

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- *Driving factors*:
  - social influence
    - neighbor's variants & status
    - social impact theory
  - functional bias

 # neighbbors with p **status**

$$\hat{\imath}_p = b_p N_p{}^a \sum_{neighbors} (s_i / d_i{}^2) / N_p$$

Functional load **distance**

Nettle's model (1999): results

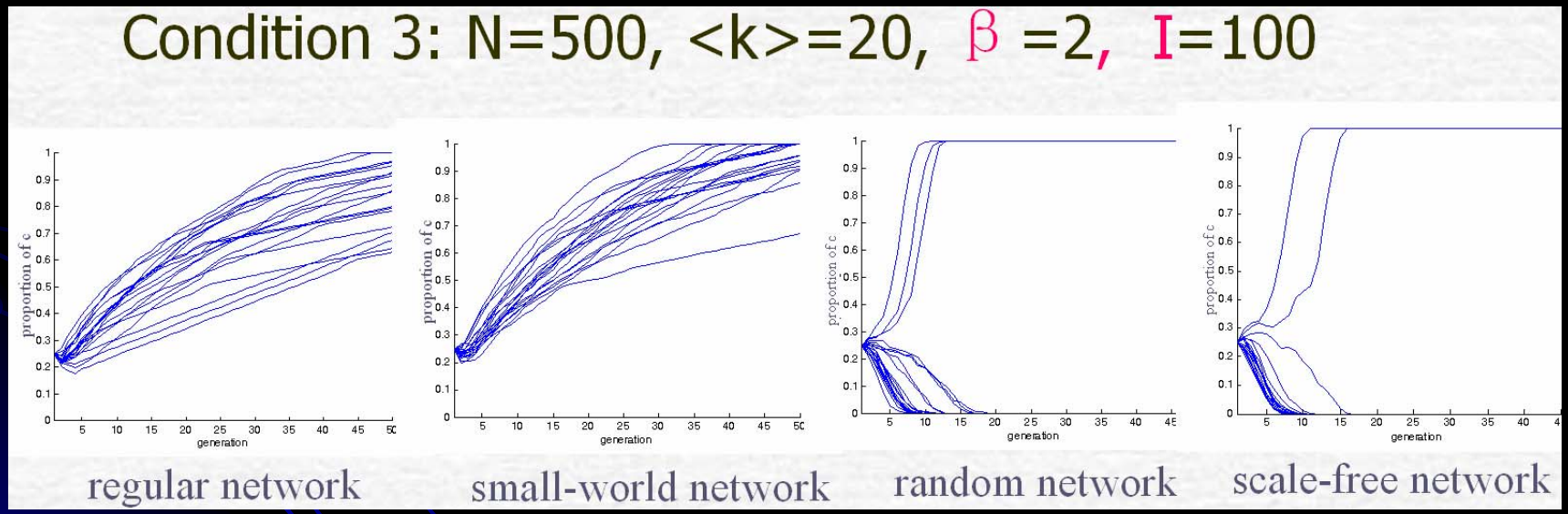
- To observe the diffusion of changes and solve the "threshold problem"
  - Need for extremely influential individuals
    - Can impose their choices to others, even at a distance
  - Functional bias?
    - Unless very high, seems less influent than *social selection*
- Larger populations → less communal changes

Beyond Nettle's original model

- ≠ social structures → ≠ dynamics

  no status here

(Ke, Gong & Wang, 2004)



Depending on the structure,

average diffusion time & proba successful diffusion ~ population size (or not)

Do these models solve all problems?

- Are hyper-influential individuals realistic?
  - Maybe but…basically influential enough to flip the whole community (no real diffusion)
  - Scaling problem?
- Functional bias
  - Without hyper-influential individuals, variants without bias in their favor do not spread
  - Especially variants with a negative bias never spread
- Meta-stable states?
  - Never observed in the simulations; either most of the population chooses *p*, either it chooses *q*

On-going attempts (1)
Refining the social structure

- Make the social structures more heterogeneous to observe meta-stable situations
- "Social clusters" in a modified small-world network
  - Each agent belong to a social "group"
  - Rewiring probability *Pr* + probability *Pc* that the rewiring takes place in the same social "group"

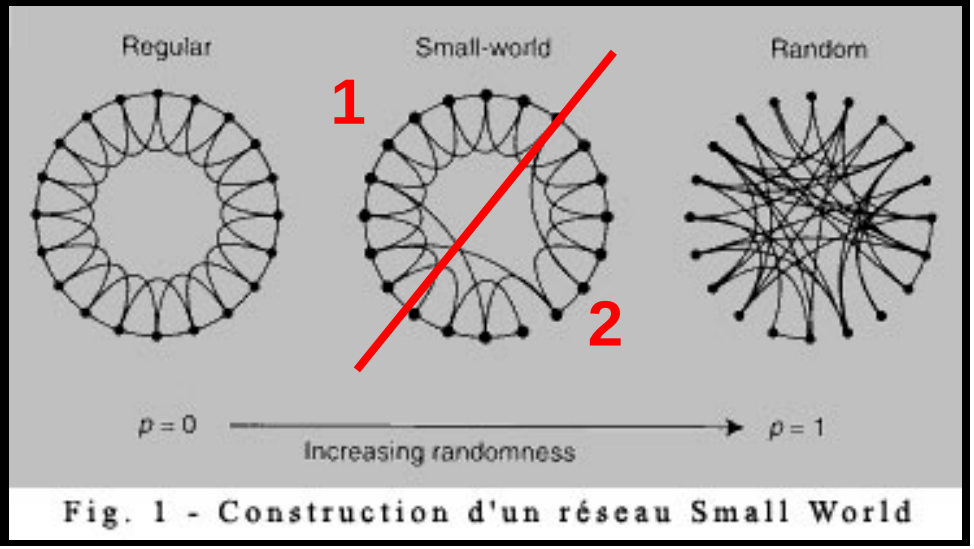
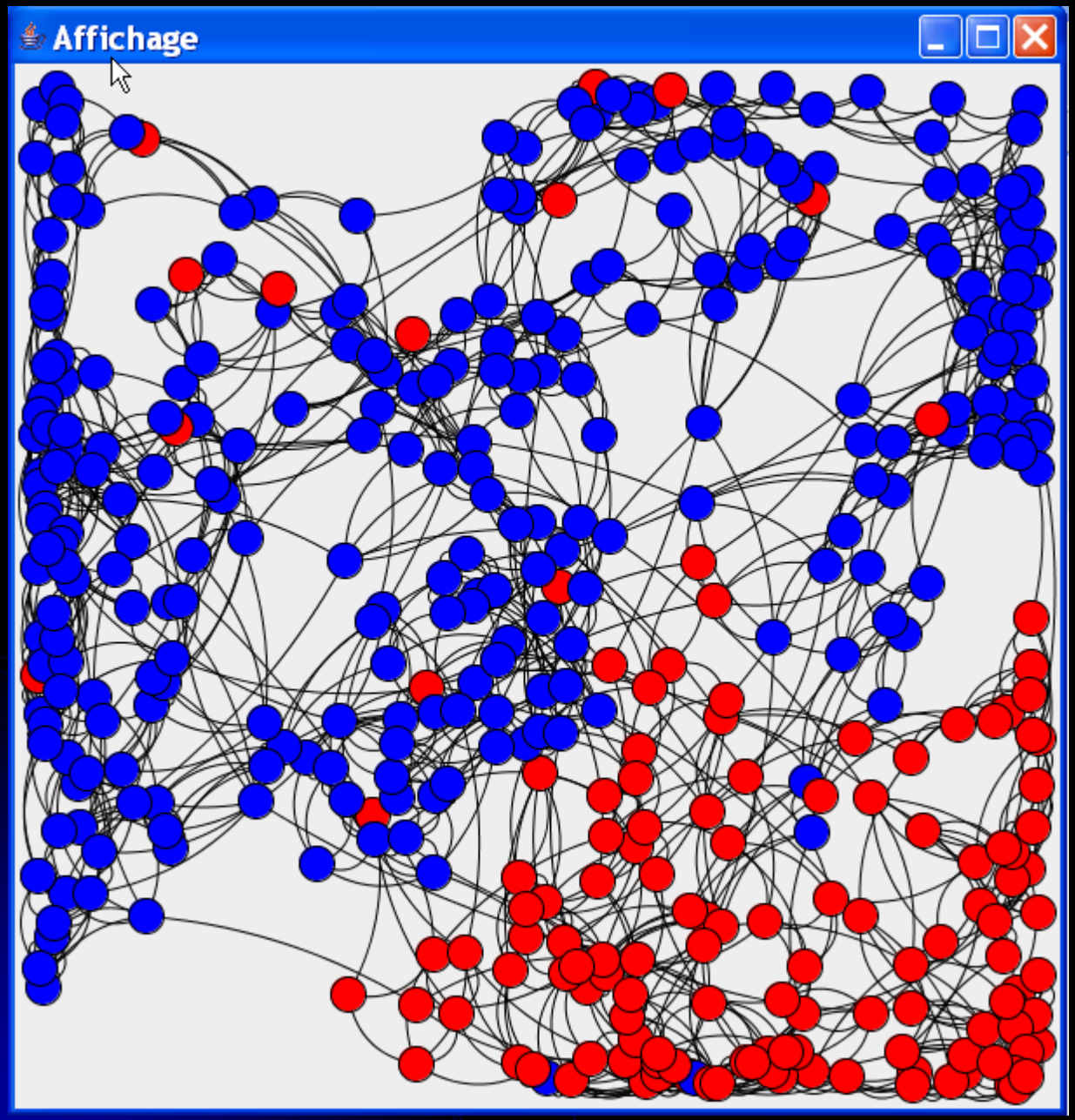


Fig. 1 - Construction d'un réseau Small World



An example of network with 4 social groups

Parameters:

N = 400, <k>=6

Pr = 0.1; Pc = .85

Here:

3 groups with the “BLUE” variant, 1 with the “BLUE” one

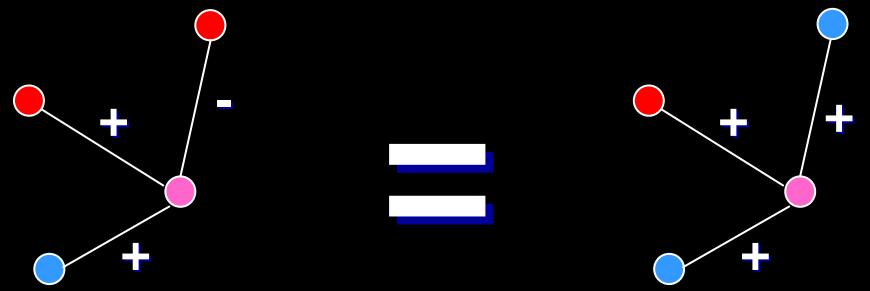
On-going attempts (2)
Introducing "repulsion"

- A suggestion
  - *"Anspach in The Why of Fashion (1967) argues that the initiating spark is the need of people to be like others and yet to be distinct from others."* [Labov, 2001, p.361]
  - "*To be distinct*" → <0 links between speakers

- Axelrod's model
  - Attraction (d<d0) or indifference (d>d0)
- For language
  - *Active* "attraction" & "repulsion"

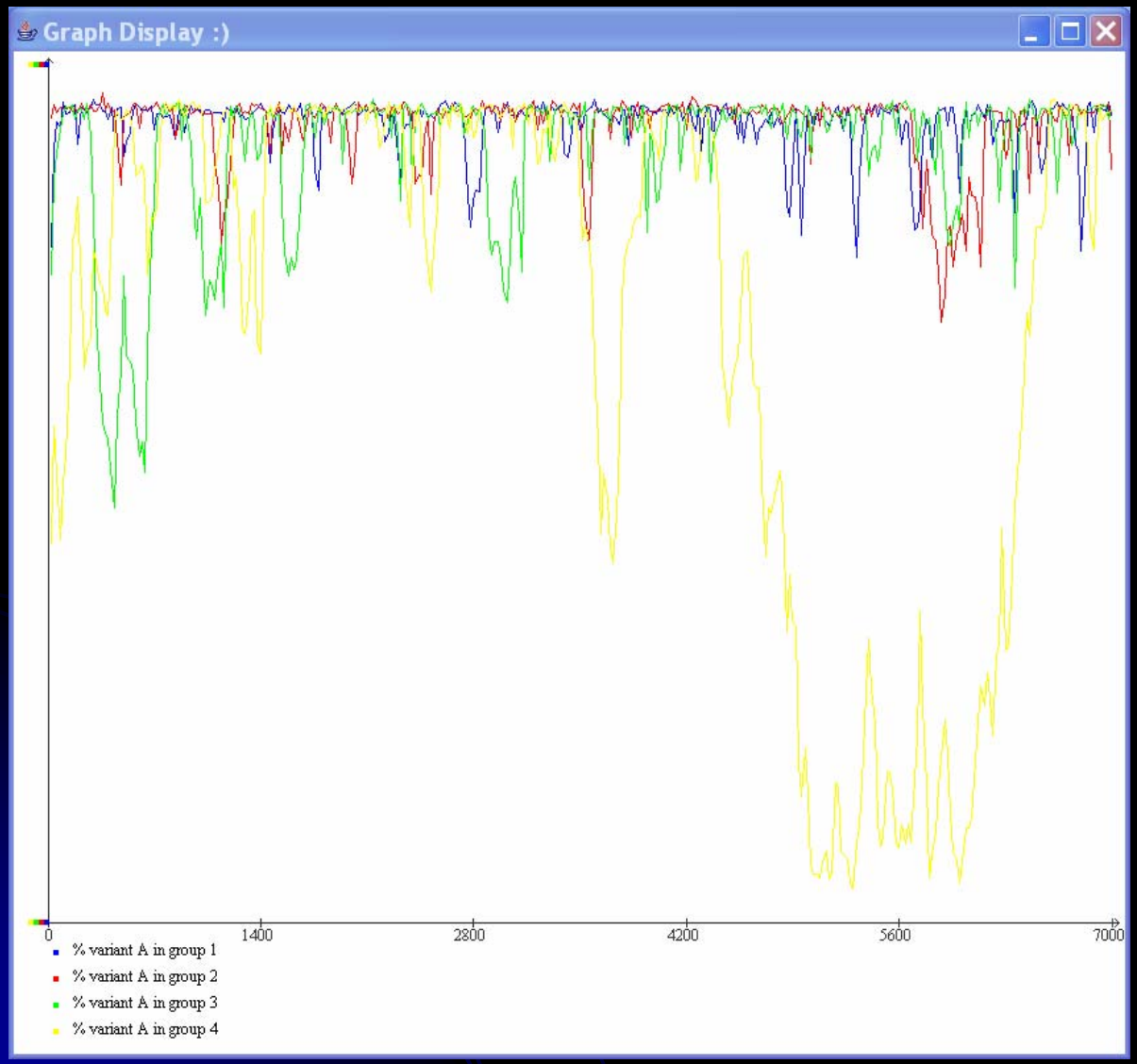
Introducing negative weights

- < 0 weights are hardly studied in network theory (?)
  - all measures (Cc, av. path lengths etc.) are based on >0 weights
  - very few guidelines + problem for analysis
- For each speaker:



- A preliminary attempt to introduce <0 links
  - Modify the previous algorithm with social groups
  - When rewiring toward another social group, probability Pn to introduce a <0 weight → inter-group repulsion & attraction

Observation of meta-stable states



No functional bias

No status, 4 groups

Pr=0.1, Pc=0.85, Pn=0.5

Punctuated equilibrium

Clustering & <0 weights: structure variations in patterns of punctuated equilibriums

Is it realistic?

Does it help for the threshold problem?

Diffusion of variants with <0 bias: not yet observed…

Conclusion & Perspectives

- Language change raises its own questions
  - Overlap with language emergence, but shift of focus
- Dynamical processes on social structures
  - How to structure the population to reproduce observed phenomena?
  - Richness of modeling choices (discrete vs. continuous, synchronous vs. asynchronous evolution, (un)directed graphs etc.) to deal with
- A dual reward
  - Some interesting questions to be addressed in linguistics
  - Some nice theoretical challenges for sociophysicists

Thank you for your kind attention

Acknowledgment:

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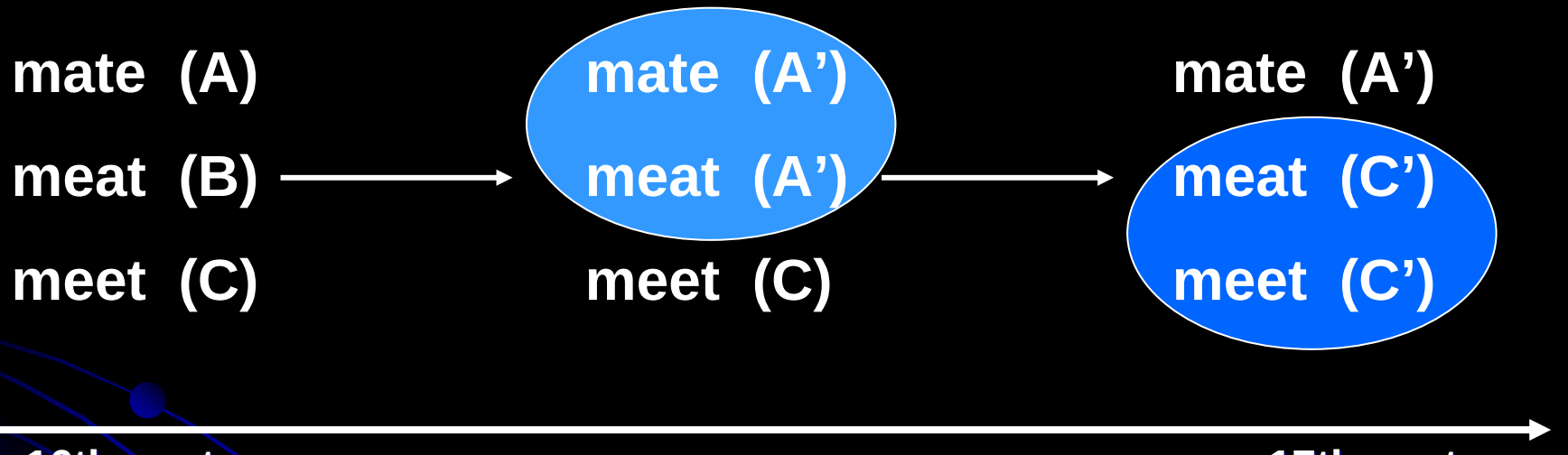
Problem n°2: Reversal of merge

Evolution of Middle English: **(Trask, 1986)**



Homophony

Why didn't (A') become (C') in *mate*??

Reversal of merge, theoretically impossible