A stochastic model of language change through prediction-driven instability

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Language variation

- Multiple ways to say the same thing
  Ex: Late Middle English

  (1) I know not the muffin man

  (2) I do not know the muffin man

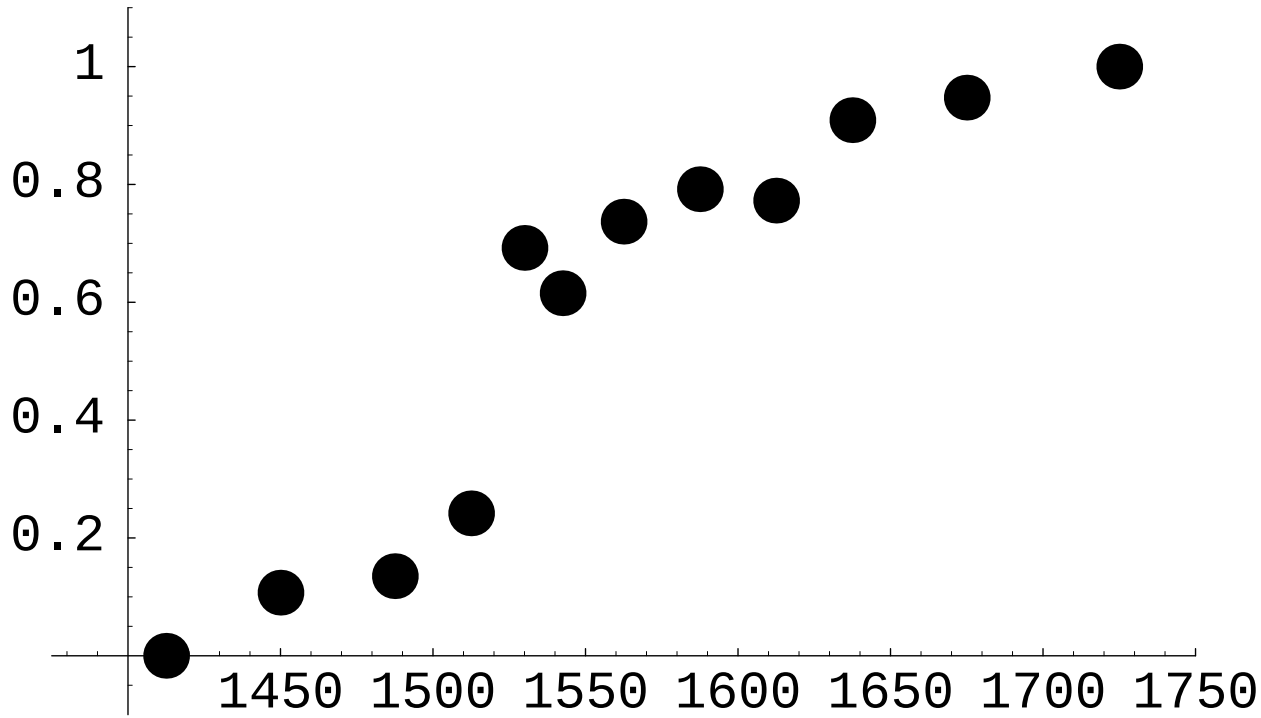
- Can be correlated to...
  - Location
  - Context
  - Gender
  - Attitude

Language change

Goal: Model spontaneous internally-driven language change

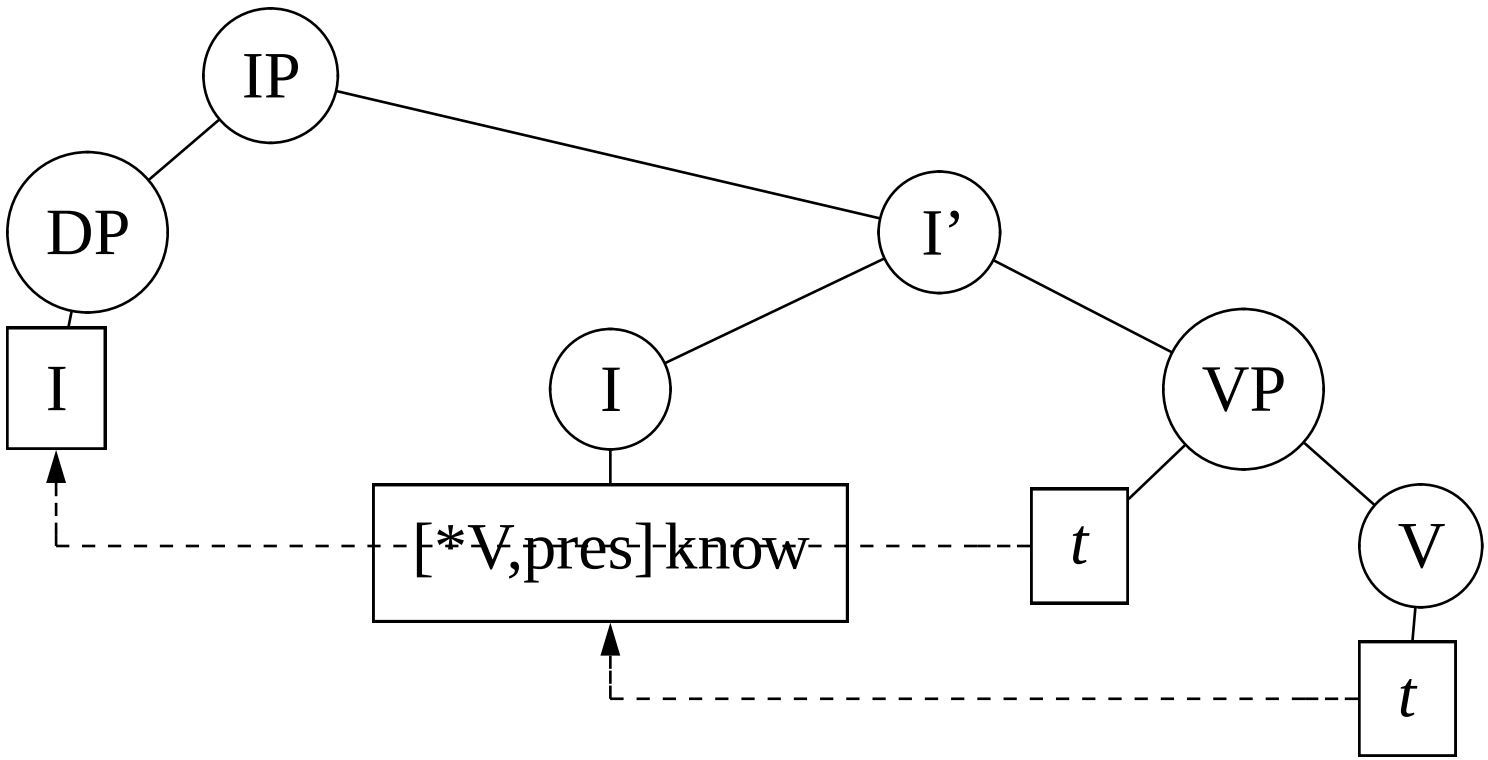
- Grows from variation
- Each speaker uses a mixture of old & new
- One variant replaces the other, mostly monotonically

Ex: *do*-support

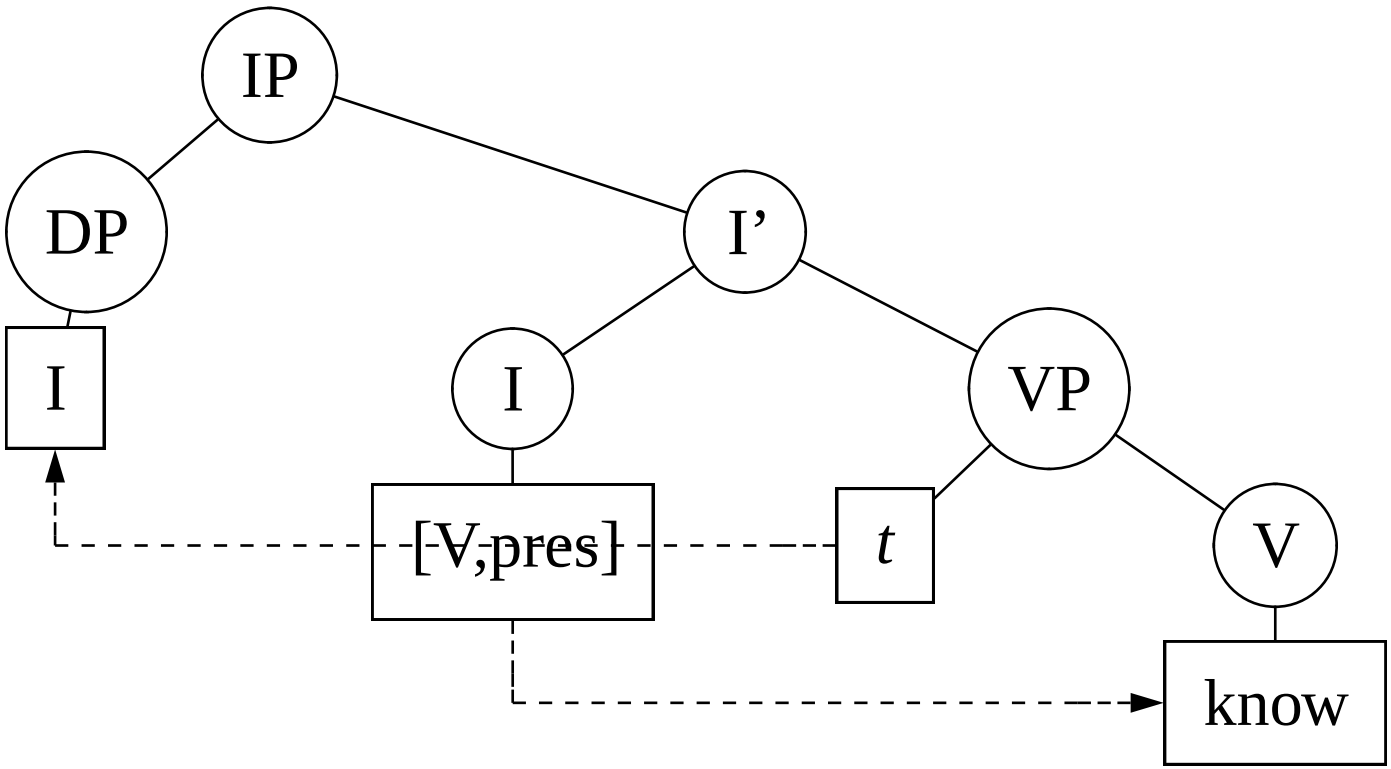


Transitive affirmative questions, fraction using *do* [Ellegård, 1953, Kroch, 1989, Warner, 2005]

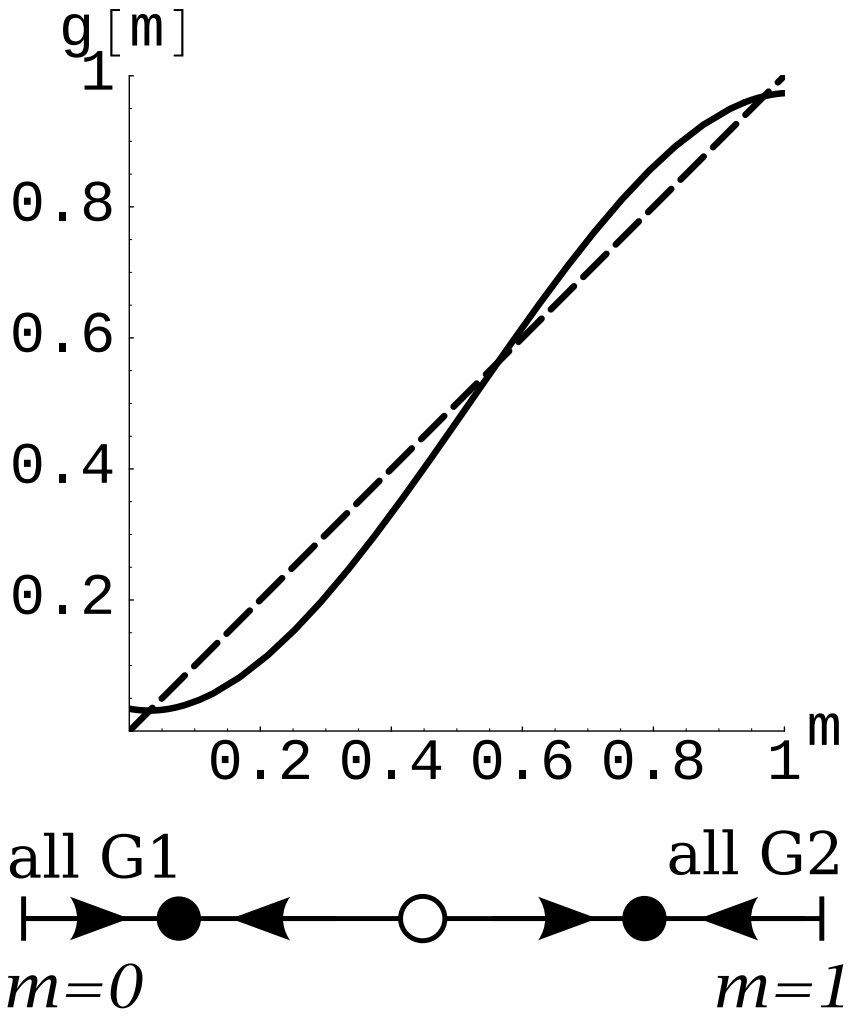
Verb raising



Affix hopping



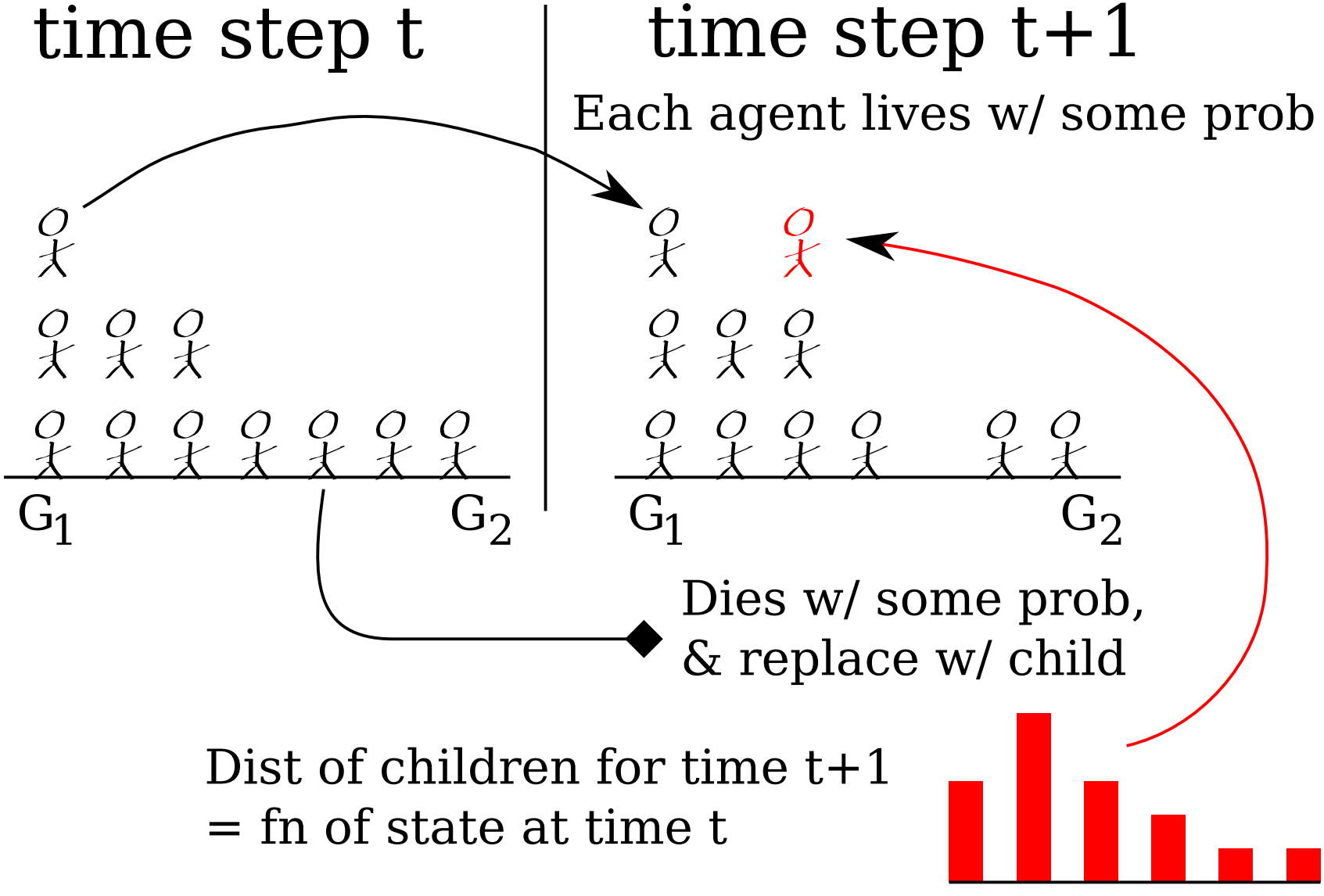
Mean field differential equation



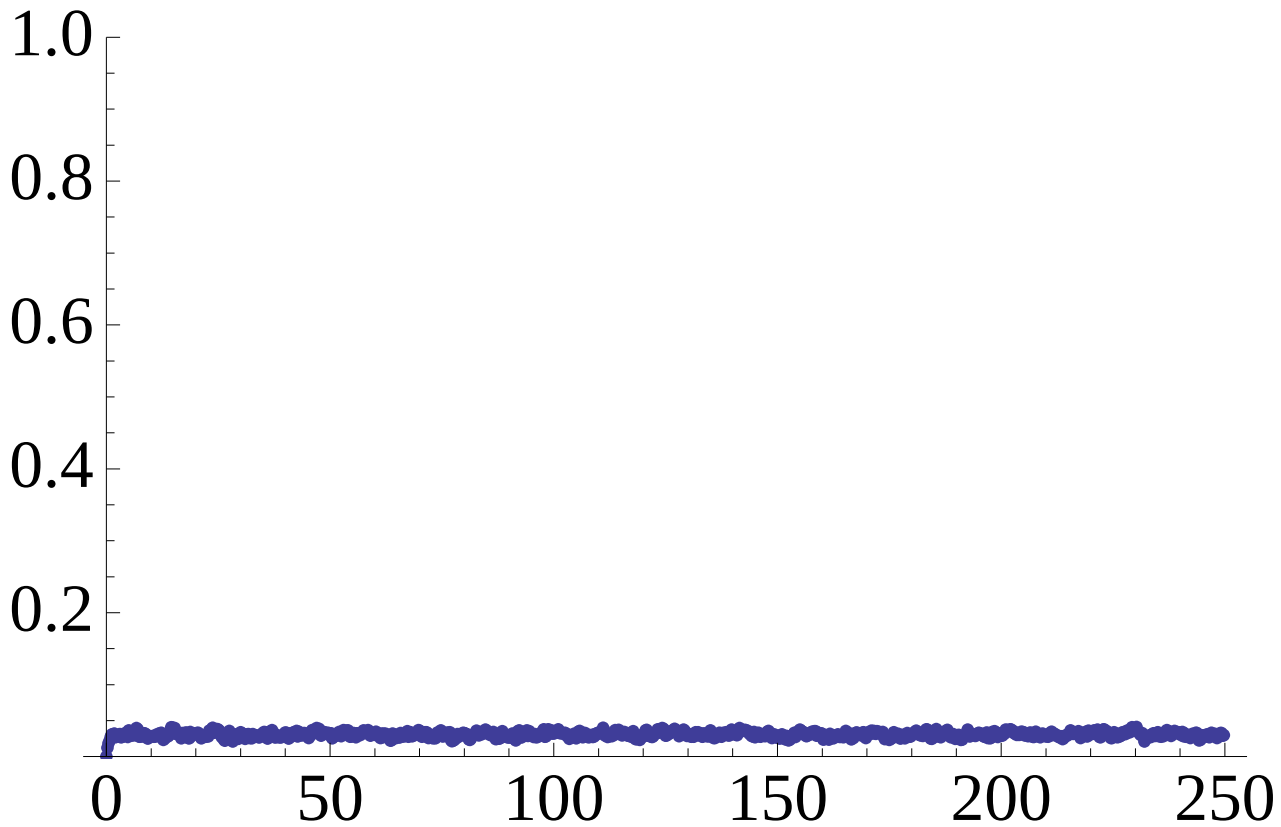
- One parameter $\Longrightarrow$ 2 grammars
  - G_1: param unset
  - G_2: param set
- $m =$ mean rate of G_2
- $g(m) =$ mean rate of children
- Birth/death process

$$\frac{dm}{dt} = g(m) - m$$

Unstructured Markov chain

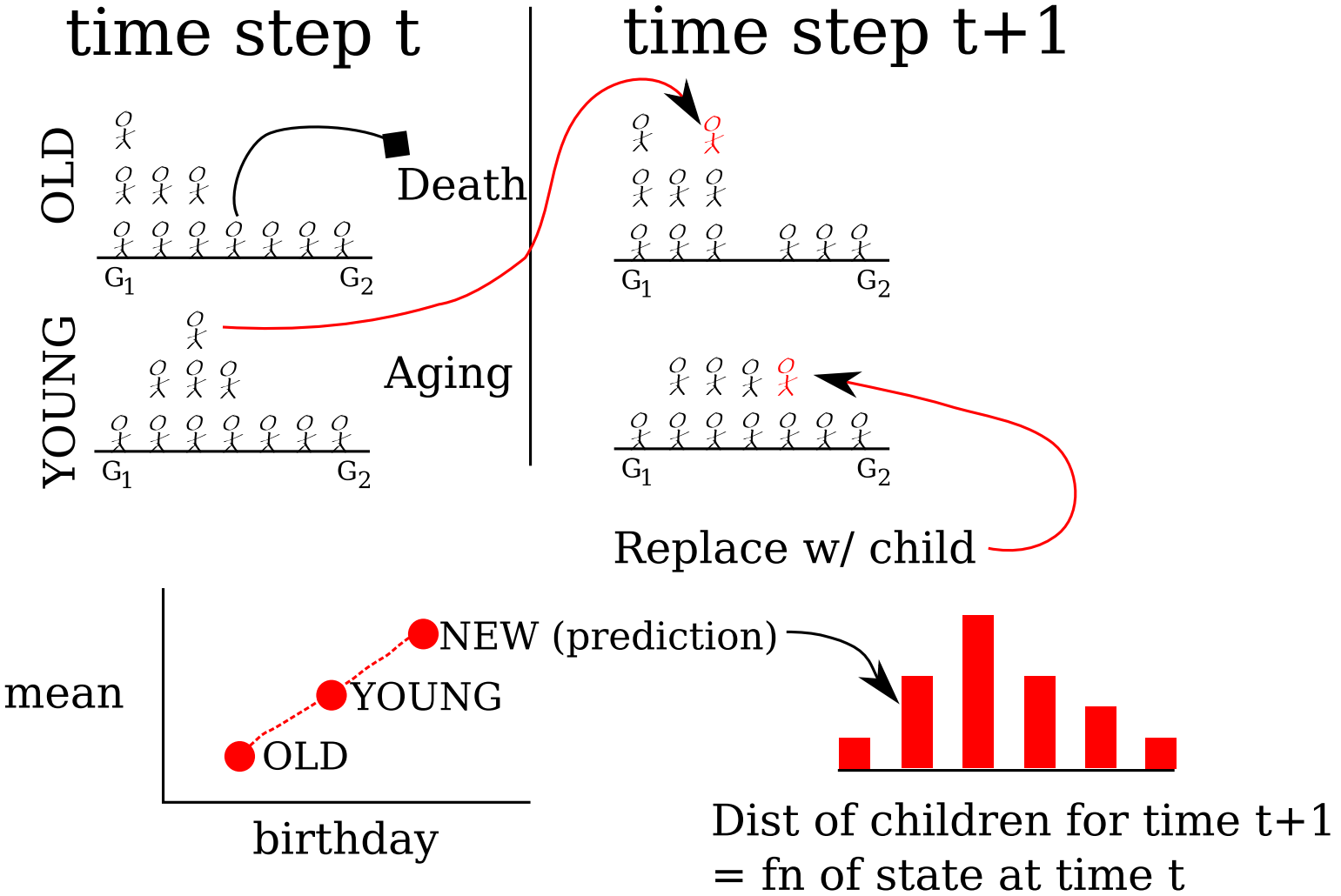


Time trace of one trajectory

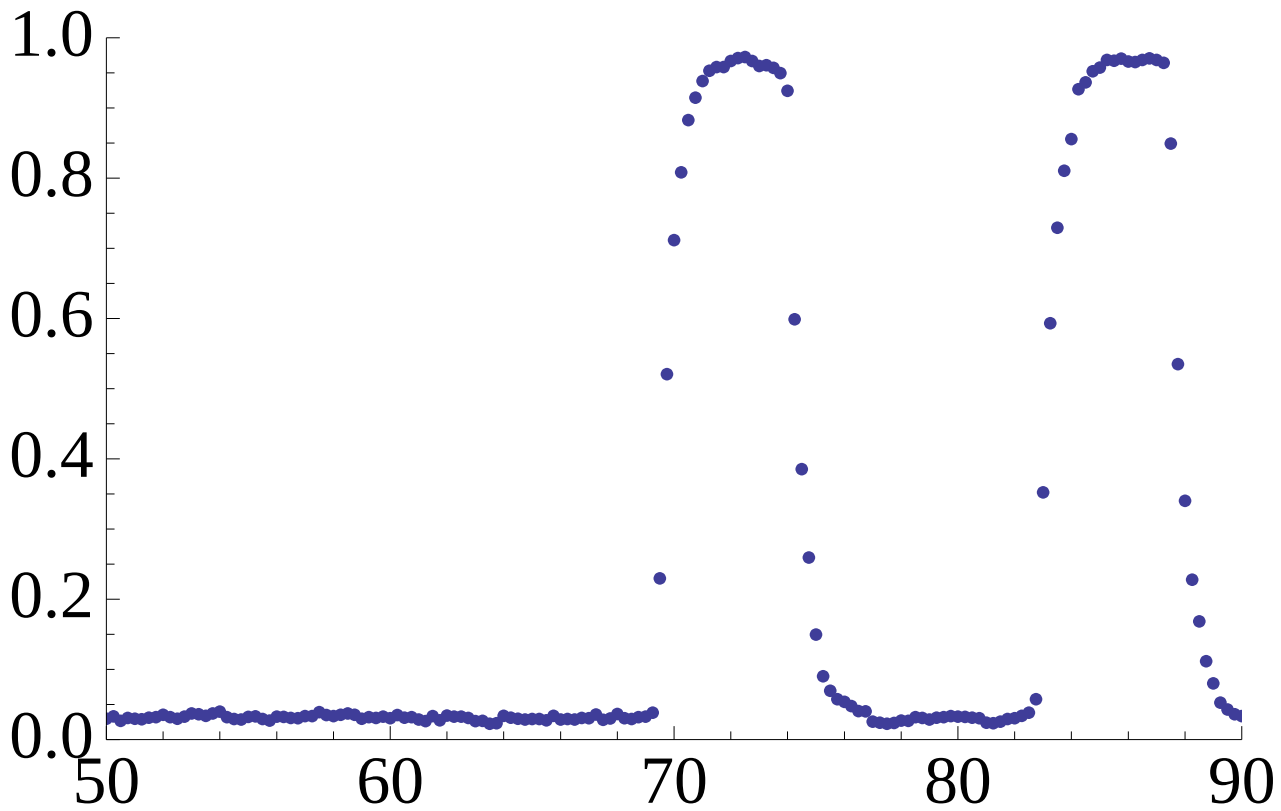


Mean usage rate of G_2 as a function of time

Age structured Markov chain: Incrementation

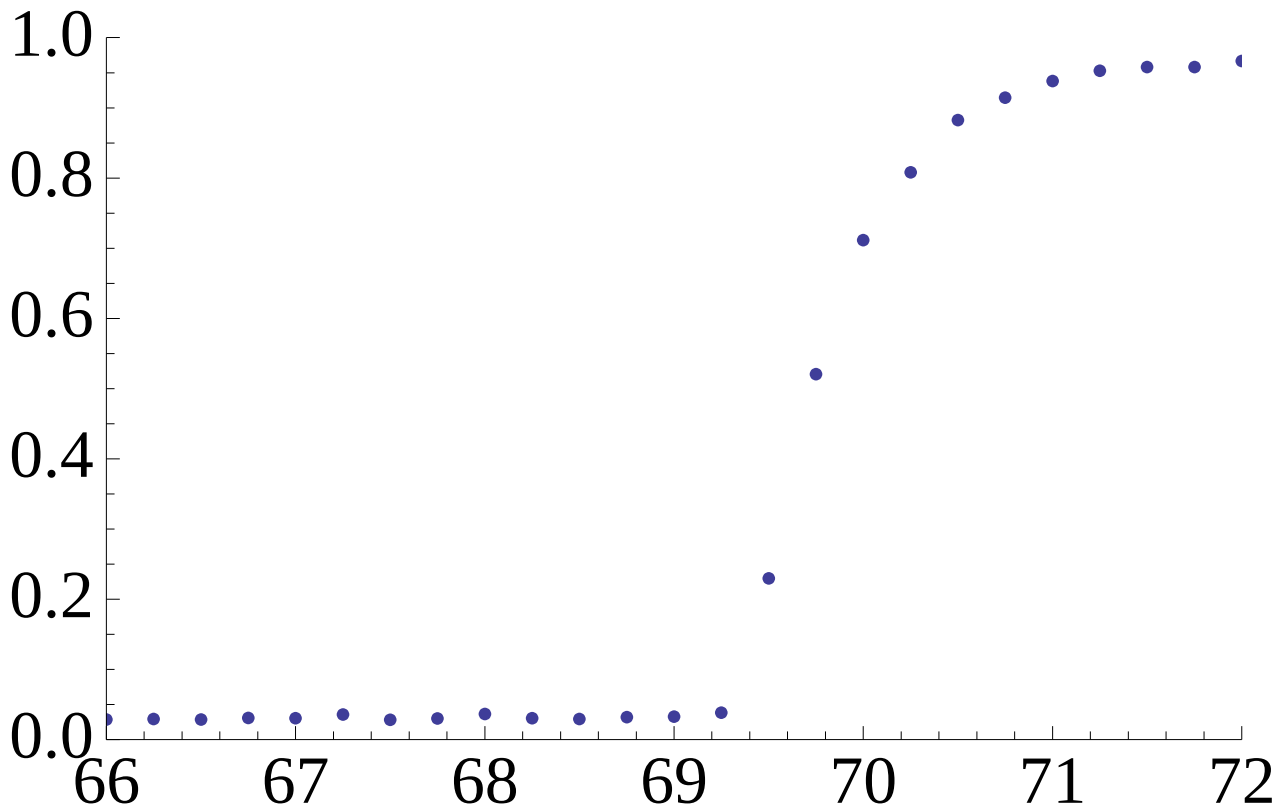


Time trace of one trajectory



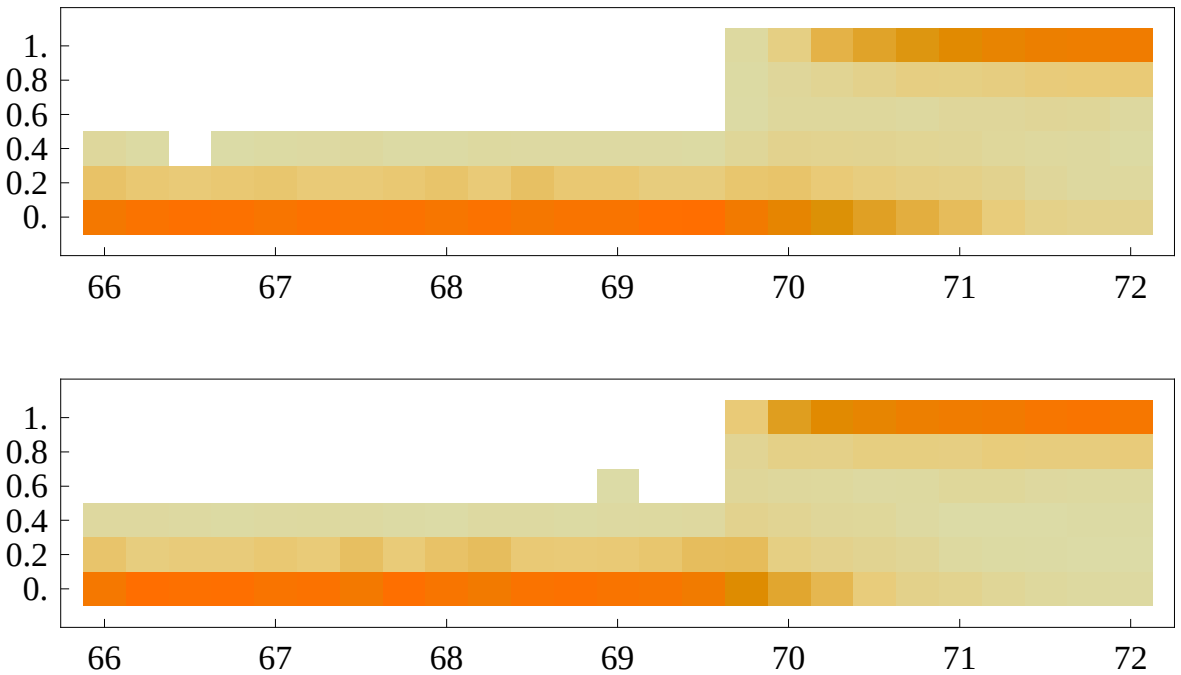
Mean usage rate of G_2 among young group as a function of time

Time trace of one trajectory: One transition



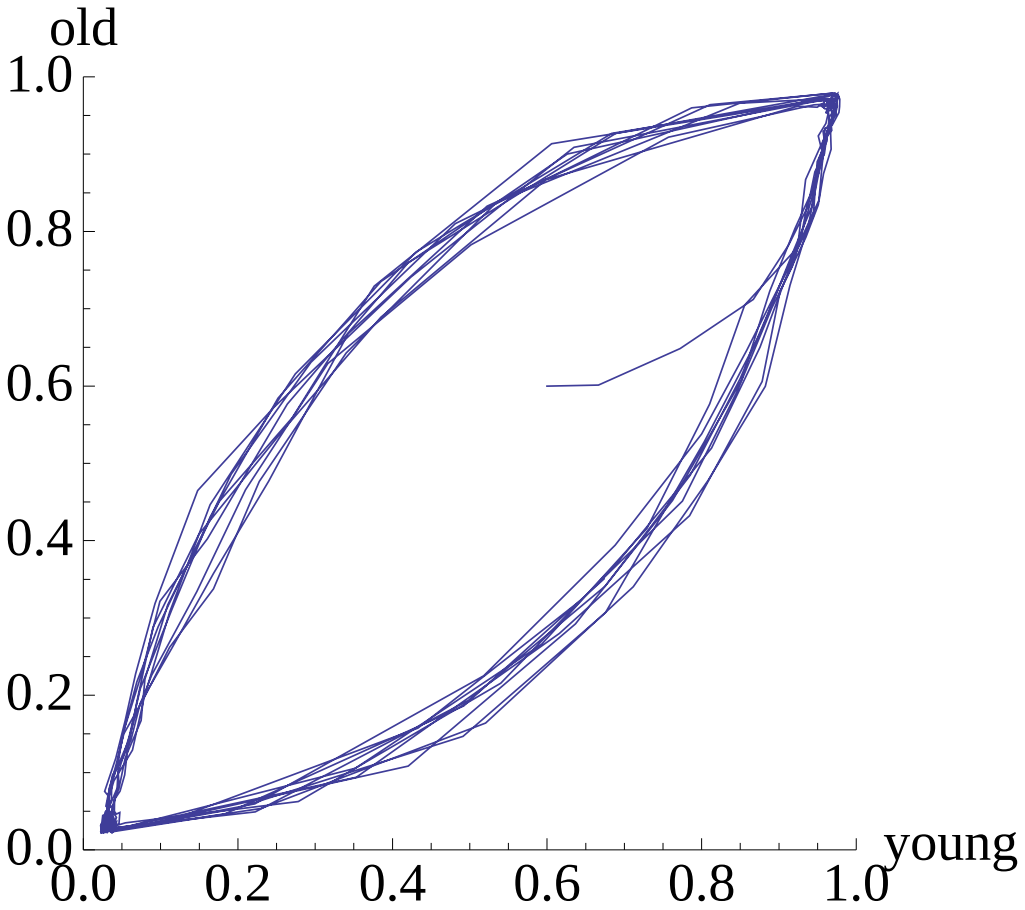
Mean usage rate of G_2 among young group as a function of time

Young distribution and old distribution

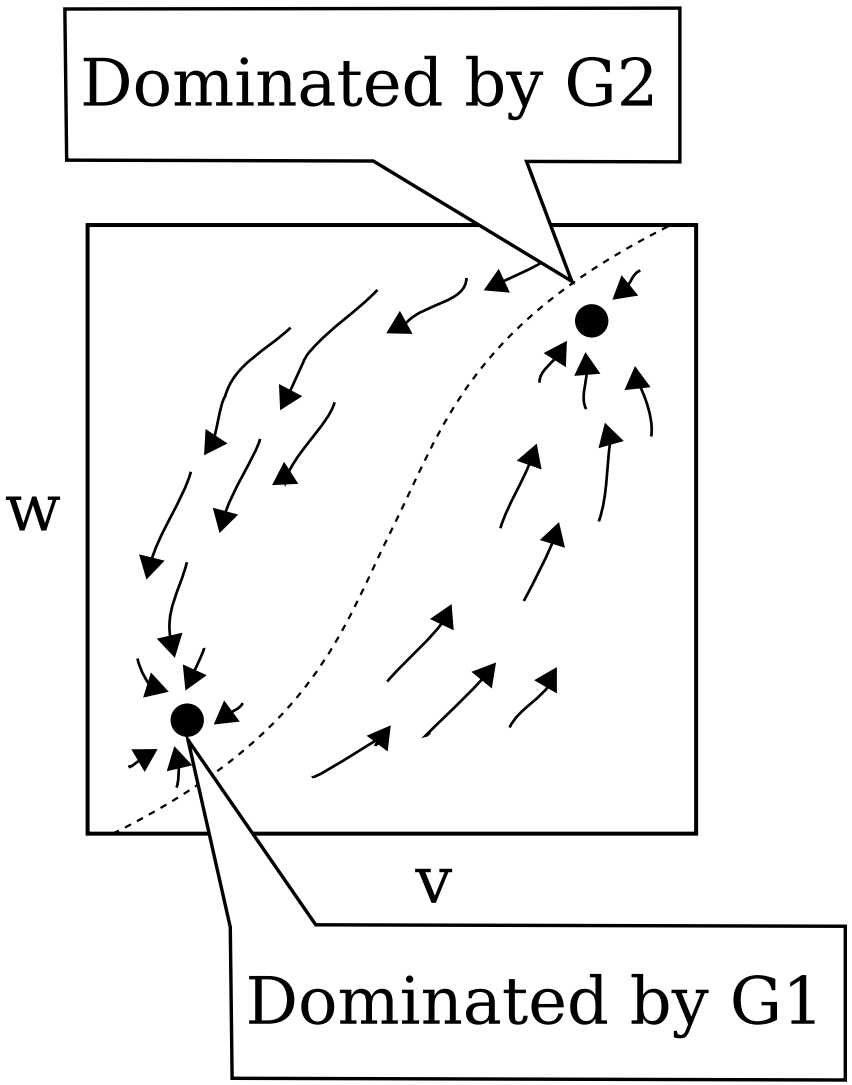


Number of people with usage rate z (vertical axes). Time increases left to right. Top: Old. Bottom: Young. Darker = more.

Old mean rate vs. young mean rate



Mean field differential equation w/ age structure

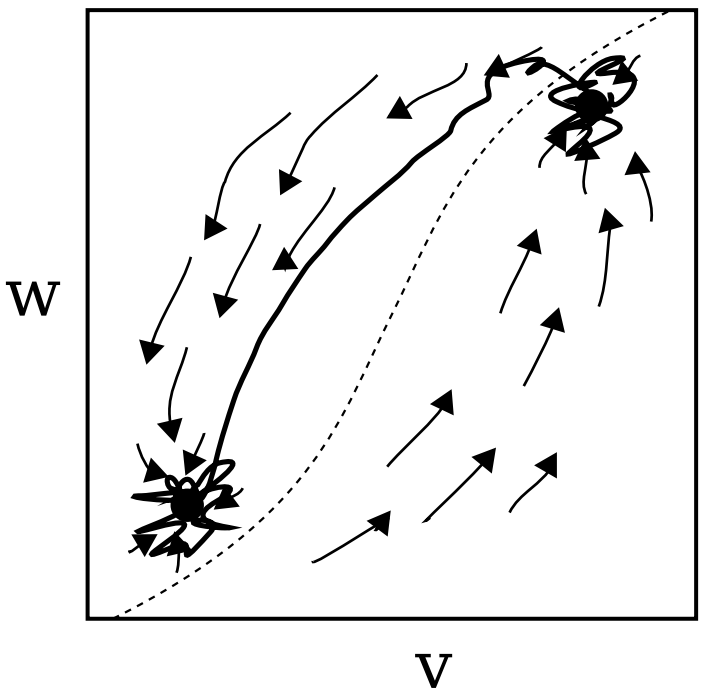


- v = mean usage rate of G_2 in the young group
- w = mean usage rate of G_2 in the old group
- Birth, learning, aging, death

$$\frac{dw}{dt} = v - w$$
$$\frac{dv}{dt} = g\big(r(v,w)\big) - v$$

- $r(v,w)$ = prediction

Mean field differential equation w/ age structure



- $v =$ mean usage rate of G_2 in the young group
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- Birth, learning, aging, death

$$\frac{dw}{dt} = v - w$$
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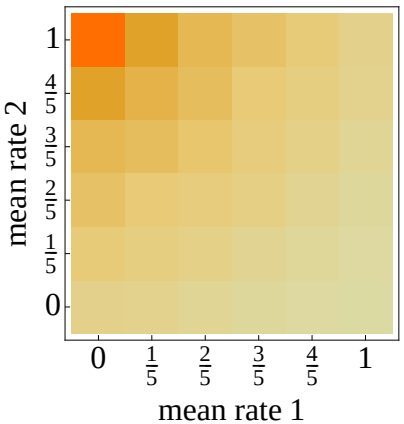
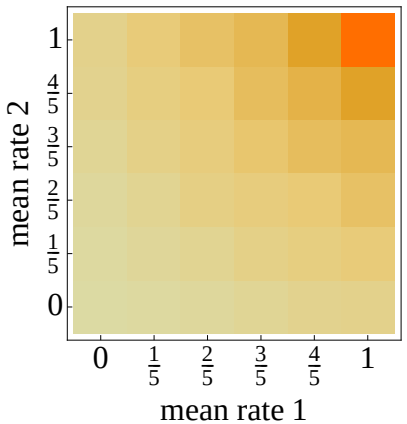
- $r(v,w) =$ prediction

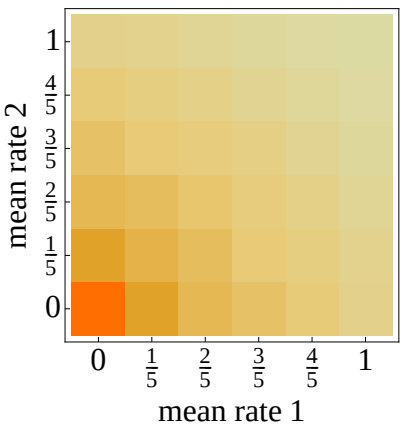
Learning two independent parameters

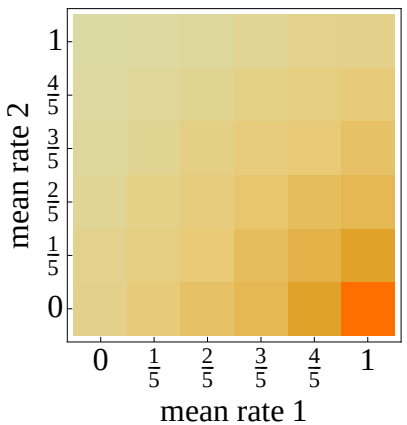
$m_2 = \frac{31}{32}$





$m_2 = \frac{1}{32}$

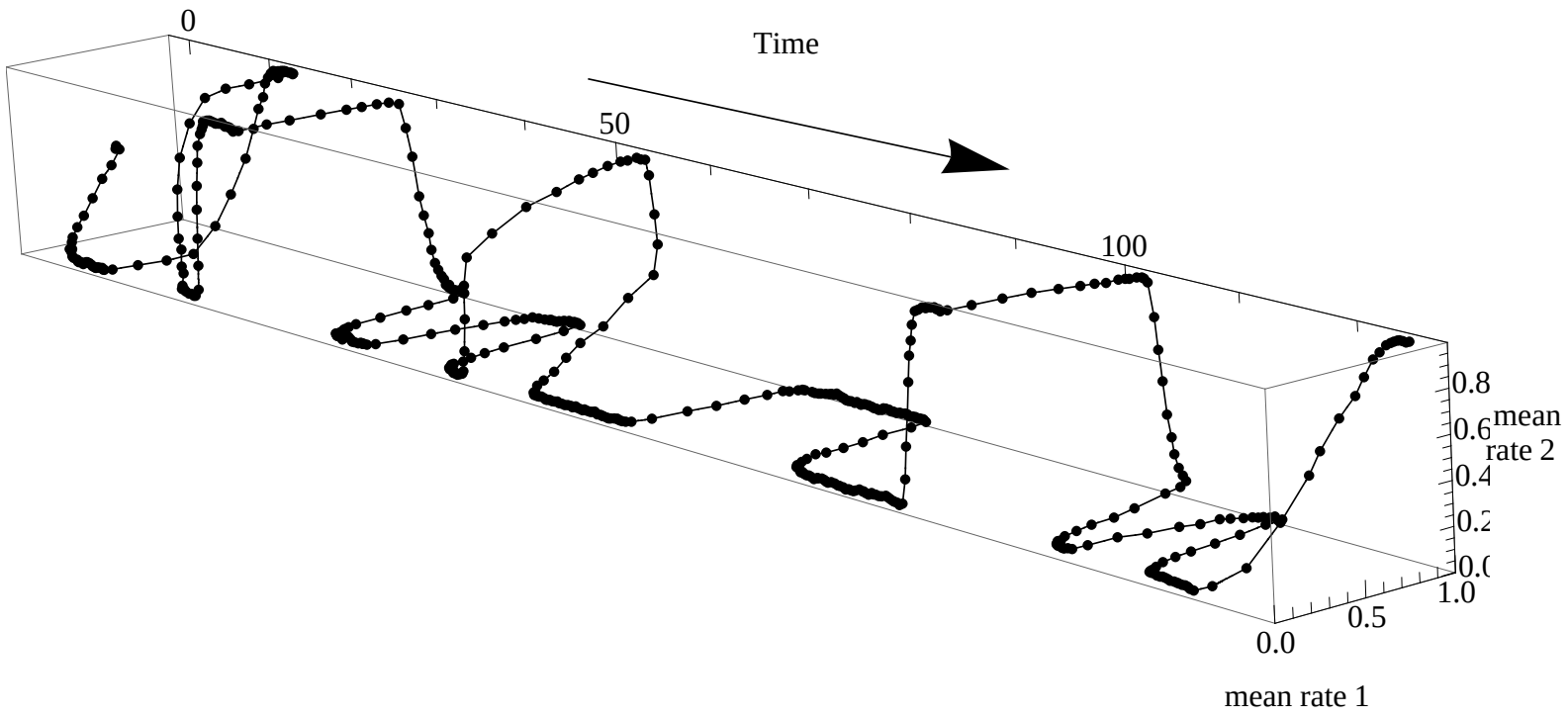




$m_1 = \frac{1}{32}$ $m_1 = \frac{31}{32}$

- Parameters 1 & 2
- Means m_1 & m_2
- Distribution of child speech = function of m_1 and m_2
- Darker = more

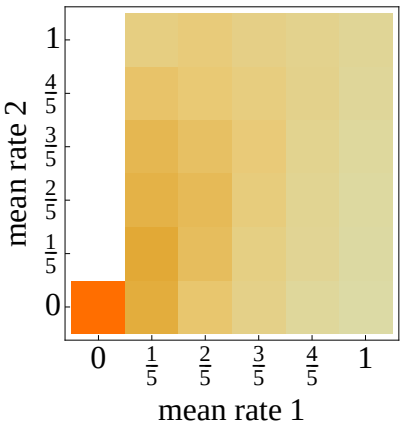
Two independent parameters: Time trace

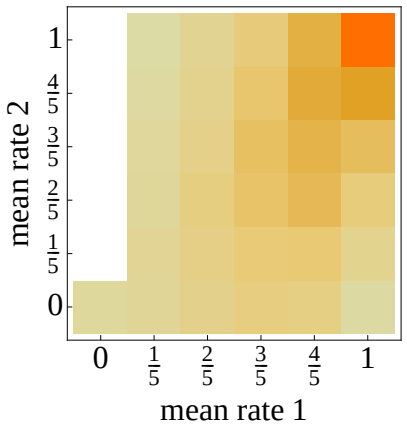


Mean usage rates among young group as a function of time

Learning two dependent parameters

$m_2 = \frac{31}{32}$





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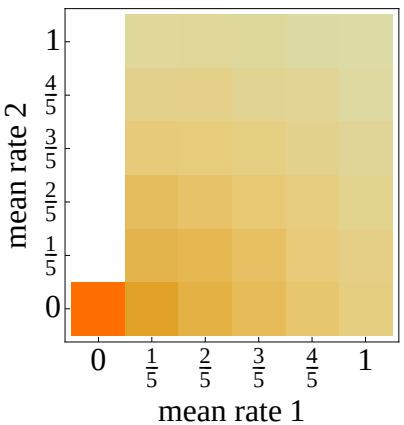
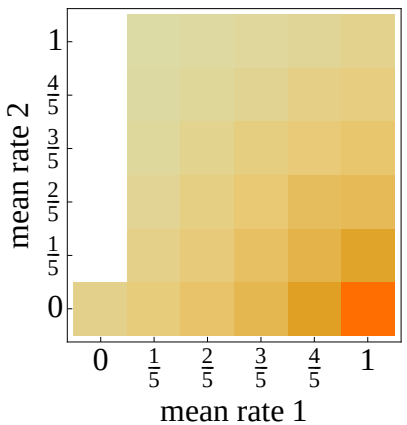
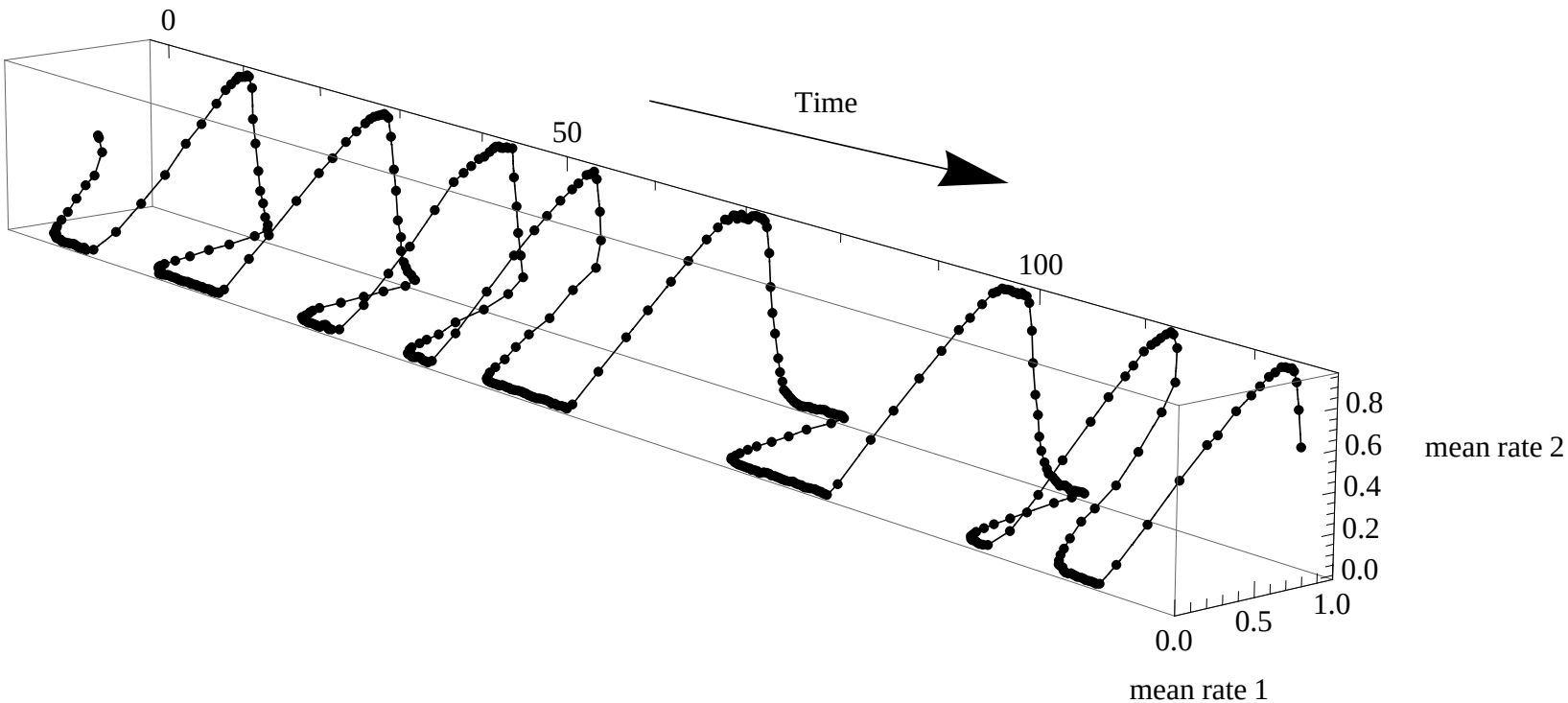




$m_1 = \frac{1}{32}$ $m_1 = \frac{31}{32}$

- Parameters 1 & 2
- Can only set 2 if 1 is set
- Means m_1 & m_2
- Distribution of child speech = function of m_1 and m_2
- Darker = more

Two dependent parameters: Time trace



Mean usage rates among young group as a function of time

Conclusion

- Model of variable speech — usage rates
- In unstructured population
  language doesn't change spontaneously
- In structured population
  language can change spontaneously
- Prediction-driven instability

Bibliography

Alvar Ellegård. *The Auxiliary do: The Establishment and Regulation of Its Use in English*. Gothenburg Studies in English. Almqvist and Wiksell, 1953.

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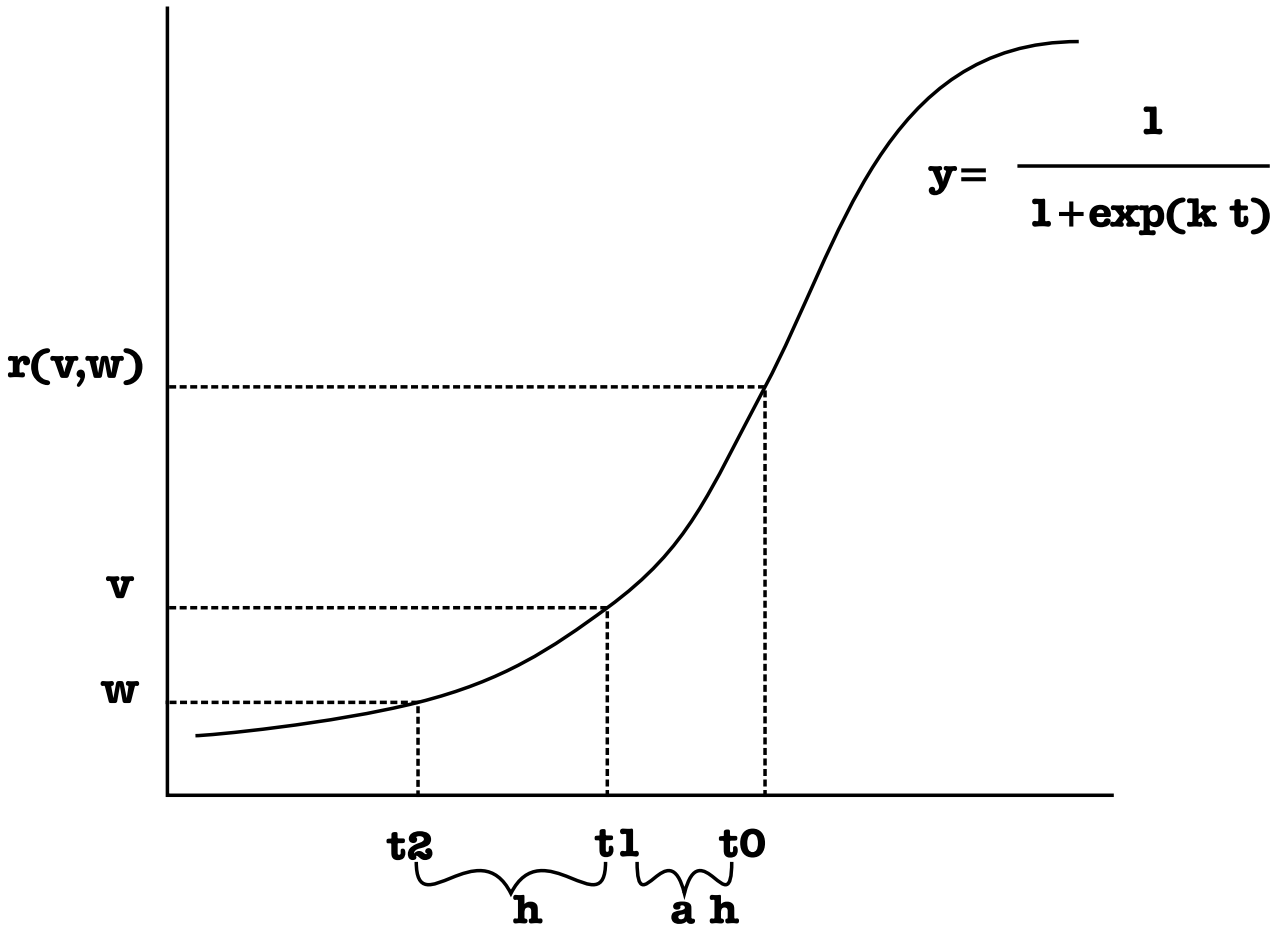
Prediction function



More *do*-support data