THE RISE OF THE GERMANIC WEAK SUFFIX AGAINST ALL ODDS

AN AGENT-BASED SIMULATION

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GERMANIC PAST TENSE INFLECTION

Strong inflection

- Vowel: *drive ~ drove*
  kijk ~ keek

- Oldest

- Indo-European aspect

- On the decline

Weak inflection

- Dental suffix: *kick ~ kick-ed*
  praat ~ praat-te

- Innovative

- Germanic

- On the rise

RESEARCH QUESTION

How could the weak inflection have grown to overthrow the strong inflection?

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How could the weak inflection have grown to overthrow the strong inflection, given that

i. The weak inflection had to start from a position vastly inferior in both type and token frequency

(↔ Hare and Elman 1995; Yang 2002)

ii. The strong inflection was still clearly regular?

(↔ Colaiori et al. 2015; Pijpops and Beuls 2015)

PROPOSALS

1. General applicability of the dental suffix

2. Restrictions on the strong system

3. Irregularization of the strong system

(Ball 1968: 164; Bailey 1997: 17)

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1. **General applicability of the dental suffix**

2. Restrictions on the strong system

3. Irregularization of the strong system

    ⇨ Irregularization may be result, rather than cause

OVERVIEW

- Simulation Design: what do we put in?
  - Conceptual level
  - Implementational level

- Results: what comes out?

- Conclusions

SIMULATION DESIGN: CONCEPTUAL LEVEL

- What do we put in?

PROPOSALS

1. **General applicability of the dental suffix**

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(Ball 1968: 164; Bailey 1997: 17)

SIMULATION DESIGN: CONCEPTUAL LEVEL

- What do we put in?

  - Single, generally applicable weak suffix vs. multiple strong classes

  - No restrictions on the strong system: each verb can be conjugated strongly

  - No irregular verbs, no ways to become irregular

  - Weak suffix starts inferior in type and token frequency to any individual ablaut class

  - Verbs show a realistic (Zipfian) frequency distribution

  - Agents are gradually replaced

SIMULATION DESIGN: CONCEPTUAL LEVEL

- Any other possible advantages for the weak inflection

⇨ Agents will never forget strong forms (↔ Taatgen and Anderson 2002: 124)

⇨ No advantage of linear segmentibility: Hearers recognize

    – *vraag-de* 'asked'

    – *vr-ie-g*   'asked'

⇨ Abstract away from language acquisition

⇨ No social structure or social preference

SIMULATION DESIGN: CONCEPTUAL LEVEL

- **Keep It Simple Stupid**   (Landsbergen 2009: 18-19)

  – Only finite past tenses

  – No influence of phonetic resemblance

SIMULATION DESIGN: CONCEPTUAL LEVEL

- Evaluation criteria

    1. Rise of the Weak Inflection   (Carroll et al. 2012; Cuskley et al. 2014)

    2. Gradual Rise   (Cuskley et al. 2014)

    3. Conserving Effect   (Bybee 2006: 715; Lieberman et al. 2007)

    4. Class Resilience   (Mailhammer 2007; Carroll et al. 2012: 163-164)

⇨ Emergence should not be dependent on specific parameter settings

⇨ Define AND delimit

SIMULATION DESIGN: IMPLEMENTATIONAL LEVEL

- Strong vowel alternations: extracted from Corpus of Spoken Dutch

  - I   ij → ee   krijg → kreeg
  - II-a   ie → oo   vlieg → vloog
  - II-b   ui → oo   kruip → kroop
  - III-a   i → o   vind → vond
  - III-b   e → o   trek → trok
  - III-c   e → ie   sterf → stierf
  - IV/V-a   ee → a   geef → gaf
  - V-b   i → a   zit → zat
  - VI   aa → oe   draag → droeg
  - VII-a   aa → ie   laat → liet
  - VII-b   a → i   hang → hing

SIMULATION DESIGN: IMPLEMENTATIONAL LEVEL

- Verbs: extracted from Corpus of Spoken Dutch

  (all can be conjugated strongly, no irregulars, realistic frequency distribution)

  - vinden 1518
  - zitten   1157
  - krijgen 359
  - liggen   208
  - …
  - stinken 11
  - dragen 11
  - eten   10
  - …
  - bidden 1

World

Events	Chance of occurrence
vinden	34%
zitten	26%
…	…
stinken	0.2%
dragen	0.2%
…	…
bidden	0.02%

→ dragen →

Speaker

Lexicon		
vinden	vond	526
zitten	zat	201
…		
dragen	droeg	9
	draagde	1

'droeg'   90%
'draagde'   10%

→

World

Events	Chance of occurrence
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…	…
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dragen →

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…		
dragen	droeg	**9**
	draagde	**1**

'droeg'   **90%**
'draagde' **10%**

→

Hearer

'droeg' → 'droeg' +1

aa → oe +1

19

World

Events	Chance of occurrence
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dragen →

Speaker

Lexicon

vinden	vond	526
zitten	zat	201
…		

Not found ↓

Grammar

I	ij → ee	250
II-a	ie → oo	100
…		
VI	aa → oe	110
VII-a	aa → ie	60
…		
weak	+de/+te	30

'droeg'	55%
'drieg'	30%
'draagde'	15%

'droeg' →

Hearer

'droeg' +1

aa → oe +1

Grammar implemented using Fluid Construction Grammar, see Steels (2011) and van Trijp et al. (2012)

20

World

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dragen →

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Lexicon		
vinden	vond	526
zitten	zat	201
…		

Not found

Grammar		
I	ij → ee	250
II-a	ie → oo	100
…		

Not found

Nothing happens:
Communication fails

Hearer

'…' → '…'

… → …

World

Events	Chance of occurrence
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…	…
stinken	0.2%
dragen	0.2%
…	…
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Speaker

Lexicon

Not found

Grammar

Not found

Nothing happens:
Communication fails

Hearer

'…' → '…'

… → …

22
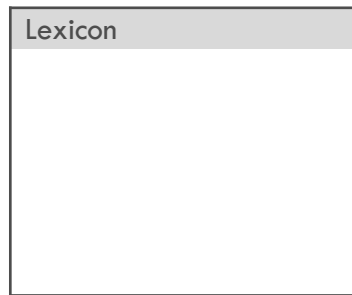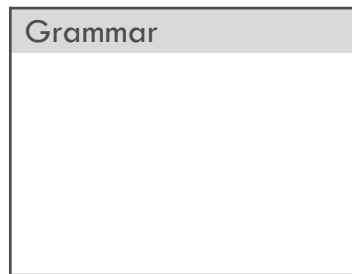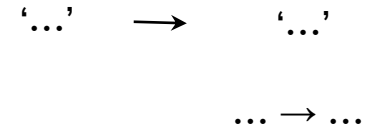
LET'S RUN A SIMULATION!

- Starting situation: only strong classes

  – All starting agents know perfectly how to conjugate each verb

  – Have access to all strong classes

Lexicon		
vinden	vond	1518
zitten	zat	1157
…		
dragen	droeg	11
…		
bidden	bad	1

Grammar		
I	ij → ee	879
II-a	ie → oo	43
II-b	ui → oo	32
III-a	i → o	1633
III-b	e → o	33
VI/V-a	ee → a	239
Vb	i → a	1366
VI	aa →oe	185
VII-a	aa → ie	65
VII-b	a → I	34

World

Speaker

Events	Chance of occurrence
vinden	34%
zitten	26%
…	…
stinken	0.2%
dragen	0.2%
…	…
bidden	0.02%

Lexicon		
vinden	vond	1518
zitten	zat	1157
…		
trekken	trok	23
…		
sterven	stierf	10
…		

"…" → ".." +1

… → … +1

Not found ↓

Grammar		
I	ij → ee	879
II-a	ie → oo	43
II-b	ui → oo	32
III-a	i → o	1633
III-b	e → o	33
III-c	e → ie	10
VI/V-a	ee → a	239
Vb	i → a	1366
VI	aa → oe	185
VII-a	aa → ie	65
VII-b	a → I	34

Not found ↓

Nothing happens:
Communication fails

World

Events	Chance of occurrence
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Not found ↓

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Vb	i → a	1366
VI	aa → oe	185
VII-a	aa → ie	65
VII-b	a → i	34

Not found ↓

Nothing happens:
Communication fails

Hearer

"…" → ".." +1

… → … +1

RESULTS: COMPETING STRONG CLASSES
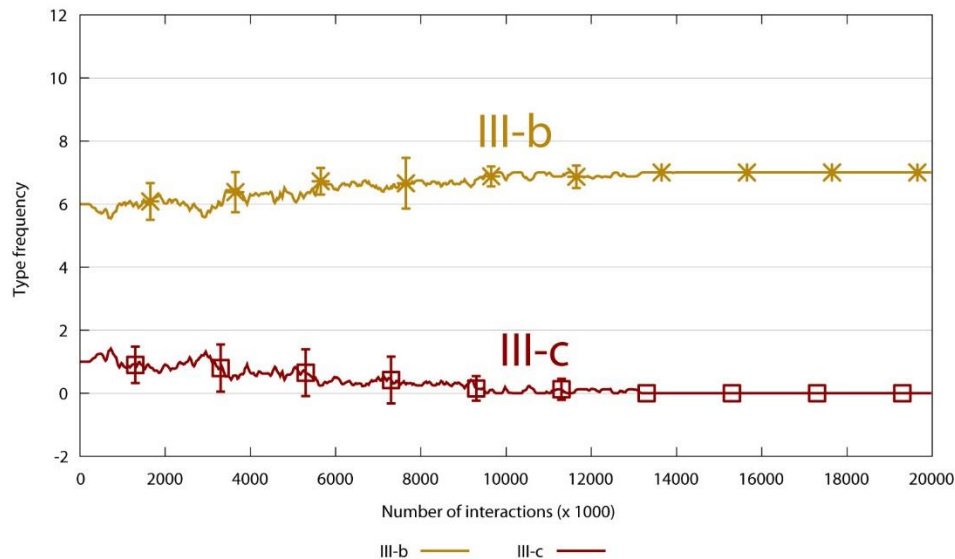
- Either both competing classes hold each other in balance

- Or the initially most frequent one prevails

RESULTS: BRING IN THE WEAK INFLECTION

Starting position of the weak inflection

- ~~Preterito-presentia~~ (Bailey 1997: 578)

- Take the starting position of the feeblest strong class, i.e. III-c (*e* → *ie*)

  - Inferior in type & token frequency to any other class

  - Direct competition with more frequent III-b class (*e* → *o*)

  - Went extinct in the previous simulation

World

Events	Chance of occurrence
vinden	34%
zitten	26%
…	…
stinken	0.2%
dragen	0.2%
…	…
bidden	0.02%

Speaker

Lexicon		
vinden	vond	1518
zitten	zat	1157
…		
trekken	trok	23
…		
sterven	**stierf**	**10**
…		

Not found ↓

Grammar		
I	ij → ee	879
II-a	ie → oo	43
II-b	ui → oo	32
III-a	i → o	1633
III-b	e → o	33
III-c	**e → ie**	**10**
VI/V-a	ee → a	239
Vb	i → a	1366
VI	aa → oe	185
VII-a	aa → ie	65
VII-b	a → I	34

Not found ↓

Nothing happens:
Communication fails

Hearer

"…"

"…" → "..." +1

… → … +1

World

Events	Chance of occurrence
vinden	34%
zitten	26%
…	…
stinken	0.2%
dragen	0.2%
…	…
bidden	0.02%

Speaker

Lexicon		
vinden	vond	1518
zitten	zat	1157
…		
trekken	trok	23
…		
sterven	**sterfde**	**10**
…		

Not found ↓

Grammar		
I	ij → ee	879
II-a	ie → oo	43
II-b	ui → oo	32
III-a	i → o	1633
III-b	e → o	33
weak	**+de/te**	**10**
VI/V-a	ee → a	239
Vb	i → a	1366
VI	aa → oe	185
VII-a	aa → ie	65
VII-b	a → I	34

Not found ↓

Nothing happens:
Communication fails

Hearer

"…" → ".." +1

… → … +1

Only difference with the III-c class is that the weak suffix can in principle be applied to all verbs

- Token frequency
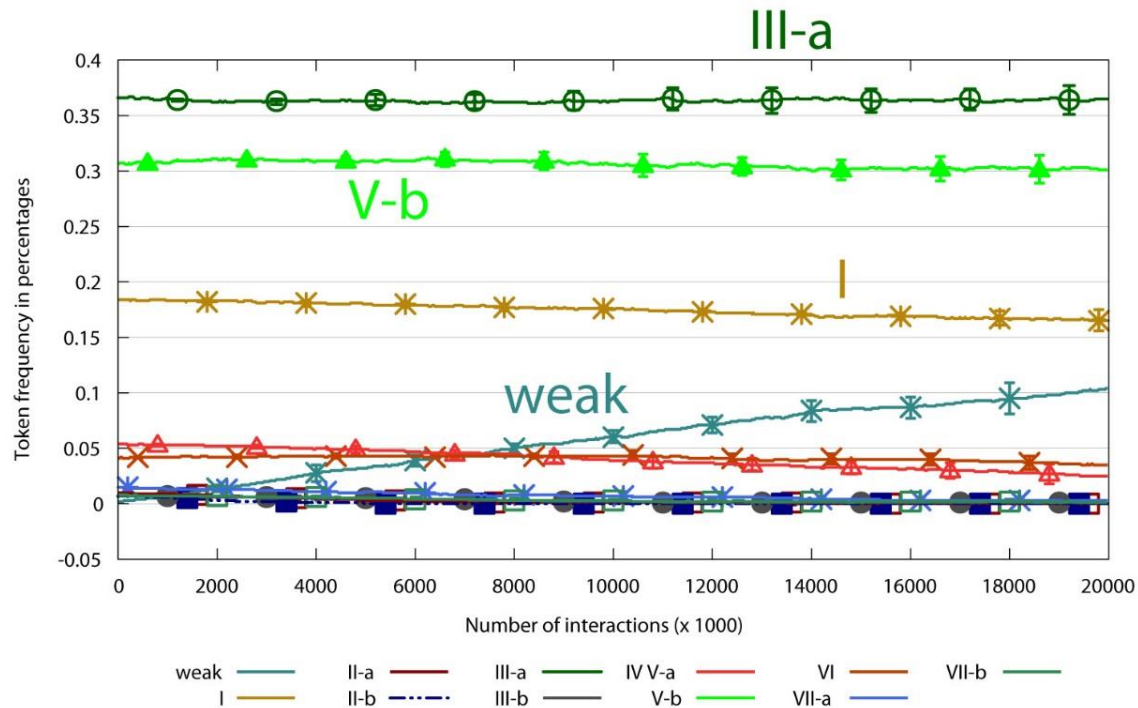
- Type frequency

1. Rise of the Weak Inflection
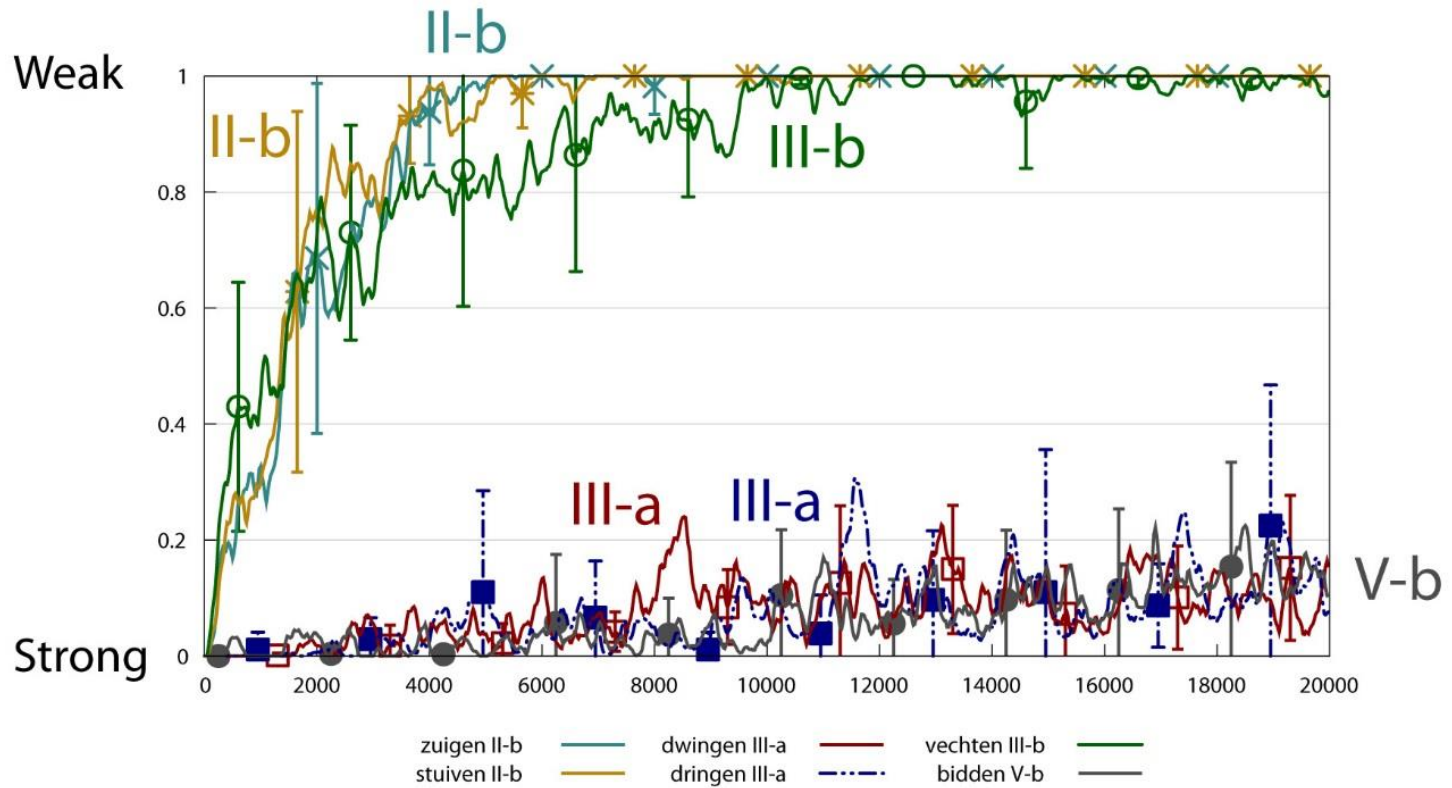
2. Gradual Rise
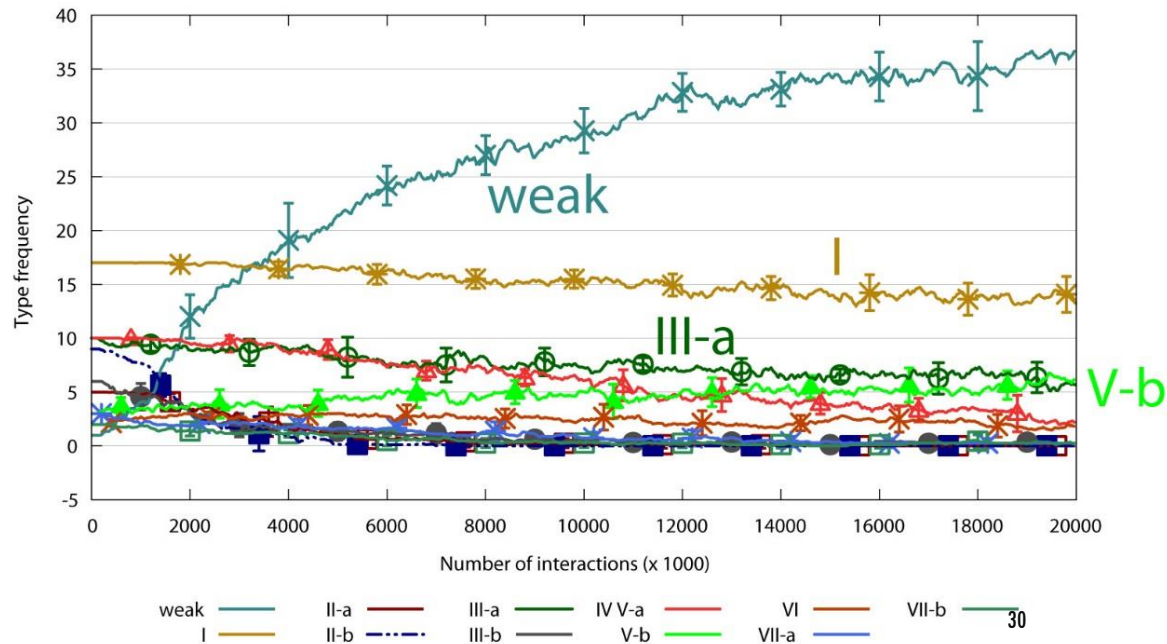
Weak type frequency (%)
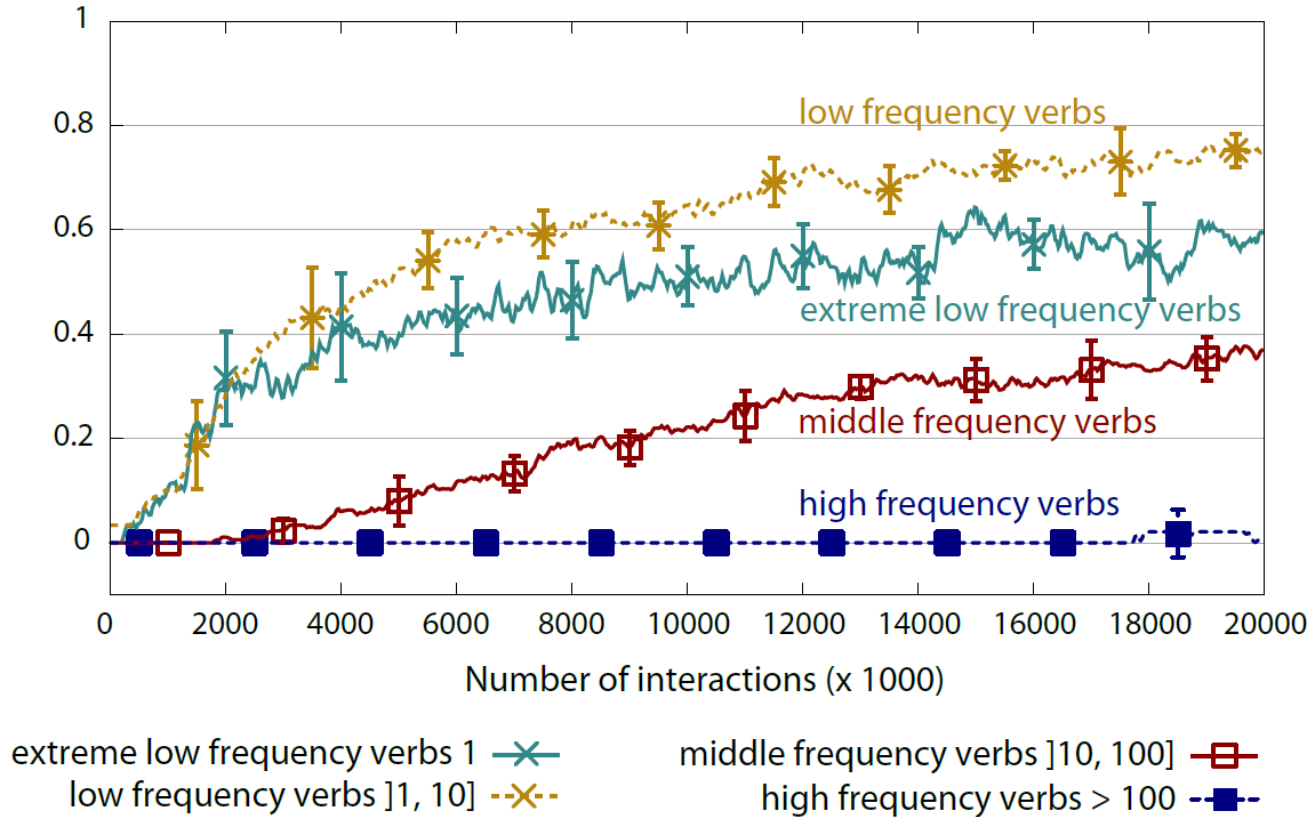
3. Conserving Effect

- Development of a number of hapaxes

4. Class Resilience

RESULTS: EFFECTS OF THE PARAMETERS

- Number of agents: more agents, slower rise

- Replacement rate: lower replacement rate, slower rise

  ⇨ Emergence of the evaluation criteria is not dependent upon specific parameter settings

  ⇨ To kill off the weak inflection, the replacement rate needs to be set extremely high

CONCLUSIONS

- The only thing that set the weak inflection apart from the strong classes in our simulation was its general applicability

- This suffices to explain

  1. Rise of the Weak Inflection

  2. Gradual Rise

  3. Conserving Effect

  4. Class Resilience

CAUSES OF THE RISE OF THE WEAK INFLECTION

1. **General applicability of the dental suffix**

2. Restrictions on the strong system

3. Irregularization of the strong system

(Ball 1968: 164; Bailey 1997: 17)

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(Ball 1968: 164; Bailey 1997: 17)

Rise of the
Weak Inflection

Starting point

Low frequency verbs become weak
&
Regularity is primarily needed by
low frequency verbs

Irregularization of the
Strong Inflection

Less need to maintain
the regularity of the
strong system

REMAINING QUESTIONS

- Origin of the dental suffix   (o.a. Loewe 1898; Collitz 1912; Ball 1968; Meid 1971; Tops 1974; Shields 1982; Ringe 2006: 179-785; Hill 2010)

- What originally made the strong system so succesful?

  – Shorter verb forms

  – Germanic first-syllable stress

  ⇨ Influx of L2-learners: advantages of the weak inflection – general applicability and greater linear segmentability – proved more decisive

  (cf. O'Neil 1978; Roberge 2010; Lupyan and Dale 2010; Bentz and Winter 2013)

FOR FURTHER INFORMATION

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https://ai.vub.ac.be/members/katrien
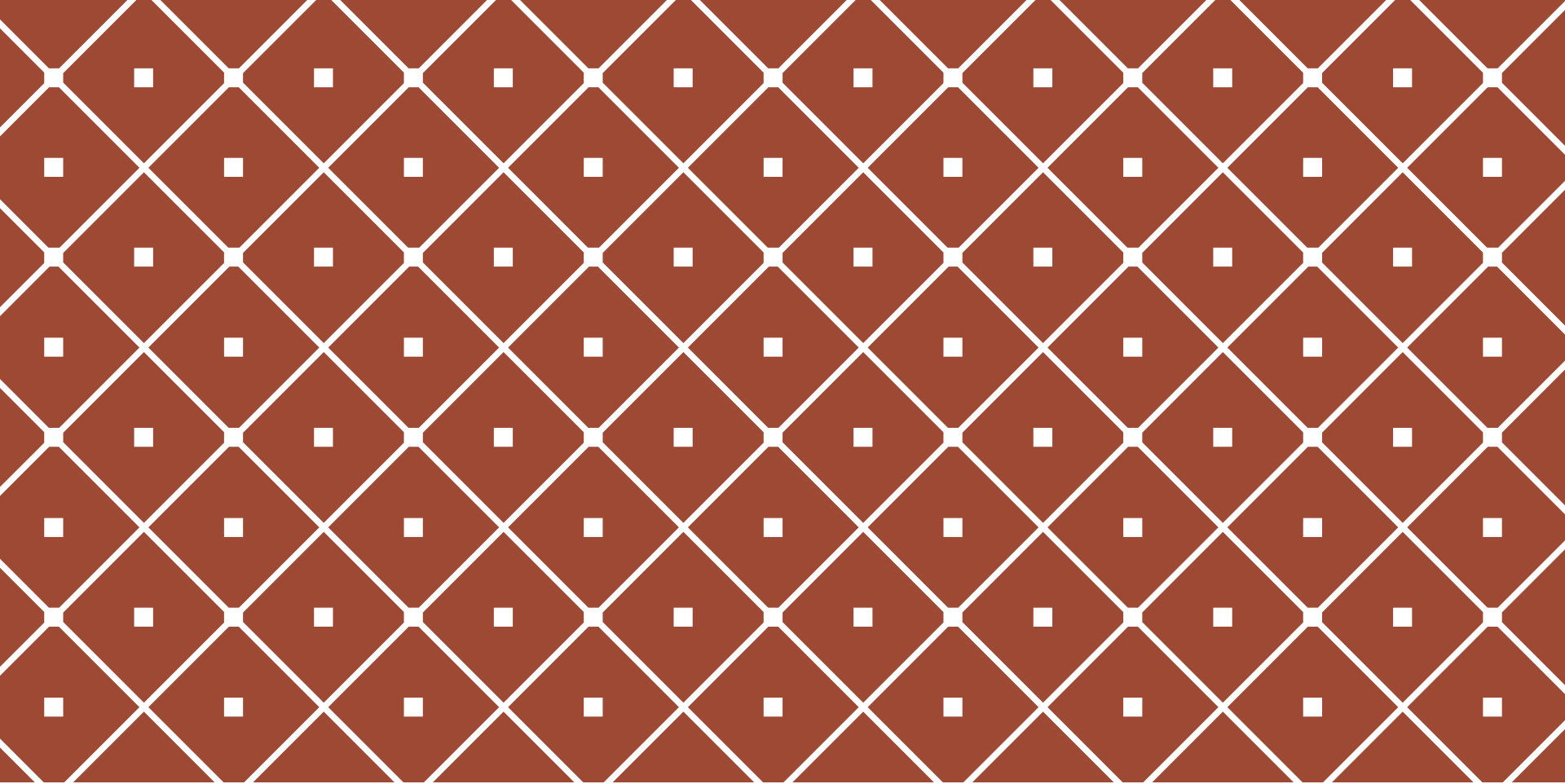

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EXTRA SLIDES

4 series of 20.000.000 interactions, 10 agents, replacement rate of 1/20.000

SIMULATION DESIGN: CONCEPTUAL LEVEL

- Agent-based simulation of communicating agents rather than iterated learning

  - General applicability is usage property

  - Usage-based view on language change   (Croft 2000, Bybee 2010)

  - Language as a Complex Adaptive System   (Gilbert 2008, Beckner et al. 2008)

- Acquisition of the Germanic past tense in models of iterated learning

Rumelhart and McClelland (1986), Pinker and Prince (1988), Macwhinney and Leinbach (1991), Plunkett and Marchman (1991, 1993), Ling and Marinov (1993), Hare & Elman (1995), Marcus et al. (1995), Plunkett and Juola (1999), Taatgen and Anderson (2002), Yang (2002), van Noord (2015)

WHY A CORPUS OF MODERN DUTCH?

- No corpora of Proto-Germanic, corpora of Middle-Dutch or Gothic arguably as 'bad' as one from Modern Dutch

- CGN is annotated and more representative of frequency distributions in spoken language

- In principle, any model which complies to the building blocks (slide 14-16) and leads to the emergence of the 4 evaluation criteria will do

    ⇨ Realistic frequency distributions important

- Intuitively interpretable, but explicitly not a realistic model of Proto-Germanic

WHY IS THE STRENGTH OF A CLASS DETERMINED BY TOKEN INSTEAD OF TYPE FREQUENCY?

- No Advantages for the weak inflection:
  Type frequency would be more beneficial for the weak inflection than token frequency (Conserving Effect)

- KISS:
  More design choices need to be made for type frequency

WHY DO THE FREQUENCIES OF THE GRAMMATICAL CONSTRUCTIONS ONLY PLAY A ROLE IF THE AGENT HAS NEVER HEARD THE VERB BEFORE?

Alternative: formula that takes into account both the frequencies of the lexical and grammatical constructions.

- More realistic, but also more complex: necessitates the inclusion of two more parameters

- Current approach makes the agents highly conservative. If anything, this impedes the rise of the weak inflection

IS IT NOT REDUNDANT FOR THE AGENTS TO KEEP BOTH THE GRAMMATICAL AND LEXICAL CONSTRUCTIONS IN MEMORY?

Yes it is, but is is also very minimal in its assumptions. It only assumes that any pattern that is recognized by humans will become more entrenched in their memory if they encounter it more often.

The alternative is a rule-list approach, which assumes that regular and irregular forms are handled fundamentally different by agent memory. That is a quite expensive assumption.
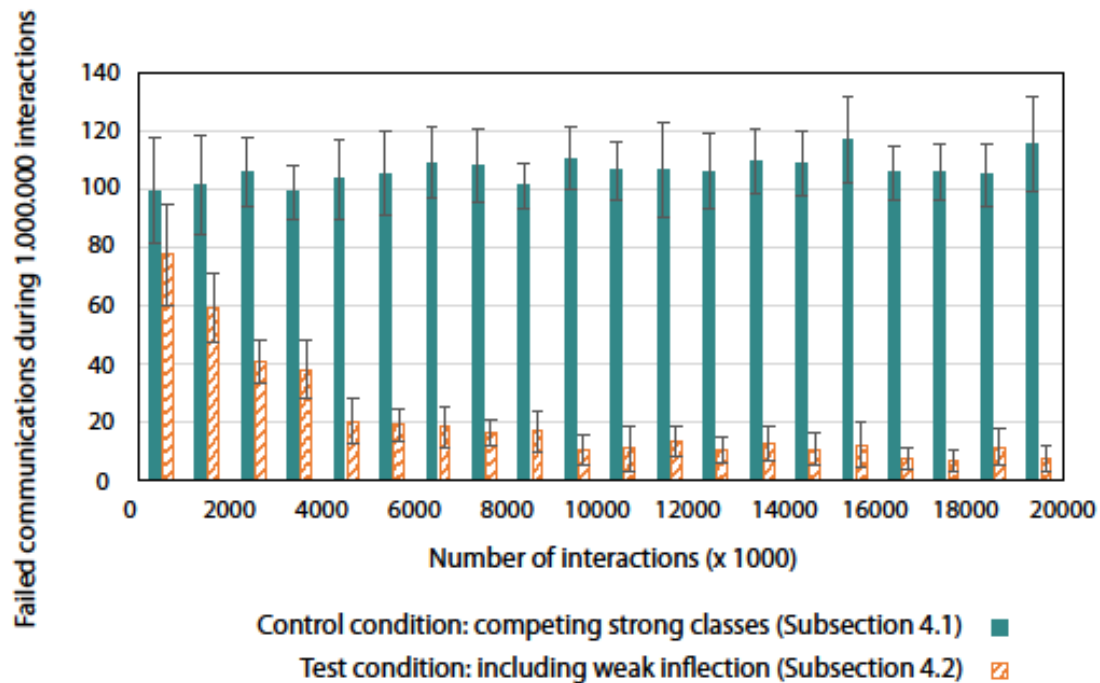
WHAT IF: NO RULES, ONLY ANALOGY?

Model does not need to change: the frequency of the grammatical constructions is exactly equal to the sum of the frequencies of its verb forms.

ARGUMENTS AGAINST GENERAL APPLICABILITY

1. Addition of the weak inflection only complicates past tense formation: only makes it harder to learn & use

ARGUMENTS AGAINST GENERAL APPLICABILITY

2. General applicability is only useful if you haven't acquired all strong classes yet. Moreover, each separate strong class is initially more frequent and thus more quickly acquired than the weak dental suffix.