

# The structure and evolution of language

Principles of Complex Systems  
CSYS/MATH 300, Fall, 2011

Irregular verbs

Word lifespans

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References

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# Outline

Irregular verbs

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# Irregular verbs

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## Cleaning up English:

“Quantifying the evolutionary dynamics of language”<sup>[1]</sup>

Lieberman et al., Nature, Vol 449, 713-716, 2007.

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- ▶ Exploration of how verbs with irregular conjugation gradually become regular over time.
- ▶ Comparison of verb behavior in Old, Middle, and Modern English.



# Irregular verbs

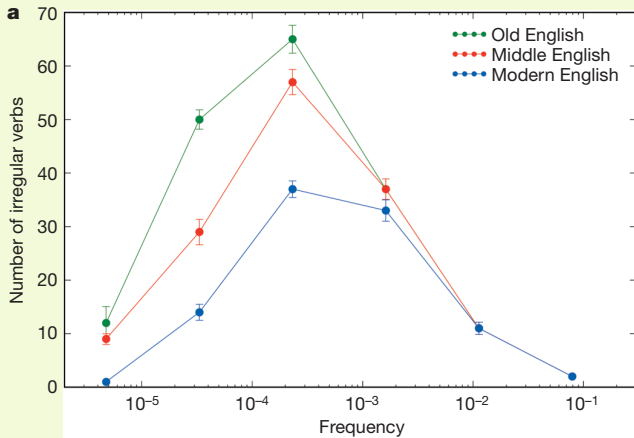
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- ▶ Universal tendency towards regular conjugation
- ▶ Rare verbs tend to be regular in the first place



# Irregular verbs

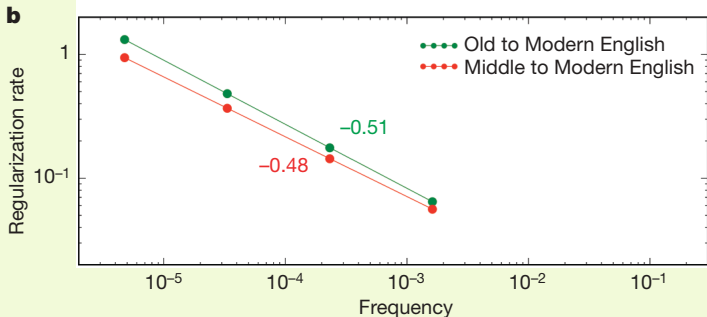
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- ▶ Rates are relative.
- ▶ The **more common** a verb is, the **more resilient** it is to change.



# Irregular verbs

**Table 1 | The 177 irregular verbs studied**

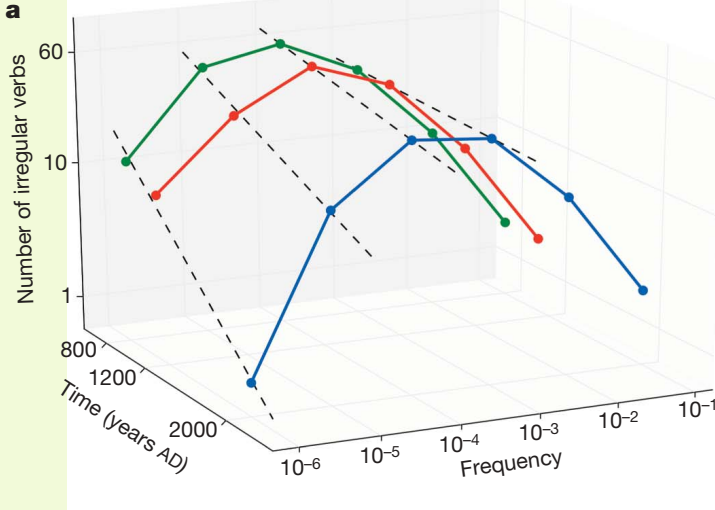
Frequency	Verbs	Regularization (%)	Half-life (yr)
10 <sup>-1</sup> -1	be, have	0	38,800
10 <sup>-2</sup> -10 <sup>-1</sup>	come, do, find, get, give, go, know, say, see, take, think	0	14,400
10 <sup>-3</sup> -10 <sup>-2</sup>	begin, break, bring, buy, choose, draw, drink, drive, eat, fall, fight, forget, grow, hang, <b>help</b> , hold, leave, let, lie, lose, <b>reach</b> , rise, run, seek, set, shake, sit, sleep, speak, stand, teach, throw, understand, <b>walk</b> , win, <b>work</b> , write	10	5,400
10 <sup>-4</sup> -10 <sup>-3</sup>	arise, <b>bake</b> , bear, beat, bind, bite, blow, <b>bow</b> , burn, burst, <b>carve</b> , <b>chew</b> , <b>climb</b> , cling, creep, <b>dare</b> , dig, <b>drag</b> , flee, <b>float</b> , flow, fly, <b>fold</b> , freeze, grind, leap, lend, <b>lock</b> , melt, <b>reckon</b> , ride, <b>rush</b> , <b>shape</b> , shine, shoot, shrink, <b>sigh</b> , sing, sink, slide, <b>slip</b> , smoke, spin, spring, <b>starve</b> , steal, <b>step</b> , <b>stretch</b> , strike, <b>stroke</b> , <b>suck</b> , <b>swallow</b> , swear, sweep, swim, swing, tear, wake, wash, weave, weep, <b>weigh</b> , wind, yell, yield	43	2,000
10 <sup>-5</sup> -10 <sup>-4</sup>	<b>bark</b> , <b>bellow</b> , bid, <b>blend</b> , <b>braid</b> , <b>brew</b> , cleave, <b>cringe</b> , <b>crow</b> , dive, drip, fare, fret, glide, gnaw, grip, heave, knead, low, milk, mourn, mow, prescribe, redden, reek, row, scrape, seethe, shear, shed, <b>shove</b> , slay, slit, smite, sow, span, <b>spurn</b> , sting, stink, strew, stride, swell, <b>tread</b> , <b>uproot</b> , <b>wade</b> , <b>warp</b> , wax, <b>wield</b> , wring, <b>writh</b>	72	700
10 <sup>-6</sup> -10 <sup>-5</sup>	bide, chide, delve, flay, hew, rue, shrive, slink, snip, spew, sup, <b>wreak</b>	91	300

177 Old English irregular verbs were compiled for this study. These are arranged according to frequency bin, and in alphabetical order within each bin. Also shown is the percentage of verbs in each bin that have regularized. The half-life is shown in years. Verbs that have regularized are indicated in red. As we move down the list, an increasingly large fraction of the verbs are red; the frequency-dependent regularization of irregular verbs becomes immediately apparent.

- ▶ **Red** = regularized
- ▶ Estimates of half-life for regularization.

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- ▶ 'Wed' is next to go.
- ▶ -ed is the winning rule...



# Irregular verbs

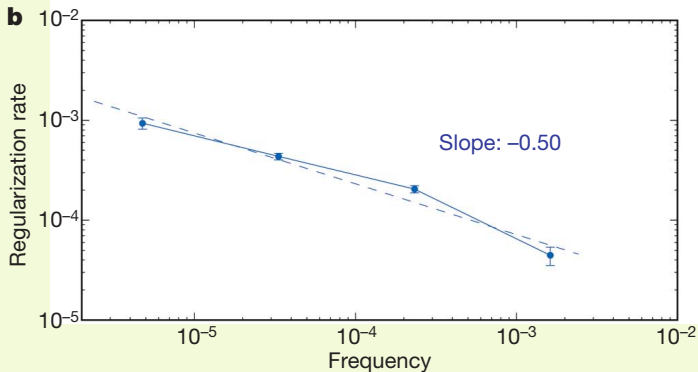
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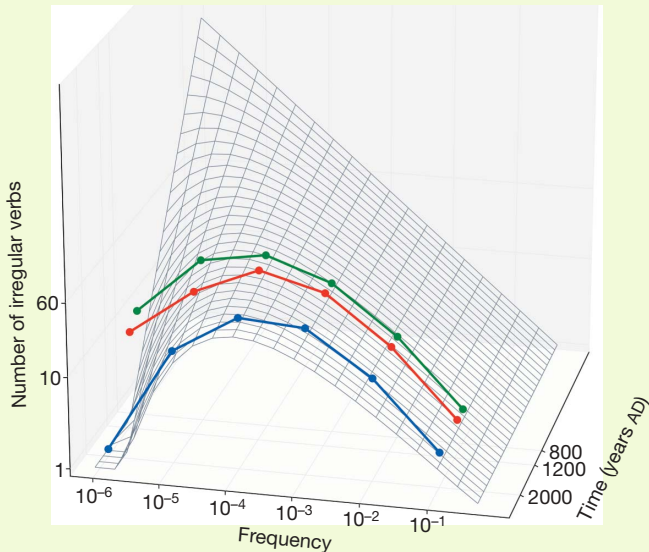
- ▶ Regularization rate  $\propto$  word frequency $^{-1/2}$
- ▶ Half life  $\propto$  word frequency $^{1/2}$





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► Projecting back in time...

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# Word meanings

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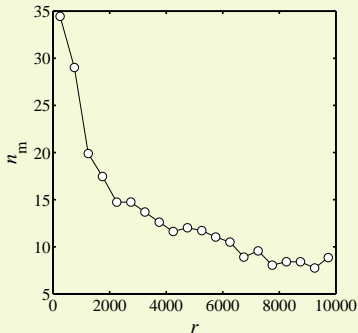
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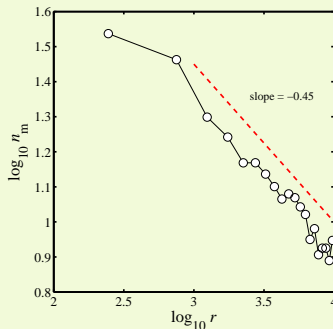
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**A.**



**B.**



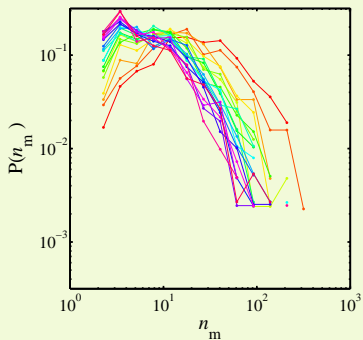
- ▶ Meaning number as a function of word rank.
- ▶ The three exponents combine within error:  
 $1.2 \times 1/3 = 0.4 \simeq 0.45$ .



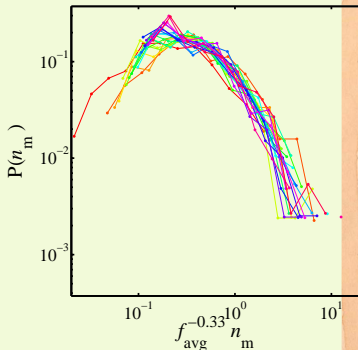
# Word meanings

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A.



B.



- ▶ Scaling collapse for meaning number distribution
- ▶ Each curve corresponds to approximately 500 words group according to rank (1–500, 501–1000, ...).
- ▶ With normalization

$$P(n_m) = f^{-1/3} G\left(f^{-1/3} n_m\right).$$

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# References I

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- [1] E. Lieberman, J.-B. Michel, J. Jackson, T. Tang, and M. A. Nowak.

Quantifying the evolutionary dynamics of language.  
[Nature](#), 449:713–716, 2007. [pdf](#) (田)

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- [2] J.-B. Michel, Y. K. Shen, A. P. Aiden, A. Veres, M. K. Gray, T. G. B. Team, J. P. Pickett, D. Hoiberg, D. Clancy, P. Norvig, J. Orwant, S. Pinker, M. A. Nowak, and E. A. Lieberman.

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- [3] H. A. Simon.

On a class of skew distribution functions.

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