How Google Books misrepresents socio-cultural-linguistic evolution

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CSYS/MATH 300, 303, & 394, 2022–2023| @pocsvox

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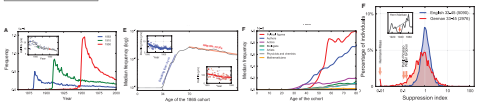
Santa Fe Institute | University of Vermont

Outline

Culturomics:

"Quantitative analysis of culture using millions of digitized books"
Michel et al.,
Science Magazine, **331**, 176–182, 2011. [1]

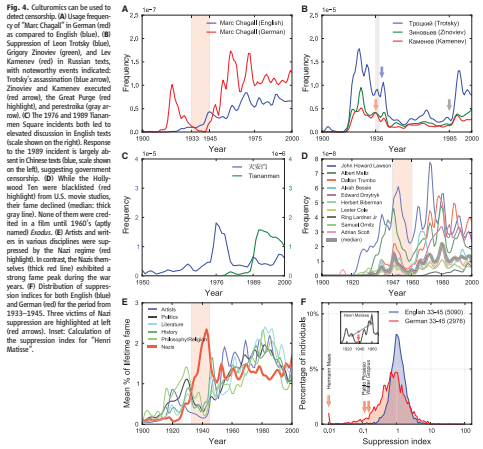


http://www.culturomics.org/ and Google Books ngram viewer

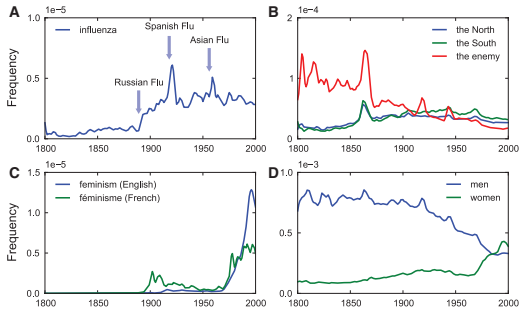
Barney Rubble:

"Characterizing the Google Books corpus: Strong limits to inferences of socio-cultural and linguistic evolution"
Pechenick, Danforth, and Dodds,
PLoS ONE, **10**, e0137041, 2015. [2]

Censorship (okayish)



Danger Will Robinson



(Search for "cherrypicking")

Seriously, Danger Will Robinson

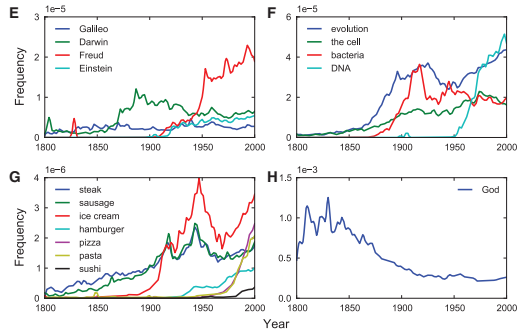


Fig. 5. Culturomics provides quantitative evidence for scholars in many fields. **(A)** Historical epidemiology: "influenza" is shown in blue; the Russian, Spanish, and Asian flu epidemics are highlighted. **(B)** History of the Civil War. **(C)** Comparative history. **(D)** Gender studies. **(E** and **F)** History of science. **(G)** Historical gastronomy. **(H)** History of religion: "God".

"Characterizing the Google Books corpus: Strong limits to inferences of socio-cultural and linguistic evolution"
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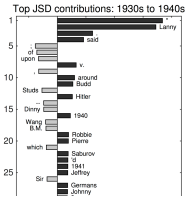
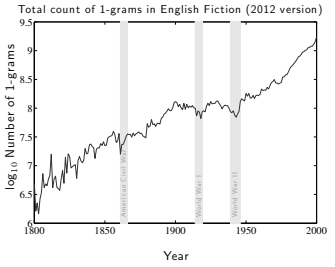


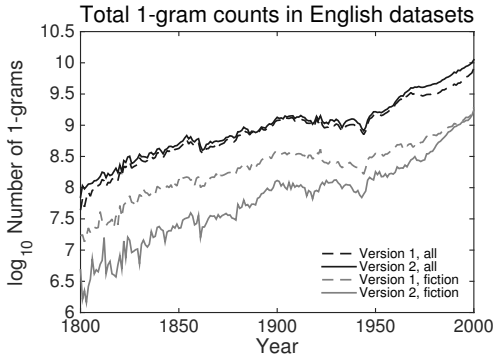
Press:

- New York Times: Google Books: A Complex and Controversial Experiment by Stephen Heyman (October 28, 2015)
- Future Tense, slate.com: Is Google Books Leading Researchers Astray? by Jacob Brogan (October 14, 2015)
- wired.com: The pitfalls of using Google Ngram to study language by Sarah Zhang (October 12, 2015)
- discovery.com Can Google Books Really Tell Us About Cultural Evolution? by Neuroskeptic (October 10, 2015)

Volume of "words"—exponential growth



- Two data sets: Version 1 (2009, around 4% of all books published) and Version 2 (2012)
- Intitial version: Around 4% of all published books.



Trouble at Mill, 1/2:

Every book gets one vote:

- Equally important:

"Harry Potter and the Sorcerer's Stone" by J. K. Rowling (1998).[3]

"Microwave Cooking for One" by Marie Smith (1999).[4]

- New editions, revisions, reprintings give very modest bump.

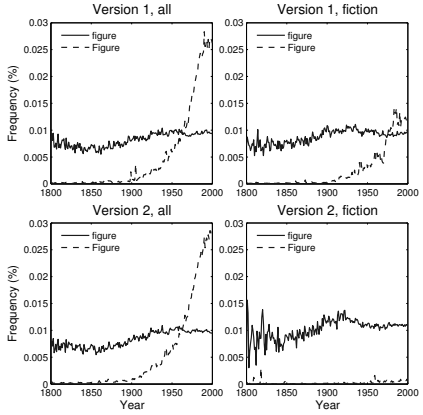
Trouble at Mill, 2/2:

Lord of the Rings is fading away:

- Search for Frodo, Gandalf in English Fiction, 2012.
- English Fiction = fiction + literary criticism.

Trouble at Mill, 2/2:

Google Books inhaled a lot of Science:



Kullback-Leibler divergence:

Given two distributions P and Q over N categories (e.g., 1-grams):

$$D_{KL}(P\,||\,Q) = \sum_{i=1}^{N} p_i \log_2 \frac{p_i}{q_i},$$

- Average number of extra bits required to encode a system with true distribution P under the belief that the true distribution is Q.
- Not symmetric.
- Can go kablooey—happens if any $q_i = 0$.

Jensen-Shannon divergence:

$$D_{\mathrm{JS}}(P\,||\,Q) = \frac{1}{2}\left(D_{KL}(P||M) + D_{KL}(Q||M)\right),$$

- $M = \frac{1}{2}(P+Q)$ is the mixed distribution of P and Q.
- Symmetric, finite, square root is a metric.
- Rewrite:

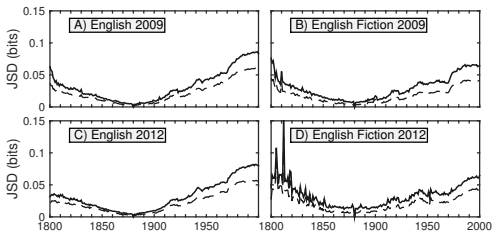
$$D_{\mathrm{JS}}(P\,||\,Q) = H(M) - \frac{1}{2}\left(H(P) + H(Q)\right)$$

- Use per word contribution to the JSD to make shifts:

$$D_{\mathrm{JS},i}(P\,||\,Q) = -m_i \log_2 m_i + \frac{1}{2}\left(p_i \log_2 p_i + q_i \log_2 q_i\right)$$

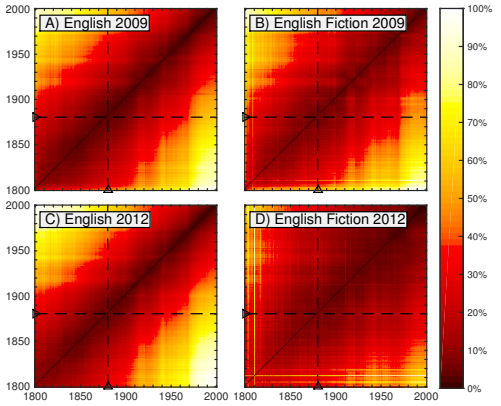
Note: Later moved beyond JSD to rank-turbulence divergence and probability-turbulence divergence.

JSD between 1880 and 1800–2000:

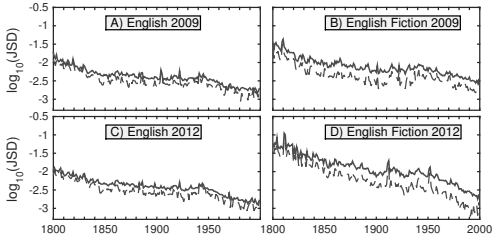


Contributions are counted for all words appearing above a 10^{-5} threshold in a given year; for the dashed curves, the threshold is 10^{-4}.

JSD between years:



JSD between consecutive years:

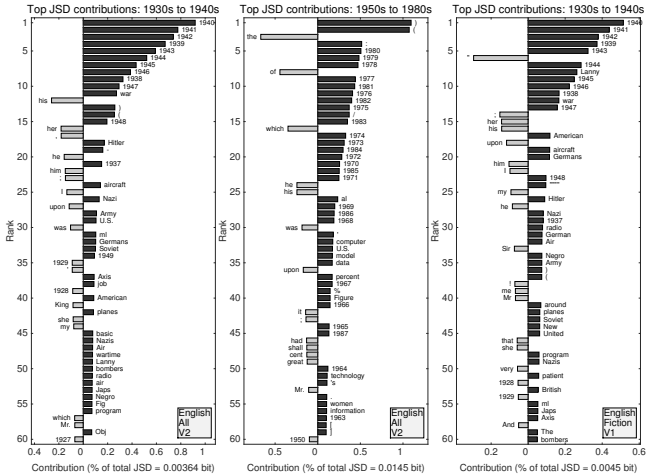


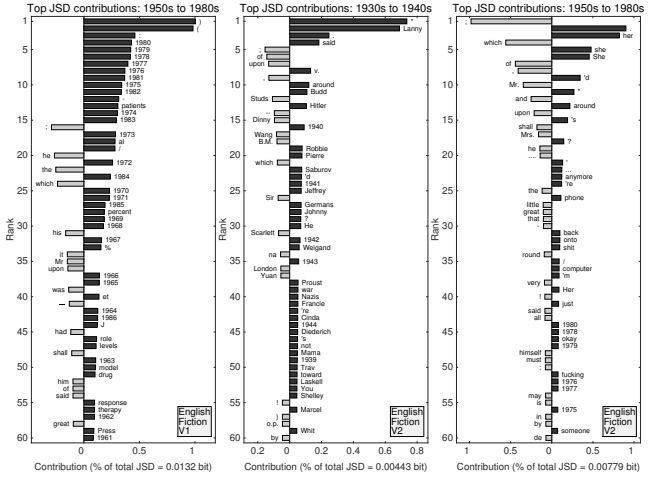
Consecutive year (between each year and the following year) base-10 logarithms of JSD, corresponding to off-diagonals. For the solid curves, contributions are counted for all words appearing above a 10^{-5} threshold in a given year; for the dashed curves, the threshold is 10^{-4}. Divergences between consecutive years typically decline through the mid-19th century, remain relatively steady until the mid-20th century, then continue to decline gradually over time.

JSD between 1880 and 1800–2000:

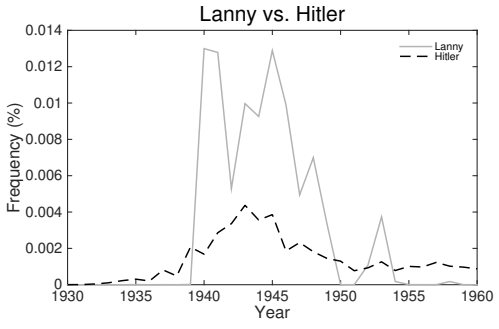
Contributions are counted for all words appearing above a 10^{-5} threshold in a given year; for the dashed curves, the threshold is 10^{-4}.

JSD between years:

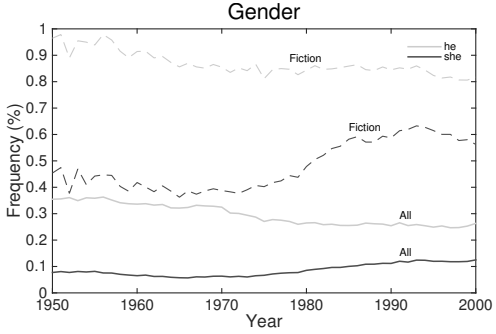




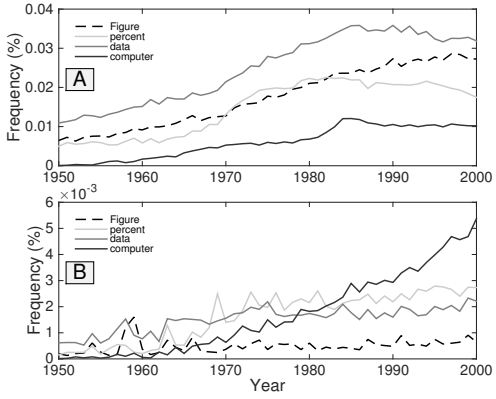
Lanny Budd, Upton Sinclair's forgotten hero



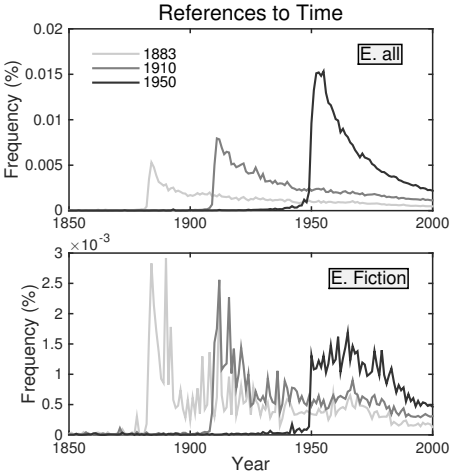
Representative of a more general shift:



More Science:



Science drives the memory story:



"God is dying"—Google Books

A deeper look reveals that the decline in sacred speech is not a recent trend, though we are only now becoming fully aware of it. By searching the Google Ngram corpus — a collection of millions of books, newspapers, webpages and speeches published between 1500 and 2008 — we can now determine the frequency of word usage over the centuries. This data shows that most religious and spiritual words have been declining in the English-speaking world since the early 20th century.

One might expect a meaty theological term like "salvation" to fade, but basic moral and religious words are also falling out of use. A study in The Journal of Positive Psychology analyzed 50 terms associated with moral virtue. Language about the virtues Christians call the fruit of the spirit — words like "love," "patience," "gentleness" and "faithfulness" — has become much rarer. Humility words, like "modesty," fell by 52 percent. Compassion words, like "kindness," dropped by 56 percent. Gratitude words, like "thankfulness," declined by 49 percent.

nytimes.com/2018/10/13/opinion/sunday/talk-god-sprituality-christian.html

theweek.com/articles/791795/death-sacred-speech
(2018-09-10)

The book to sell: Learning to Speak God from Scratch: Why Sacred Words Are Vanishing–and How We Can Revive Them

"God feels fine!" —Also Google Books

Language Log goodness:

- Lexico-cultural decay?
  http://languagelog.ldc.upenn.edu/nll/?p=40222
  Mark Liberman
  Architecture would appear to be failing with relative decreases in: stairway, foundation, roof, eaves, arch, cornice.
- "More on trends in the Google ngrams corpus"
  http://languagelog.ldc.upenn.edu/nll/?p=40349
  Mark Liberman, again
  "God talk" words have all been going up after 2000.

We fight the good fight with a (towering) Twitter thread, an essential tool of science:
https://twitter.com/compstorylab/status/1052708929795497990

Wikipedia's entry on Google ngrams:

Criticism [edit]

The data set has been criticized for its reliance upon inaccurate OCR, an overabundance of scientific literature, and for including large numbers of incorrectly dated and categorized texts.[12][13] Because of these errors, and because it is uncontrolled for bias[14] (such as the increasing amount of scientific literature, which causes other terms to appear to decline in popularity), it is risky to use this corpus to study language or test theories.[15] Since the data set does not include metadata, it may not reflect general linguistic or cultural change[16] and can only hint at such an effect.

Another issue is that the corpus is in effect a library, containing one of each book. A single, prolific author is thereby able to noticeably insert new phrases into the Google Books lexicon, whether the author is widely read or not.[14]

OCR issues [edit]

Optical character recognition, or OCR, is not always reliable, and some characters may not be scanned correctly. In particular, systemic errors like the confusion of "s" and "f" in pre-19th century texts (due to the use of the long_s which was similar in appearance to "f") can cause systemic bias. Although Google Ngram Viewer claims that the results are reliable from 1800 onwards, poor OCR and insufficient data mean that frequencies given for languages such as Chinese may only be accurate from 1970 onward, with earlier parts of the corpus showing no results at all for common terms, and data for some years containing more than 50% noise.[17][18]

- Ref. 14 = Pechenick *et al.* [2]

Shell of the nut:

- First issue: Google Books has the appearance of cultural popularity.
- But it's really a representation of a quasi-lexicon.
- Depopularizing: Each book appears once (in principle).
- But natural unevenness of Zipf distribution for words gives veneer of popularity.
- Second issue: Inclusion of massive amounts of scientific literature makes a mess.
- Upshot: Google Books needs a lot more metadata.

References I

[1] J.-B. Michel, Y. K. Shen, A. P. Aiden, A. Veres, M. K. Gray, The Google Books Team, J. P. Pickett, D. Hoiberg, D. Clancy, P. Norvig, J. Orwant, S. Pinker, M. A. Nowak, and E. A. Lieberman.
Quantitative analysis of culture using millions of digitized books.
Science Magazine, 331:176–182, 2011. pdf

[2] E. A. Pechenick, C. M. Danforth, and P. S. Dodds.
Characterizing the Google Books corpus: Strong limits to inferences of socio-cultural and linguistic evolution.
PLoS ONE, 10:e0137041, 2015. pdf

[3] J. K. Rowling.
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References II

[4] M. Smith.
Microwave Cooking for One.
Pelican Publishing, 1999.