

Linguistic Pollyanna Principle: The positivity bias of language

Last updated: 2021/10/27, 00:38:45 EDT

Principles of Complex Systems, Vols. 1 & 2
CSYS/MATH 300 and 303, 2021-2022 | @pocsvox

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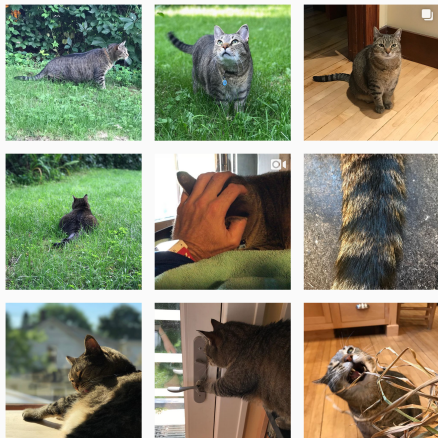
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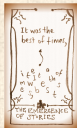
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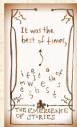




“Human language reveals a universal
positivity bias” 

Dodds et al.,

Proc. Natl. Acad. Sci., **112**, 2389–2394,
2015. ^[2]



Who are we?

- 🧱 Stories we tell about how we should/could/must behave vary enormously.
- 🧱 Jainism to Rand's Objectivism.

Basic observations:

- 🧱 Language is our great social technology.
- 🧱 And we convey stories through language.

Basic question:

- 🧱 What's the distribution of emotional content of the atoms of language?

Data we've generated:

- 🧱 English plus nine other languages.
- 🧱 Key: incorporate word usage frequency (= size).

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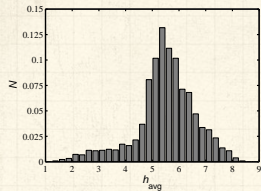
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English's scale-invariant, positive bias: [8]



Social organism story manifested in language.



Pollyanna Hypothesis: Interactions are predominantly positive



Positive anchor of concepts: Unhappy but not unsad.



Many ways for things to go wrong: "All happy families are alike; each unhappy family is unhappy in its own way."



Guns, Germs, and Steel^[1] invokes the Anna Karenina Principle



But: must account for frequency of word usage ...

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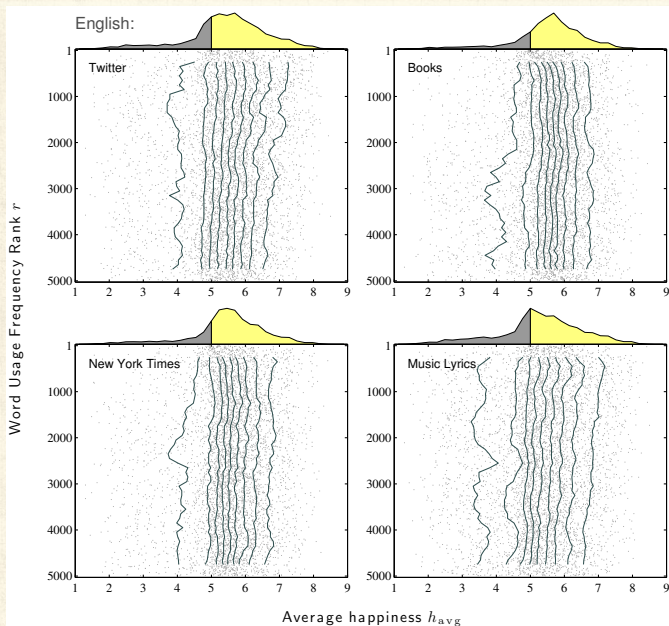
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Jellyfish plots:

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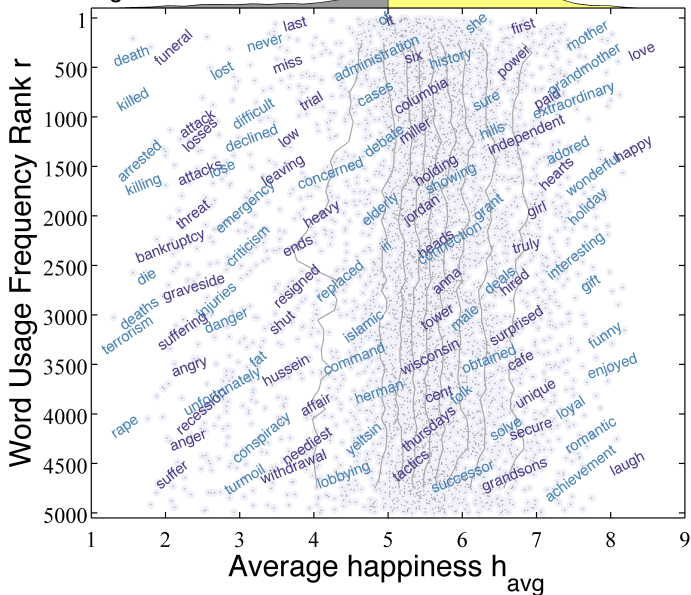
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English: New York Times



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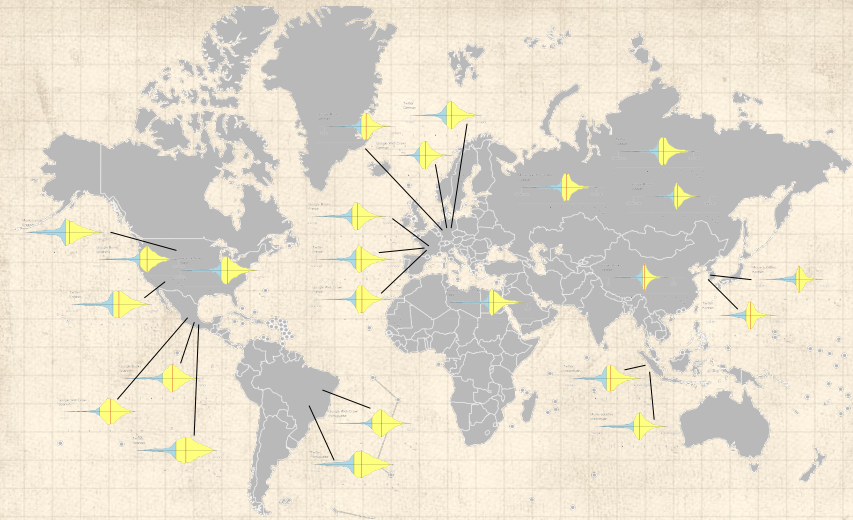
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Dodds/Tivnan/Danforth et al.,
Proc. Natl. Acad. Sci. 2015,
"Human language reveals a universal positivity bias." [2]
Global press including National Geographic
Top 100 altmetric article, 2015 [↗](#)



Good buzz according to Altmetric ...(report is no longer findable):

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As of May 7, 2015:

-  Altmetric Score: 772.
-  Ranked 3rd out of 933 articles published in PNAS surrounding 12 weeks.
-  Ranked 24th out of 34,050 articles in PNAS all time. (Mean score 13.5.)
-  Ranked 60th out of all 109,841 tracked articles published in surrounding 12 weeks.
-  Ranked 459th out of 3,724,005 tracked articles all time.

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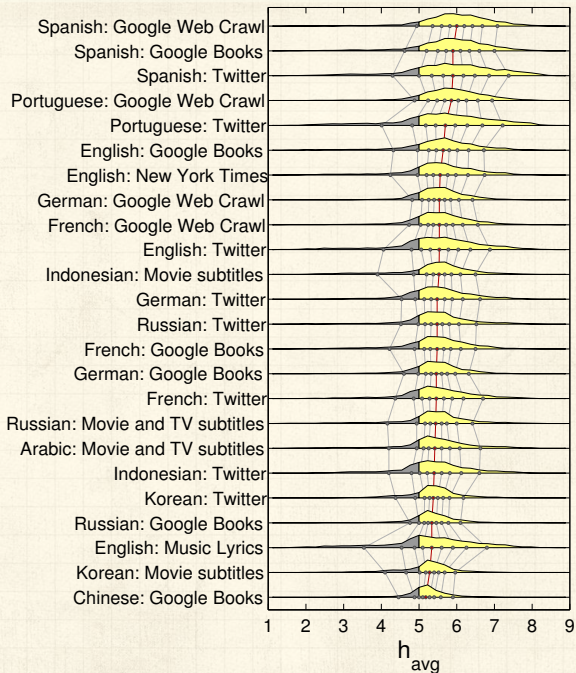
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This doesn't mean it's a good article ... but it is.





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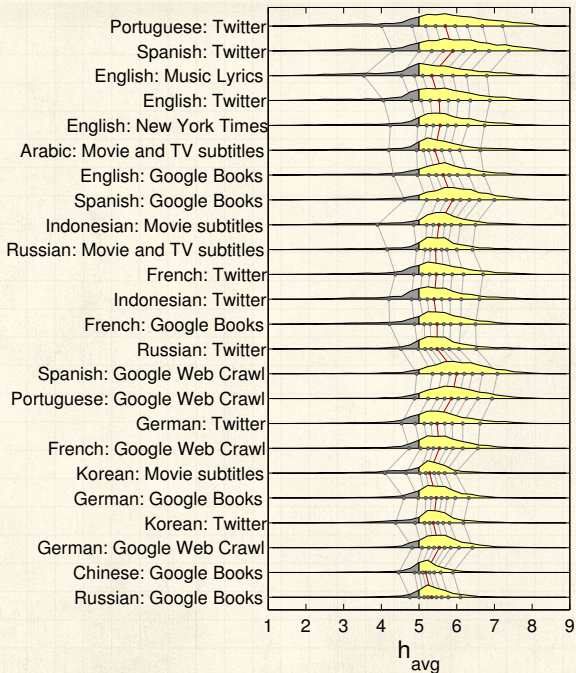
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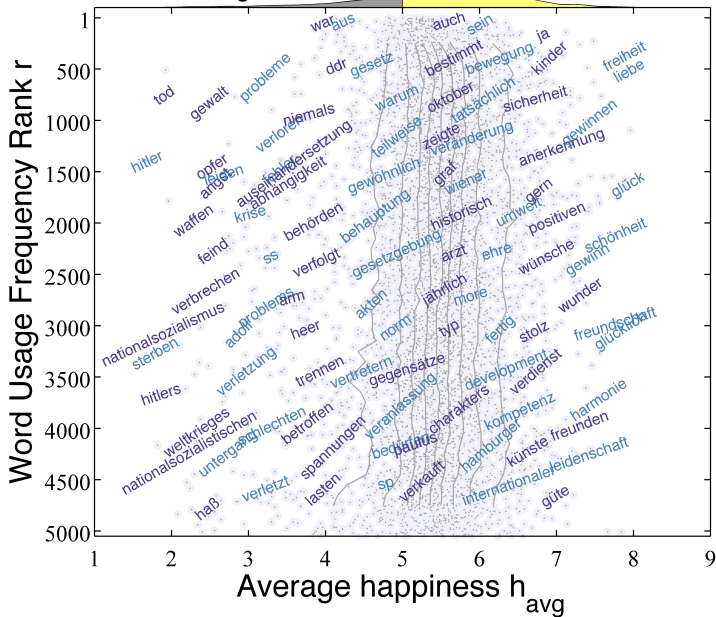
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German: Google Books



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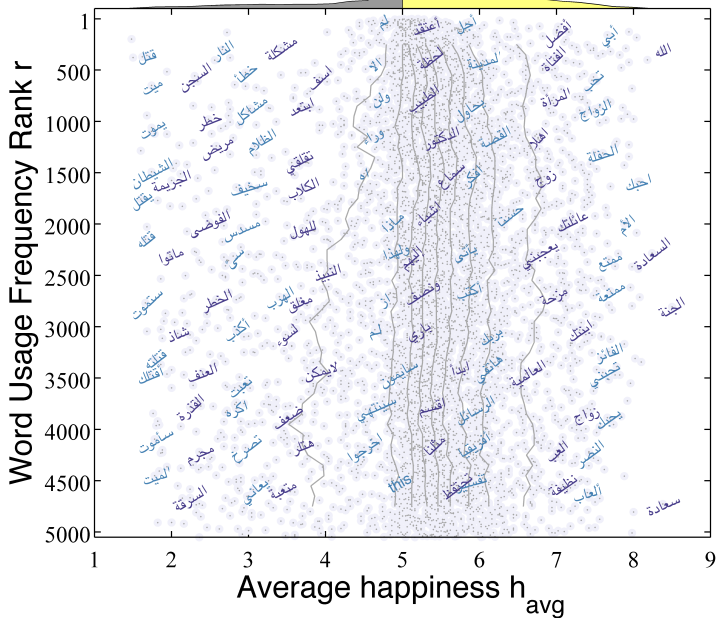
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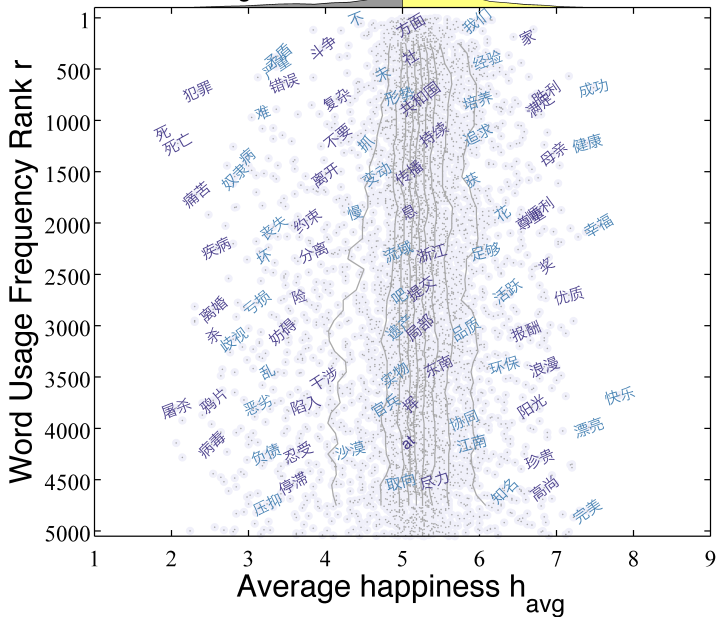
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Arabic: Movie and TV subtitles



Chinese: Google Books



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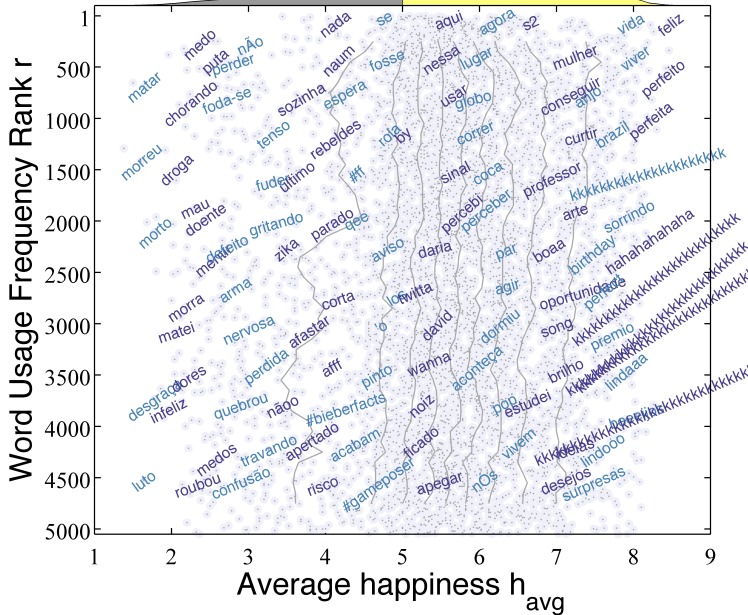
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Portuguese: Twitter



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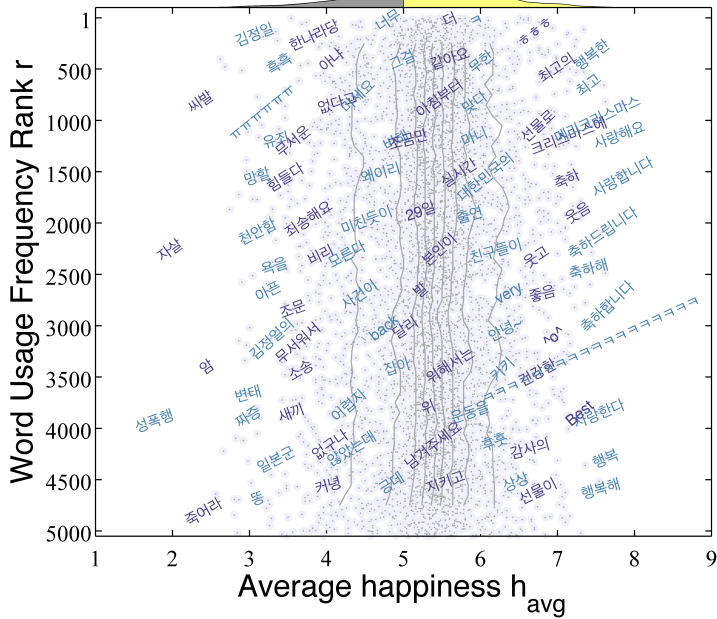
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Korean: Twitter



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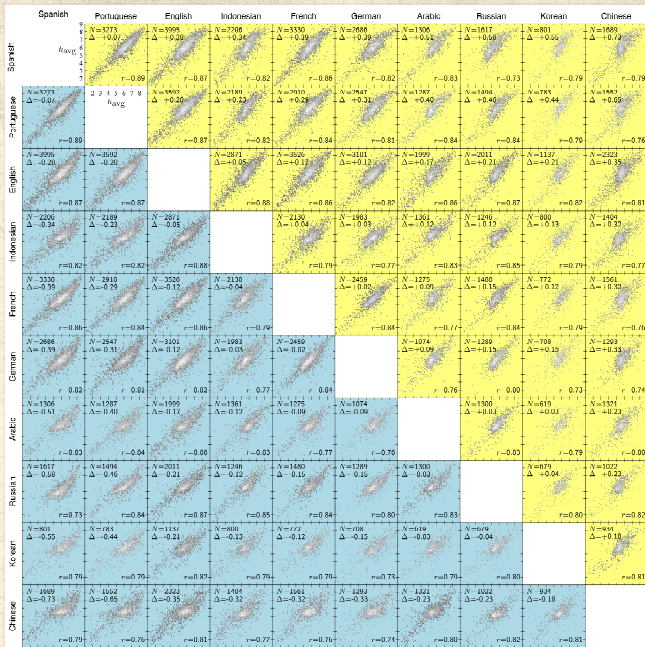
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No one understands anything:

A revealing letter and our reply:



“Language-dependent relationship between word happiness and frequency” ↗

Garcia, Garas, and Schweitzer,
Proc. Natl. Acad. Sci., , , 2015. [7]



“Reply to Garcia et al.: Common mistakes in measuring frequency dependent word characteristics” ↗

Dodds et al.,
Proc. Natl. Acad. Sci., , , 2015. [4]

Full version here: <http://arxiv.org/abs/1406.3855> ↗

Abstract:

The concerns expressed by Garcia *et al.* [7] are misplaced due to a range of misconceptions about word usage frequency, word rank, and expert-constructed word lists such as LIWC [11]. We provide a complete response in our paper’s online appendices [3].

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LIWC function words are not neutral:

- 🧱 "greatest" ($h_{\text{avg}}=7.26$),
- 🧱 "best" ($h_{\text{avg}}=7.26$),
- 🧱 "unique" ($h_{\text{avg}}=6.98$),
- 🧱 "negative" ($h_{\text{avg}}=2.42$),
- 🧱 "worst" ($h_{\text{avg}}=2.10$).

Common scientific sense for text analysis:

Always look at the words.

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More LIWC function words:

| High | h_{avg} | Neutral | h_{avg} | Low | h_{avg} |
|-------------|-----------|----------------|-----------|------------|-----------|
| billion | 7.56 | been | 5.04 | wouldnt | 3.86 |
| million | 7.38 | other | 5.04 | not | 3.86 |
| couple | 7.30 | into | 5.04 | shouldn't | 3.84 |
| millions | 7.26 | theyre | 5.04 | none | 3.84 |
| greatest | 7.26 | it | 5.02 | haven't | 3.82 |
| rest | 7.18 | some | 5.02 | wouldn't | 3.78 |
| best | 7.18 | where | 5.02 | fewer | 3.72 |
| equality | 7.08 | themselves | 5.02 | lacking | 3.71 |
| unique | 6.98 | im | 5.02 | won't | 3.70 |
| plenty | 6.98 | quarterly | 5.02 | wasnt | 3.70 |
| truly | 6.86 | ive | 5.02 | dont | 3.70 |
| hopefully | 6.84 | because | 5.00 | don't | 3.70 |
| first | 6.82 | whereas | 5.00 | down | 3.66 |
| plus | 6.76 | id | 5.00 | nobody | 3.64 |
| well | 6.68 | til | 5.00 | doesn't | 3.62 |
| greater | 6.68 | the | 4.98 | couldnt | 3.58 |
| highly | 6.60 | to | 4.98 | without | 3.54 |
| me | 6.58 | by | 4.98 | no | 3.48 |
| done | 6.54 | or | 4.98 | cant | 3.48 |
| extra | 6.52 | part | 4.98 | zero | 3.44 |
| infinite | 6.44 | rather | 4.98 | against | 3.40 |
| simply | 6.42 | its | 4.96 | never | 3.34 |
| equally | 6.40 | when | 4.96 | cannot | 3.32 |
| sixteen | 6.39 | perhaps | 4.96 | lack | 3.16 |
| we | 6.38 | yall | 4.96 | negative | 2.42 |
| soon | 6.34 | of | 4.94 | worst | 2.10 |

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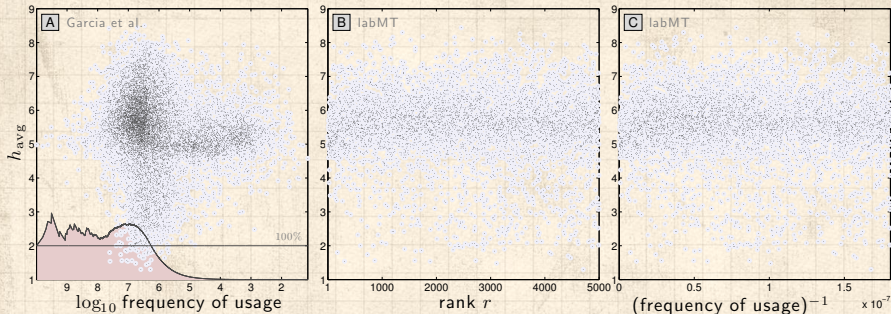
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The jellyfish knows:



Scatterplot of h_{avg} as a function of word usage frequency for the English Google Books word list generated by Garcia *et al.*. Uncontrolled subsampling of lower frequency words yields a lexicon that is not statistically representative of any natural language corpus. The lower curve provides a coarse estimate of cumulative lexicon coverage as a function of usage frequency f using Zipf's law $f_r \sim f_1 r^{-1}$ inverted as $r \sim f_1/f_r$. The rapid drop off begins at around rank 5000, the involved lexicon size for Google Books in labMT [3, 6]. **B.** and Scatterplot of h_{avg} as a function of rank r for the 5000 words for Google Books contributing to labMT, the basis of our jellyfish plots [3]. **C.** Same data as **B** plotted against f . Linear regression fits for the first two scatterplots are $h_{\text{avg}} \approx 0.089 \log_{10} f + 4.85$ and

$h_{\text{avg}} \approx -3.04 \times 10^{-5} r + 5.62$ (as reported in [3]). Note difference in signs, and the far weaker trend for the statistically appropriate regression against rank in **B.** Pearson correlation coefficients: +0.105, -0.042, and -0.043 with p -values 6.15×10^{-26} , 3.03×10^{-3} , and 2.57×10^{-3} . Spearman correlation coefficients: +0.201, -0.013, and -0.013 with p -values 6.37×10^{-92} , 0.350, and 0.350.

Nutshell:

- 🧱 Linguistic positivity bias holds for 10 major languages.
- 🧱 Spread across 24 corpora: books, news, social media, movie titles, ...
- 🧱 Languages and evaluating groups spread around the world.
- 🧱 Diverse in language origins.
- 🧱 Language appears to reflect social, cooperative tendency of people.
- 🧱 Negative emotion is more variable—must be specific, Tolstoyfully.

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| Corpus: | # Words | Reference(s) |
|---------------------------------|---------|--------------|
| English: Twitter | 5000 | [?, 6] |
| English: Google Books Project | 5000 | [10] |
| English: The New York Times | 5000 | [12] |
| English: Music lyrics | 5000 | [5] |
| Portuguese: Google Web Crawl | 7133 | [?] |
| Portuguese: Twitter | 7119 | [?] |
| Spanish: Google Web Crawl | 7189 | [?] |
| Spanish: Twitter | 6415 | [?] |
| Spanish: Google Books Project | 6379 | [10] |
| French: Google Web Crawl | 7056 | [?] |
| French: Twitter | 6569 | [?] |
| French: Google Books Project | 6192 | [10] |
| Arabic: Movie and TV subtitles | 9999 | MITRE |
| Indonesian: Twitter | 7044 | [?] |
| Indonesian: Movie subtitles | 6726 | MITRE |
| Russian: Twitter | 6575 | [?] |
| Russian: Google Books Project | 5980 | [10] |
| Russian: Movie and TV subtitles | 6186 | [?] |
| German: Google Web Crawl | 6902 | [?] |
| German: Twitter | 6459 | [?] |
| German: Google Books Project | 6097 | [10] |
| Korean: Twitter | 6728 | [?] |
| Korean: Movie subtitles | 5389 | MITRE |
| Chinese: Google Books Project | 10000 | [10] |

| Language | Participants' location(s) | # of participants | Average words scored |
|--------------------|---------------------------|-------------------|----------------------|
| English | US, India | 384 | 1302 |
| German | Germany | 196 | 2551 |
| Indonesian | Indonesia | 146 | 3425 |
| Russian | Russia | 125 | 4000 |
| Arabic | Egypt | 185 | 2703 |
| French | France | 179 | 2793 |
| Spanish | Mexico | 236 | 2119 |
| Portuguese | Brazil | 208 | 2404 |
| Simplified Chinese | China | 128 | 3906 |
| Korean | Korea, US | 109 | 4587 |

Number and main country/countries of location for participants evaluating the 10,000 common words for each of the 10 languages we studied. Also recorded is the average number of words evaluated by each participant (rounded to the nearest integer). We note that each word received 50 evaluations from distinct individuals. The English word list was evaluated via Mechanical Turk for our initial study [9]. The nine languages evaluated through Appen-Butler Hill yielded a higher participation rate likely due to better pay and the organization's quality of service.

We used the services of Appen Butler Hill (<http://www.appen.com>) for all word evaluations excluding English, for which we had earlier employed Mechanical Turk (<https://www.mturk.com/> [9]).

English instructions were translated to all other languages and given to participants along with survey questions, and an example of the English instruction page is below. Non-english language experiments were conducted through a custom interactive website built by Appen Butler Hill, and all participants were required to pass a stringent aural proficiency test in their own language.

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Measuring the Happiness of Words

Our overall aim is to assess how people feel about individual words. With this particular survey, we are focusing on the dual emotions of sadness and happiness. You are to rate 100 individual words on a 9 point unhappy-happy scale.

Please consider each word carefully. If we determine that your ratings are randomly or otherwise inappropriately selected, or that any questions are left unanswered, we may not approve your work. These words were chosen based on their common usage. As a result, a small portion of words may be offensive to some people, written in a different language, or nonsensical.

Before completing the word ratings, we ask that you answer a few short demographic questions. We expect the entire survey to require 10 minutes of your time. Thank you for participating!

Example:



Read the word and click on the face that best corresponds to your emotional response.

Demographic Questions

1. What is your gender? (Male/Female)
2. What is your age? (Free text)
3. Which of the following best describes your highest achieved education level?
Some High School, High School Graduate, Some college, no degree, Associates degree, Bachelors degree, Graduate degree (Masters, Doctorate, etc.)
4. What is the total income of your household?
5. Where are you from originally?
6. Where do you live currently?
7. Is _____ your first language? (Yes/No) If it is not, please specify what your first language is.
8. Do you have any comments or suggestions? (Free text)



Of our 24 corpora, we received 17 already parsed by the source: the Google Books Project (6 corpora), the Google Web Crawl (8 corpora), and Movie and TV subtitles (3 corpora). For the other 7 corpora (Twitter, New York Times, and Music Lyrics), we extracted words by standard white space separation (more on Twitter below). We acknowledge the many complications with inflections and variable orthography. We have found merit in not collapsing related words, which would require a more sophisticated treatment going beyond the present paper's bounds. Moreover, we have observed that allowing, say, different conjugation of verbs to stand in our corpora is valuable as human evaluations of such have proved to be distinguishable (e.g., present versus past tense [6]).

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Twitter was easily the most variable and unruly of our text sources and required additional treatment. We first checked if a string contains at least one valid utf8 letter, discarding if not. Next we filtered out strings containing invisible control characters, as these symbols can be problematic. We ignored all strings that start with < and end with > (generally html code). We ignored strings with a leading @ or &, or either preceded with standard punctuation (e.g., Twitter ID's), but kept hashtags. We also removed all strings starting with www. or http: or end in .com (all websites). We stripped the remaining strings of standard punctuation, and we replaced all double quotes (") by single quotes ('). Finally, we converted all Latin alphabet letters to lowercase.

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Tokenization example:

| Term | count | | Term | count |
|--------|-------|---|--------|-------|
| love | 10 | | love | 19 |
| LoVE | 5 | | #love | 3 |
| love! | 2 | → | love87 | 1 |
| #love | 3 | | | |
| .love | 2 | | | |
| @love | 1 | | | |
| love87 | 1 | | | |

The term '@love' is discarded, and all other terms map to either 'love' or 'love87'.



There is no single, principled way to merge corpora to create an ordered list of words for a given language. For example, it is impossible to weight the most commonly used words in the New York Times against those of Twitter. Nevertheless, we are obliged to choose some method for doing so to facilitate comparisons across languages and for the purposes of building adaptable linguistic instruments. For each language where we had more than one corpus, we created a single quasi-ranked word list by finding the smallest integer r such that the union of all words with rank $\leq r$ in at least one corpus formed a set of at least 10,000 words.

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| | Spanish | Portuguese | English | Indonesian | French | German | Arabic |
|------------|-------------|------------|-------------|-------------|-------------|-------------|-------------|
| Spanish | 1.00, 0.00 | 1.01, 0.03 | 1.06, -0.07 | 1.22, -0.88 | 1.11, -0.24 | 1.22, -0.84 | 1.13, -0.22 |
| Portuguese | 0.99, -0.03 | 1.00, 0.00 | 1.04, -0.03 | 1.22, -0.97 | 1.11, -0.33 | 1.21, -0.86 | 1.09, -0.08 |
| English | 0.94, 0.06 | 0.96, 0.03 | 1.00, 0.00 | 1.13, -0.66 | 1.06, -0.23 | 1.16, -0.75 | 1.05, -0.10 |
| Indonesian | 0.82, 0.72 | 0.82, 0.80 | 0.88, 0.58 | 1.00, 0.00 | 0.92, 0.48 | 0.99, 0.06 | 0.89, 0.71 |
| French | 0.90, 0.22 | 0.90, 0.30 | 0.94, 0.22 | 1.09, -0.52 | 1.00, 0.00 | 1.08, -0.44 | 0.99, 0.12 |
| German | 0.82, 0.69 | 0.83, 0.71 | 0.86, 0.65 | 1.01, -0.06 | 0.92, 0.41 | 1.00, 0.00 | 0.91, 0.61 |
| Arabic | 0.88, 0.19 | 0.92, 0.08 | 0.95, 0.10 | 1.12, -0.80 | 1.01, -0.12 | 1.10, -0.68 | 1.00, 0.00 |
| Russian | 0.76, 0.88 | 0.80, 0.75 | 0.83, 0.75 | 0.98, -0.04 | 0.89, 0.45 | 0.93, 0.24 | 0.89, 0.56 |
| Korean | 0.62, 1.70 | 0.62, 1.81 | 0.66, 1.67 | 0.77, 1.17 | 0.73, 1.37 | 0.78, 1.12 | 0.71, 1.53 |
| Chinese | 0.63, 1.46 | 0.63, 1.51 | 0.68, 1.43 | 0.75, 1.07 | 0.71, 1.26 | 0.76, 1.03 | 0.70, 1.41 |

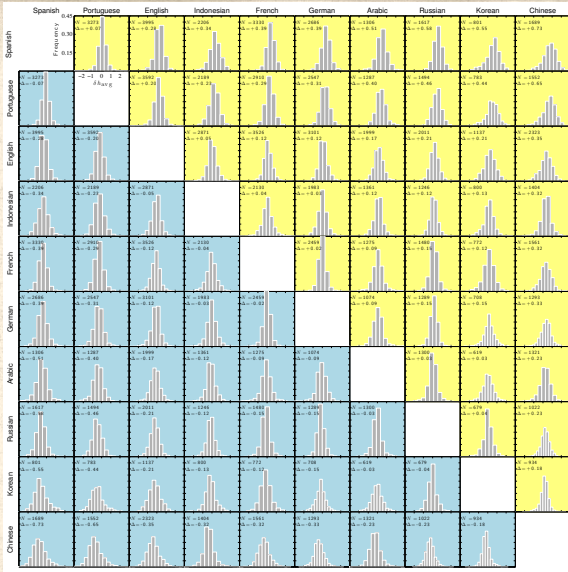
Reduced Major Axis (RMA) regression fits for row language as a linear function of the column language: $h_{\text{avg}}^{(\text{row})}(w) = m h_{\text{avg}}^{(\text{column})}(w) + c$ where w indicates a translation-stable word. Each entry in the table contains the coefficient pair m and c . We use RMA regression, also known as Standardized Major Axis linear regression, because of its accommodation of errors in both variables.

| | Spanish | Portuguese | English | Indonesian | French | German | Arabic | Russian |
|------------|---------|------------|---------|------------|--------|--------|--------|---------|
| Spanish | 1.00 | 0.89 | 0.87 | 0.82 | 0.86 | 0.82 | 0.83 | 0.73 |
| Portuguese | 0.89 | 1.00 | 0.87 | 0.82 | 0.84 | 0.81 | 0.84 | 0.84 |
| English | 0.87 | 0.87 | 1.00 | 0.88 | 0.86 | 0.82 | 0.86 | 0.87 |
| Indonesian | 0.82 | 0.82 | 0.88 | 1.00 | 0.79 | 0.77 | 0.83 | 0.85 |
| French | 0.86 | 0.84 | 0.86 | 0.79 | 1.00 | 0.84 | 0.77 | 0.84 |
| German | 0.82 | 0.81 | 0.82 | 0.77 | 0.84 | 1.00 | 0.76 | 0.80 |
| Arabic | 0.83 | 0.84 | 0.86 | 0.83 | 0.77 | 0.76 | 1.00 | 0.83 |
| Russian | 0.73 | 0.84 | 0.87 | 0.85 | 0.84 | 0.80 | 0.83 | 1.00 |
| Korean | 0.79 | 0.79 | 0.82 | 0.79 | 0.79 | 0.73 | 0.79 | 0.80 |
| Chinese | 0.79 | 0.76 | 0.81 | 0.77 | 0.76 | 0.74 | 0.80 | 0.82 |

Pearson correlation coefficients for translation-stable words for all language pairs. All p -values are $< 10^{-118}$.

| | Spanish | Portuguese | English | Indonesian | French | German | Arabic | Russian |
|------------|---------|------------|---------|------------|--------|--------|--------|---------|
| Spanish | 1.00 | 0.85 | 0.83 | 0.77 | 0.81 | 0.77 | 0.75 | 0.74 |
| Portuguese | 0.85 | 1.00 | 0.83 | 0.77 | 0.78 | 0.77 | 0.77 | 0.81 |
| English | 0.83 | 0.83 | 1.00 | 0.82 | 0.80 | 0.78 | 0.78 | 0.81 |
| Indonesian | 0.77 | 0.77 | 0.82 | 1.00 | 0.72 | 0.72 | 0.76 | 0.77 |
| French | 0.81 | 0.78 | 0.80 | 0.72 | 1.00 | 0.80 | 0.67 | 0.79 |
| German | 0.77 | 0.77 | 0.78 | 0.72 | 0.80 | 1.00 | 0.69 | 0.76 |
| Arabic | 0.75 | 0.77 | 0.78 | 0.76 | 0.67 | 0.69 | 1.00 | 0.74 |
| Russian | 0.74 | 0.81 | 0.81 | 0.77 | 0.79 | 0.76 | 0.74 | 1.00 |
| Korean | 0.74 | 0.75 | 0.75 | 0.71 | 0.71 | 0.64 | 0.69 | 0.70 |
| Chinese | 0.68 | 0.66 | 0.70 | 0.71 | 0.64 | 0.62 | 0.68 | 0.66 |

Spearman correlation coefficients for translation-stable words. All p -values are $< 10^{-82}$.



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Histograms of the change in average happiness for translation-stable words between each language pair. The largest deviations correspond to strong changes in a word's perceived primary meaning (e.g., 'lying' and 'acostado'). The inset quantities are N , the number of translation-stable words, and Δ is the average difference in translation-stable word happiness between the row language and column language.

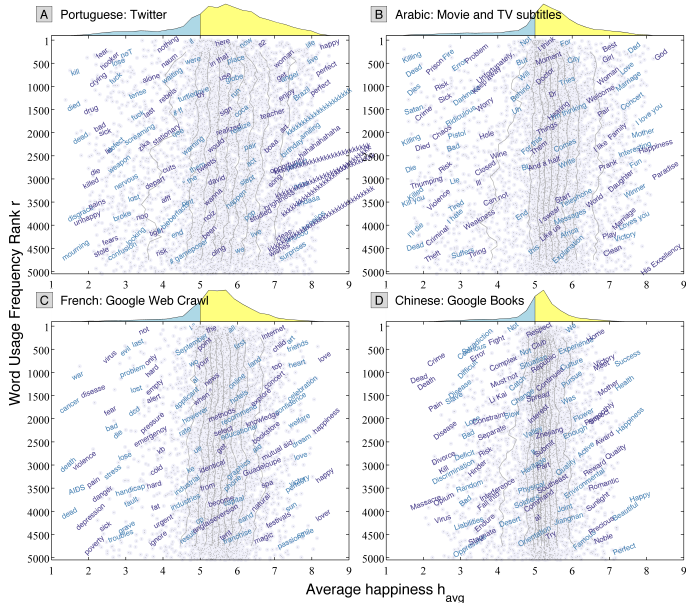


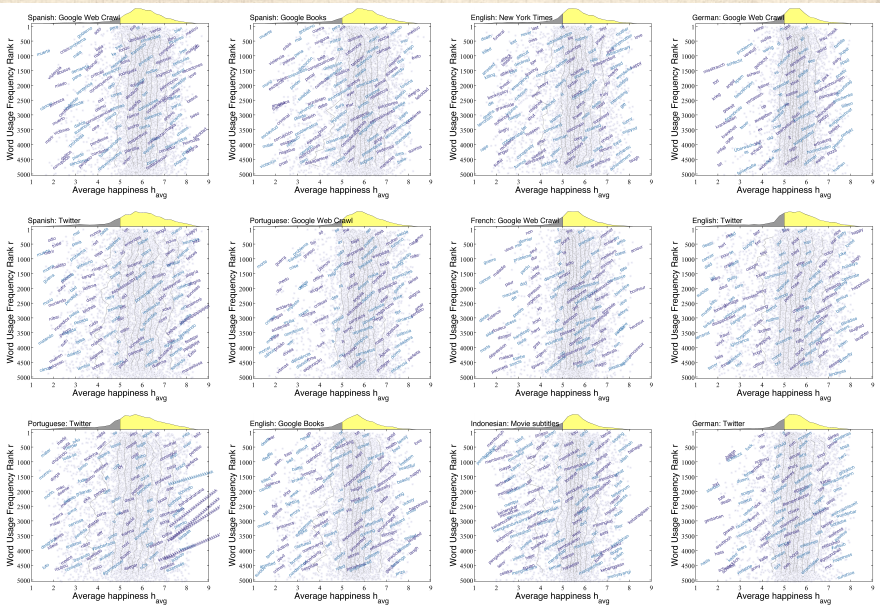
| Language: Corpus | ρ_p | p -value | ρ_s | p -value | α | β |
|---------------------------------|----------|------------------------|----------|------------------------|------------------------|---------|
| Spanish: Google Web Crawl | -0.114 | 3.38×10^{-22} | -0.090 | 1.85×10^{-14} | -5.55×10^{-5} | 6.10 |
| Spanish: Google Books | -0.040 | 1.51×10^{-3} | -0.016 | 1.90×10^{-1} | -2.28×10^{-5} | 5.90 |
| Spanish: Twitter | -0.048 | 1.14×10^{-4} | -0.032 | 1.10×10^{-2} | -3.10×10^{-5} | 5.94 |
| Portuguese: Google Web Crawl | -0.085 | 6.33×10^{-13} | -0.060 | 3.23×10^{-7} | -3.98×10^{-5} | 5.96 |
| Portuguese: Twitter | -0.041 | 5.98×10^{-4} | -0.030 | 1.15×10^{-2} | -2.40×10^{-5} | 5.73 |
| English: Google Books | -0.042 | 3.03×10^{-3} | -0.013 | 3.50×10^{-1} | -3.04×10^{-5} | 5.62 |
| English: New York Times | -0.056 | 6.93×10^{-5} | -0.044 | 1.99×10^{-3} | -4.17×10^{-5} | 5.61 |
| German: Google Web Crawl | -0.096 | 1.11×10^{-15} | -0.082 | 6.75×10^{-12} | -3.67×10^{-5} | 5.65 |
| French: Google Web Crawl | -0.105 | 9.20×10^{-19} | -0.080 | 1.99×10^{-11} | -4.50×10^{-5} | 5.68 |
| English: Twitter | -0.097 | 6.56×10^{-12} | -0.103 | 2.37×10^{-13} | -7.78×10^{-5} | 5.67 |
| Indonesian: Movie subtitles | -0.039 | 1.48×10^{-3} | -0.063 | 2.45×10^{-7} | -2.04×10^{-5} | 5.45 |
| German: Twitter | -0.054 | 1.47×10^{-5} | -0.036 | 4.02×10^{-3} | -2.51×10^{-5} | 5.58 |
| Russian: Twitter | -0.052 | 2.38×10^{-5} | -0.028 | 2.42×10^{-2} | -2.55×10^{-5} | 5.52 |
| French: Google Books | -0.043 | 6.80×10^{-4} | -0.030 | 1.71×10^{-2} | -2.31×10^{-5} | 5.49 |
| German: Google Books | -0.003 | 8.12×10^{-1} | +0.014 | 2.74×10^{-1} | -1.38×10^{-6} | 5.45 |
| French: Twitter | -0.049 | 6.08×10^{-5} | -0.023 | 6.31×10^{-2} | -2.54×10^{-5} | 5.54 |
| Russian: Movie and TV subtitles | -0.029 | 2.36×10^{-2} | -0.033 | 9.17×10^{-3} | -1.57×10^{-5} | 5.43 |
| Arabic: Movie and TV subtitles | -0.045 | 7.10×10^{-6} | -0.029 | 4.19×10^{-3} | -1.66×10^{-5} | 5.44 |
| Indonesian: Twitter | -0.051 | 2.14×10^{-5} | -0.018 | 1.24×10^{-1} | -2.50×10^{-5} | 5.46 |
| Korean: Twitter | -0.032 | 8.29×10^{-3} | -0.016 | 1.91×10^{-1} | -1.24×10^{-5} | 5.38 |
| Russian: Google Books | +0.030 | 2.09×10^{-2} | +0.070 | 5.08×10^{-8} | $+1.20 \times 10^{-5}$ | 5.35 |
| English: Music Lyrics | -0.073 | 2.53×10^{-7} | -0.081 | 1.05×10^{-8} | -6.12×10^{-5} | 5.45 |
| Korean: Movie subtitles | -0.187 | 8.22×10^{-44} | -0.180 | 2.01×10^{-40} | -9.66×10^{-5} | 5.41 |
| Chinese: Google Books | -0.067 | 1.48×10^{-11} | -0.050 | 5.01×10^{-7} | -1.72×10^{-5} | 5.21 |

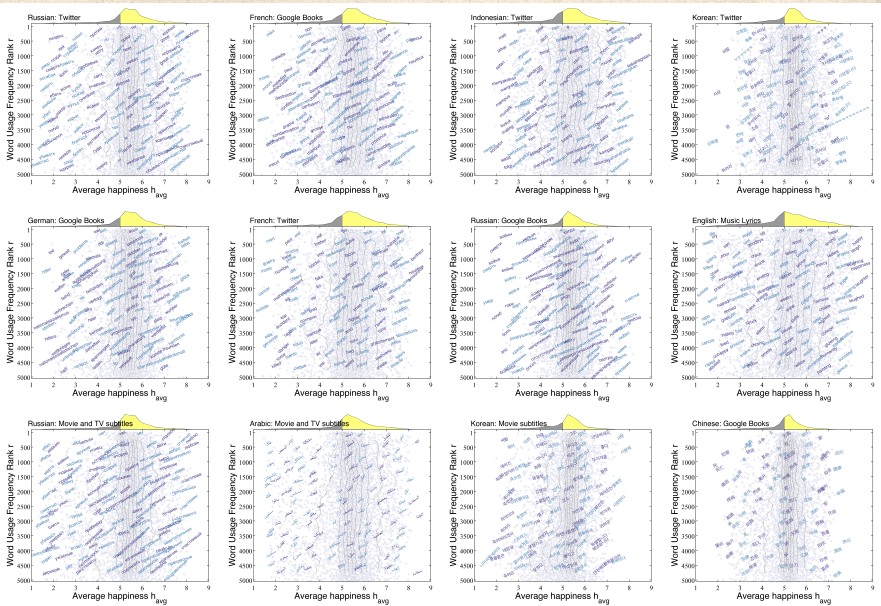
Pearson correlation coefficients and p -values, Spearman correlation coefficients and p -values, and linear fit coefficients, for average word happiness h_{avg} as a function of word usage frequency rank r . We use the fit is $h_{\text{avg}} = \alpha r + \beta$ for the most common 5000 words in each corpora, determining α and β via ordinary least squares, and order languages by the median of their average word happiness scores (descending). We note that stemming of words may affect these estimates.

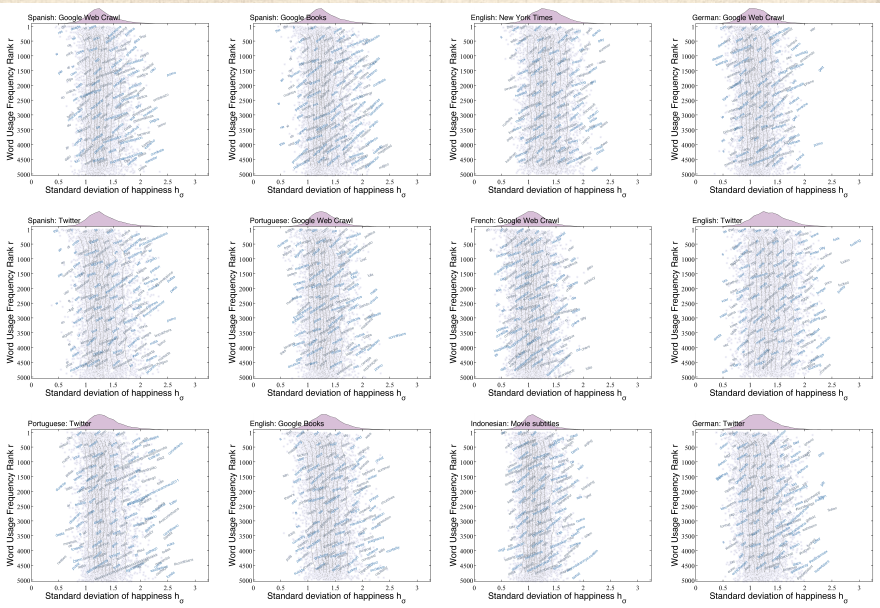
| Language: Corpus | ρ_p | p -value | ρ_s | p -value | α | β |
|---------------------------------|----------|------------------------|----------|------------------------|-----------------------|---------|
| Portuguese: Twitter | +0.090 | 2.55×10^{-14} | +0.095 | 1.28×10^{-15} | 1.19×10^{-5} | 1.29 |
| Spanish: Twitter | +0.097 | 8.45×10^{-15} | +0.104 | 5.92×10^{-17} | 1.47×10^{-5} | 1.26 |
| English: Music Lyrics | +0.129 | 4.87×10^{-20} | +0.134 | 1.63×10^{-21} | 2.76×10^{-5} | 1.33 |
| English: Twitter | +0.007 | 6.26×10^{-1} | +0.012 | 4.11×10^{-1} | 1.47×10^{-6} | 1.35 |
| English: New York Times | +0.050 | 4.56×10^{-4} | +0.044 | 1.91×10^{-3} | 9.34×10^{-6} | 1.32 |
| Arabic: Movie and TV subtitles | +0.101 | 7.13×10^{-24} | +0.101 | 3.41×10^{-24} | 9.41×10^{-6} | 1.01 |
| English: Google Books | +0.180 | 1.68×10^{-37} | +0.176 | 4.96×10^{-36} | 3.36×10^{-5} | 1.27 |
| Spanish: Google Books | +0.066 | 1.23×10^{-7} | +0.062 | 6.53×10^{-7} | 9.17×10^{-6} | 1.26 |
| Indonesian: Movie subtitles | +0.026 | 3.43×10^{-2} | +0.027 | 2.81×10^{-2} | 2.87×10^{-6} | 1.12 |
| Russian: Movie and TV subtitles | +0.083 | 7.60×10^{-11} | +0.075 | 3.28×10^{-9} | 1.06×10^{-5} | 0.89 |
| French: Twitter | +0.072 | 4.77×10^{-9} | +0.076 | 8.94×10^{-10} | 1.07×10^{-5} | 1.05 |
| Indonesian: Twitter | +0.072 | 1.17×10^{-9} | +0.072 | 1.73×10^{-9} | 8.16×10^{-6} | 1.12 |
| French: Google Books | +0.090 | 1.02×10^{-12} | +0.085 | 1.67×10^{-11} | 1.25×10^{-5} | 1.02 |
| Russian: Twitter | +0.055 | 6.83×10^{-6} | +0.053 | 1.67×10^{-5} | 7.39×10^{-6} | 0.91 |
| Spanish: Google Web Crawl | +0.119 | 4.45×10^{-24} | +0.106 | 2.60×10^{-19} | 1.45×10^{-5} | 1.23 |
| Portuguese: Google Web Crawl | +0.093 | 4.06×10^{-15} | +0.083 | 2.91×10^{-12} | 1.07×10^{-5} | 1.26 |
| German: Twitter | +0.051 | 4.45×10^{-5} | +0.050 | 5.15×10^{-5} | 7.39×10^{-6} | 1.15 |
| French: Google Web Crawl | +0.104 | 2.12×10^{-18} | +0.088 | 9.64×10^{-14} | 1.27×10^{-5} | 1.01 |
| Korean: Movie subtitles | +0.171 | 1.39×10^{-36} | +0.185 | 8.85×10^{-43} | 2.58×10^{-5} | 0.88 |
| German: Google Books | +0.157 | 6.06×10^{-35} | +0.162 | 4.96×10^{-37} | 2.17×10^{-5} | 1.03 |
| Korean: Twitter | +0.056 | 4.07×10^{-6} | +0.062 | 4.25×10^{-7} | 6.98×10^{-6} | 0.93 |
| German: Google Web Crawl | +0.099 | 2.05×10^{-16} | +0.085 | 1.18×10^{-12} | 1.20×10^{-5} | 1.07 |
| Chinese: Google Books | +0.099 | 3.07×10^{-23} | +0.097 | 3.81×10^{-22} | 8.70×10^{-6} | 1.16 |
| Russian: Google Books | +0.187 | 5.15×10^{-48} | +0.177 | 2.24×10^{-43} | 2.28×10^{-5} | 0.81 |

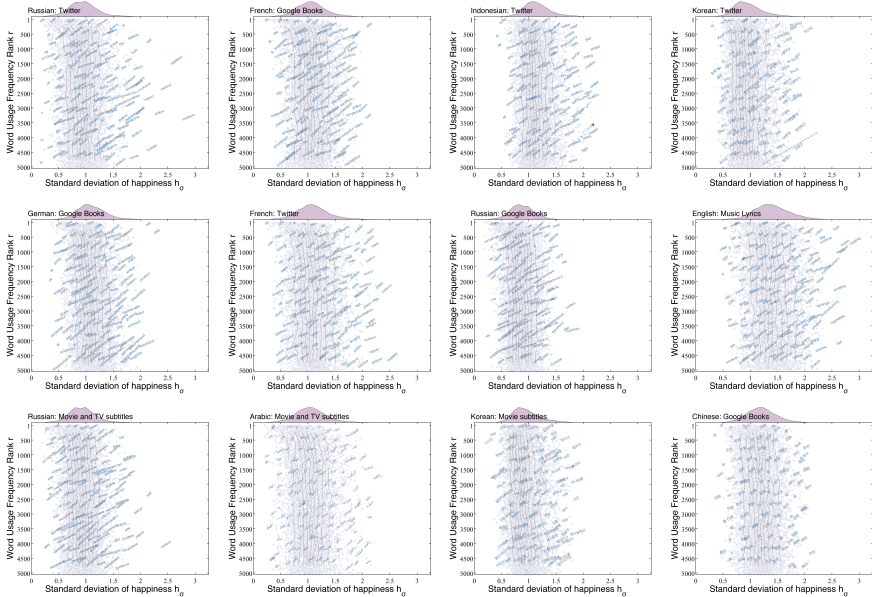
Pearson correlation coefficients and p -values, Spearman correlation coefficients and p -values, and linear fit coefficients for standard deviation of word happiness h_{std} as a function of word usage frequency rank r . We consider the fit is $h_{\text{std}} = \alpha r + \beta$ for the most common 5000 words in each corpora, determining α and β via ordinary least squares, and order corpora according to their emotional variance (descending).

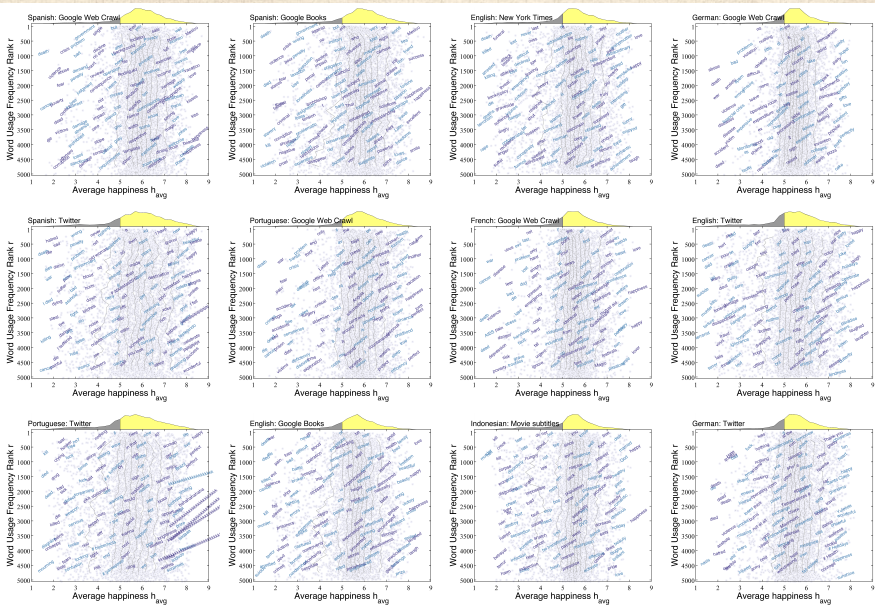


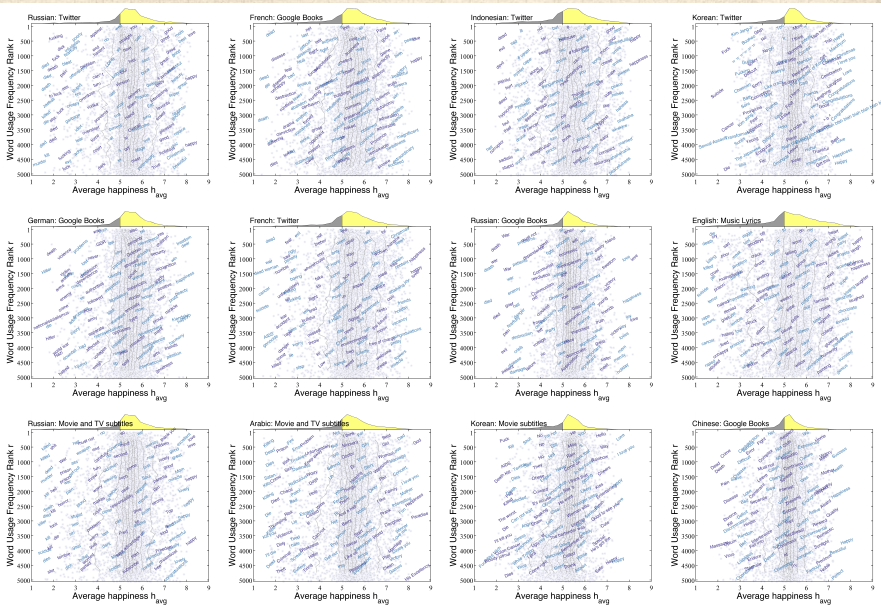


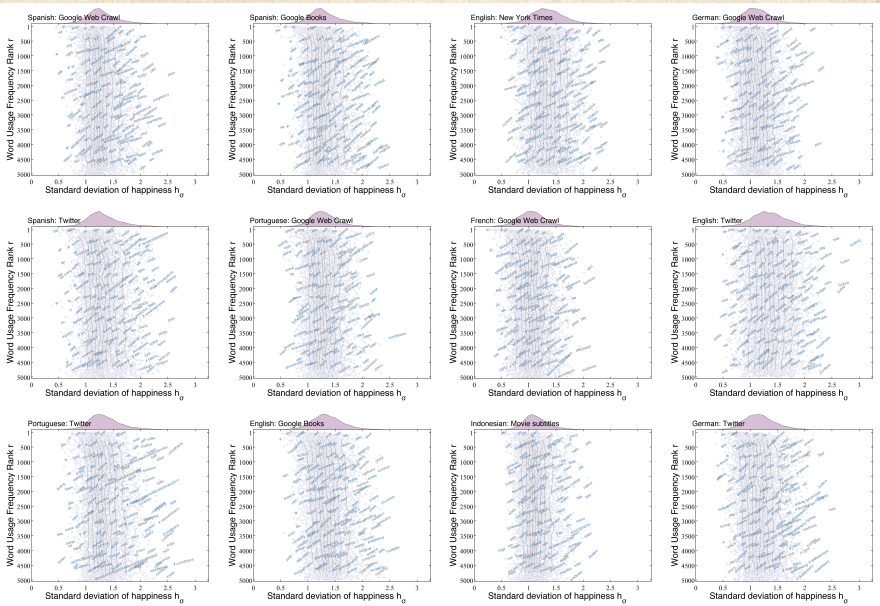


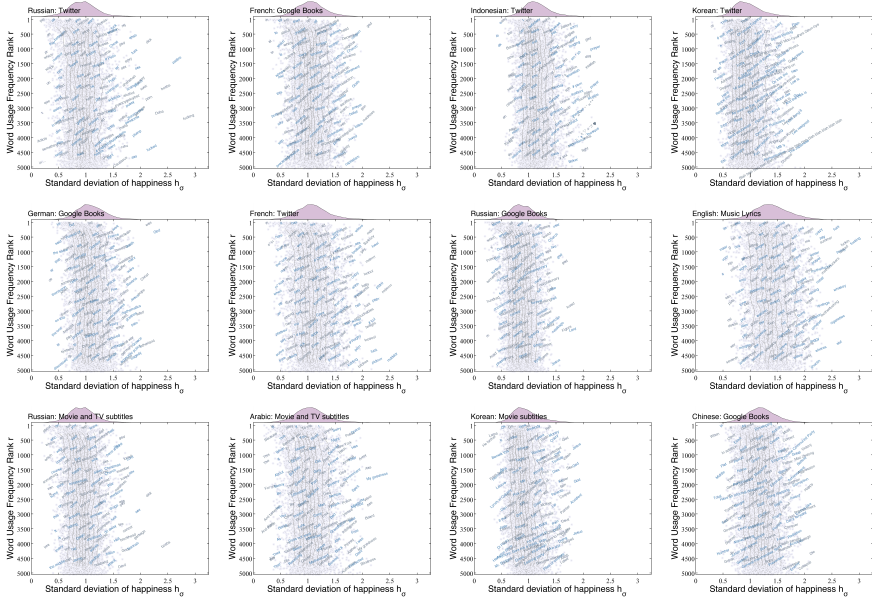












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