



Historical language records reveal a surge of cognitive distortions in recent decades

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Individuals with depression are prone to maladaptive patterns of thinking, known as cognitive distortions, whereby they think about themselves, the world, and the future in overly negative and inaccurate ways. These distortions are associated with marked changes in an individual's mood, behavior, and language. We hypothesize that societies can undergo similar changes in their collective psychology that are reflected in historical records of language use. Here, we investigate the prevalence of textual markers of cognitive distortions in over 14 million books for the past 125 y and observe a surge of their prevalence since the 1980s, to levels exceeding those of the Great Depression and both World Wars. This pattern does not seem to be driven by changes in word meaning, publishing and writing standards, or the Google Books sample. Our results suggest a recent societal shift toward language associated with cognitive distortions and internalizing disorders.

cognitive distortions | internalizing disorders | historical language analysis

Depression is a leading contributor to the burden of disability worldwide (1, 2). Some evidence indicates that disability attributed to depression has been rising over the past decades, particularly among youth (3–5). Can societies collectively become more or less depressed over time, as their populations are exposed to stressors such as war, political upheaval, economic collapse, food insecurity, inequality, and disease (6, 7)? This question is difficult to answer for long time scales because formal diagnostic criteria were introduced only 40 y ago and these criteria have undergone changes over time (8).

Depression is associated with distinct and recognizable maladaptive thinking patterns, referred to as cognitive distortions, wherein individuals think about themselves, the future, and the world in inaccurate and overly negative ways (9–12). For example, a cognitive distortion seen in depression occurs when individuals label themselves in negative, absolutist terms (e.g., “I am a loser”). They may talk about future events in dichotomous, extreme terms (e.g., “My meeting will be a complete disaster”) or make unfounded assumptions about someone else’s state of mind (e.g., “Everybody will think that I am a failure”). Typologies of cognitive distortions generally differentiate between a number of partially overlapping types, such as “catastrophizing,” “dichotomous reasoning,” “disqualifying the positive,” “emotional reasoning,” “fortune telling,” “labeling and mislabeling,” “magnification and minimization,” “mental filtering,” “mindreading,” “overgeneralizing,” “personalizing,” and “should statements.”

The theory underlying cognitive-behavioral therapy (CBT), the gold standard for the treatment of depression and other internalizing disorders (13), holds that cognitive distortions are associated with internalizing disorders; they reflect negative affectivity and avoidant behavioral patterns in the context of environmental stress (14, 15). Language is closely intertwined with this dynamic. In fact, recent research shows that individu-

als with internalizing disorders express significantly higher levels of cognitive distortions in their language (16, 17) to the point that their prevalence may be used as an index of vulnerability for depression (18, 19).

Here, we leverage the connection between depression and language to investigate whether societies as a whole, similar to individuals with depression, can undergo changes in their collective language that are associated with cognitive distortions. We analyze the prevalence of a large set of markers of cognitive distortions over the past 125 y in a collection of more than 14 million books (Google Books) published in English, Spanish, and German. Specifically, we are examining the longitudinal prevalence of hundreds of short sequences of one to five words (n-grams), labeled cognitive distortion schemata (CDS), that were designed by a team of CBT experts, computational linguists, and bilingual native speakers and externally validated by a panel of CBT experts, to capture the expression of 12 types of cognitive distortions (9). The CDS n-grams were designed as short, unambiguous, and stand-alone statements that expressed the core of a particular cognitive distortion type, using highly frequent terms (Fig. 1 and *SI Appendix, Tables S1–S3*). For example, the 3-gram “I am a” captures a labeling and mislabeling distortion, regardless of its context or the precise labeling involved (“lady,” “honorable person,” “loser,” etc.). These same n-grams were in earlier research shown to be significantly more

Significance

Can entire societies become more or less depressed over time? Here, we look for the historical traces of cognitive distortions, thinking patterns that are strongly associated with internalizing disorders such as depression and anxiety, in millions of books published over the course of the last two centuries in English, Spanish, and German. We find a pronounced “hockey stick” pattern: Over the past two decades the textual analogs of cognitive distortions surged well above historical levels, including those of World War I and II, after declining or stabilizing for most of the 20th century. Our results point to the possibility that recent socioeconomic changes, new technology, and social media are associated with a surge of cognitive distortions.

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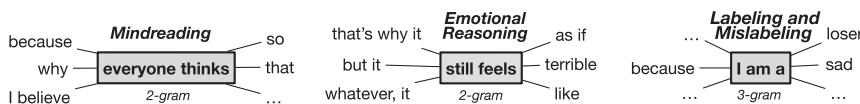


Fig. 1. Examples of CDS n-grams shown inside gray boxes, surrounded by plausible context words that may vary without affecting whether the n-gram marks the expression of a cognitive distortion of the given type (e.g., mindreading, emotional reasoning, or labeling and mislabeling). CDS were designed by a team of CBT experts, linguists, and native language speakers to capture the expression of a particular cognitive distortion type, regardless of its specific lexical context. For English (US), Spanish, and German the team of experts defined respectively 241, 435, and 296 n-grams to mark 12 commonly distinguished types of cognitive distortions. Note that our prevalence measurements count only the CDS n-gram occurrence regardless of context ("everyone thinks," "still feels," and "I am a"). A complete list of all CDS n-grams by distortion type is provided in *SI Appendix, Tables S1–S3*.

prevalent in the language of individuals with depression vs. a random sample (17).

To account for changes in publication volume, for each CDS n-gram we define its prevalence in a given year as the number of times it occurred that year in the Google Books data divided by the total volume published (estimated from end-of-sentence punctuation numbers). All resulting time series are converted to z scores, to provide the same scale of comparison between different CDS n-grams, and compared to a null model of randomly chosen n-grams for the same years and set of books (*Materials and Methods*).

Results

We perform this analysis for three unique geographic and linguistic spheres: 1) the United States of America (US English), 2) the German-speaking countries (German), and 3) all Spanish-speaking countries (Spanish). English (US), Spanish, and German were chosen as the focal points of our analysis because they share a common alphabet, a common history and vary in terms of whether they are spoken as a first language either in a particular geographic region (US books only and German-speaking countries) or across several continents (Spanish) as a control. We limit our analysis to the range 1855 to 2019 since it provides 125 y of persistently high publishing volume for all three languages and few grammatical, orthographic, or spelling changes that would affect our analysis. Although books published in a specific language in a particular geographic area are not necessarily a representative reflection of society as a whole, persistent language trends over decades and centuries, observed from tens of millions of books, have in previous research been shown to signal cultural, linguistic, and psychological changes (18, 20–28).

Trends for English (US), Spanish, and German. We first examine the history of the median prevalence (z scores) of the entire set of

English cognitive distortion schemata ($n = 241$) in English (US) books ($N = 9,018,119$, United States only), from 1855 to 2019 (Fig. 2A). Since these data pertain only to books published in the United States, we mark notable events in US history or notable changes in the time series: the end of the century in 1899; the start of World War I; the financial collapse of 1929; the start of World War II; a peak of CDS prevalence in 1968; and distinct trend changes in 1978, 1999, and 2007.

The overall trend of CDS prevalence for most of the 20th century pointed distinctly downward toward a historic minimum in 1978, with only a few noticeable peaks, one surrounding the turn of the century in 1899 (possibly related to the Spanish–American war), a slight peak from 1940 to 1945 (around the time of World War II), and a sharp peak in 1968 (possibly related to social and political unrest). From 1978, we observe an accelerating increase in CDS prevalence. This acceleration seems to be separated into three periods: an accelerating increase from 1978 to 1999 (where CDS prevalence first exceeds levels observed in the 1910s), an even more rapid increase after 1999 to roughly 2007, followed by an acceleration after 2007, and a possible stabilization in 2010. The so-called “bursting of the dot.com bubble” seems to coincide with an acceleration of the increase of CDS prevalence after 1999 whereas the acceleration since 2007 seems to coincide with the widespread uptake of social media and the start of the Great Recession. Present CDS prevalence levels exceed those observed since the 1900s by almost two standard deviations (excepting the 1899 peak).

We include Spanish in our analysis as a control vs. English (US) and German since it is not confined to a particular geographic region; i.e., these data encompass all books published in Spanish, which includes Spain (Europe) and most of Latin America ($N = 1,658,438$ books). The prevalence of Spanish CDS markers ($N = 435$ n-grams) remains quite stable throughout the 20th century, with a moderate increase around the start of World War I, a very short moderate spike in 1929, and an upward

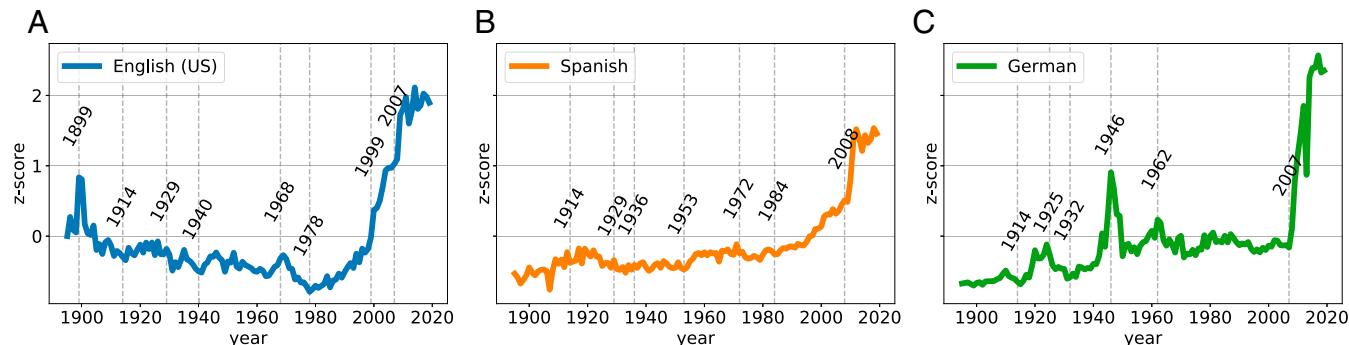


Fig. 2. (A–C) Median z scores of time series of CDS n-gram prevalence from 1855 to 2020 (125 y) in US English (A), Spanish (B), and German (C) with year markers added for major historical events. All time series reveal stable or declining levels for most of the 20th century followed by a sharp surge of cognitive distortions in the past three decades. US English shows declining levels from 1899 to 1978, with minor peaks around 1914 and 1940 (World War I and World War II) and notably 1968. This decline is followed by a surge of CDS prevalence starting in 1978 that continues to 2019. For Spanish we find stable levels from 1895 to the early 1980s at which point a trend occurs toward higher CDS prevalence levels above any of those previously observed. German shows stable CDS prevalence levels, with the exception of strong peaks around and after World War I and World War II, until 2007 at which point a sudden surge occurs.

departure from a 30-y downward trend in 1953 after which levels seem to level off until 1984 (Fig. 2B). Starting in 1984, however, we observe the same hockey-stick pattern as we saw for English (US): a sharp acceleration of an upward trend starting in 1984 leading to present CDS prevalence levels that exceed the historical baseline by more than one standard deviation. This trend seems to accelerate in 2008.

The pattern of prevalence for German (Fig. 2C) books ($N = 3,843,962$) provides face validity for the ability of our CDS markers ($N = 296$ n-grams) to capture significant moments of stress in a population, since they match major historical and geopolitical events that are specific to German-speaking countries (predominantly Germany and Austria). Contrary to English and Spanish CDS, prevalence levels start relatively low around the 1900s, but sharply increase since the start of World War I, reaching a peak in 1920 and 1923, coinciding with the aftermath of World War I in Germany and a devastating recession in 1923. Throughout the existence of the Weimar Republic, we observe decreasing levels of CDS markers.

However, this trend is interrupted in 1932 at which point cognitive distortion levels increase sharply. This period includes major social upheaval, economic struggles, the end of the Weimar Republic, the emergence of the Nazi regime, and the start of World War II. CDS prevalence levels increase rapidly during World War II, reaching their peak in 1946, the year after Germany was defeated. CDS prevalence declines sharply afterward and reaches a stable plateau throughout the 1950s to 2007, with only a minor peak in 1962 and no indications of accelerating CDS prevalence levels during the 1970s or 1980s as we observe for English (US) and Spanish. Notably, in 2007, at the start of the worldwide Great Recession we see a nearly immediate increase of CDS prevalence levels to nearly two standard deviations above the historical mean.

Null Model of Randomly Chosen N-Grams. We compare the pattern of change for all three languages in terms of the 95% confidence intervals of CDS prevalence (*Materials and Methods, Bootstrapping*) for English (US), Spanish, and German against a null model of 10,000 sets of 241 randomly chosen n-grams (Fig. 3). These sets of random n-grams were sampled from all n-grams in the respective English, Spanish, and German Google n-gram corpus such that they have the same number of 1- to 5-grams as the respective CDS set and the same bias toward recently published books due to increased publication volume over time (*Materials and Methods, Null Model*).

We provide annotations that mark significant historical events in the graph that have affected the three populations such as the

financial crisis of 1929 (“Wall St. crash”), the two World Wars, and the great recession starting in 2007. CDS prevalence levels for English (US), Spanish, and German significantly exceed those of this null model in recent decades, but in the case of Germany also during World War I and World War II. Note that English (US) levels fall below those of the null model from the 1920s to the 1990s (*SI Appendix, Fig. S6*).

Trends for Distinct Cognitive Distortion Types. We plot the time series of yearly mean CDS prevalence separated by 12 commonly recognized cognitive distortion types (14) for English (US), Spanish, and German (Fig. 4). For all three languages and across most cognitive distortion types we see the characteristic hockey-stick signature of stable or declining CDS prevalence levels followed by a surge above historical levels during the period 1980 to 2010 to levels well above the historical mean. The one exception is should statements, which, due to their grammatical structure, may be difficult to translate to n-grams uniquely associated with the specific cognitive distortion.

For English we frequently see a “tilted hockey stick” pattern where certain types of CDS n-grams declined over the 20th century followed by a rapid surge of prevalence since 1978. This is the case for fortune telling, overgeneralizing, magnification and minimization, mindreading, and labeling and mislabeling and perhaps most pronounced for dichotomous reasoning, suggesting that these distortion types are likely responsible for the decline of CDS prevalence observed throughout the 20th century (Fig. 24). We also find slight peaks for catastrophizing, emotional reasoning, and mindreading at the time of the US involvement in World War II. For German, however, we see peaks surrounding World War I and World War II for dichotomous reasoning, fortune telling, labeling and mislabeling, mental filtering, mindreading, overgeneralizing, personalizing, and should statements, possibly indicating the widespread effects of the two World Wars on German language use.

Robustness and Limitations. As our observations could be caused by a number of effects and biases, we conducted a number of mitigation controls and sensitivity analyses to test alternative explanations for the observed patterns.

Language effects. We caution that changes in meaning or semantic shift of the CDS n-grams may potentially bias our results. As a rhetorical example, the 1-gram “ever” could acquire a different meaning or usage over time and hence lose its meaning as a marker of a cognitive distortion of the dichotomizing

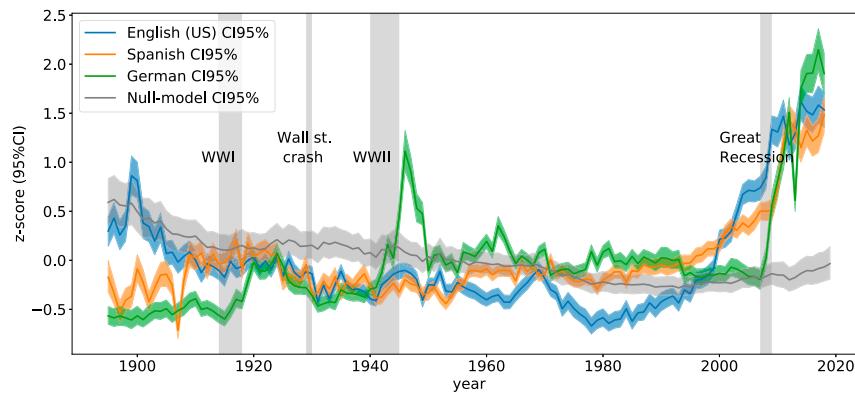


Fig. 3. CDS prevalence for English, Spanish, and German superimposed with a null-model estimate of random n-gram prevalence. Colored bands indicate 95% confidence intervals of yearly z-score values estimated with 10,000-fold bootstrap of the set of individual CDS time series. Gray band indicates 95% confidence interval of a null model of 10,000 sets of 241 randomly chosen n-grams with the same length distribution as the English (US) CDS set (*Materials and Methods, Null Model*).

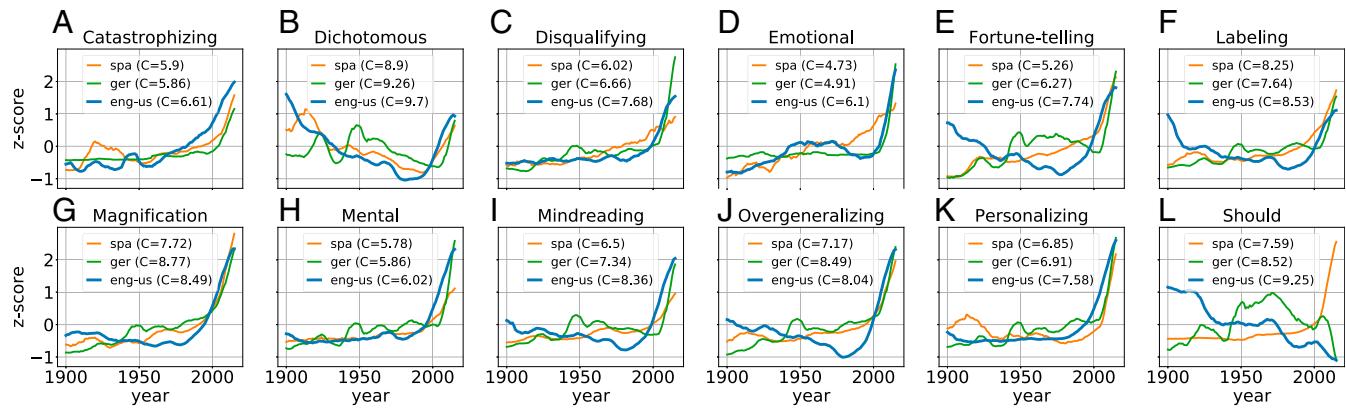


Fig. 4. (A–L) CDS n-gram prevalence from 1855 to 2019 (median z score smoothed by 10-y rolling mean), for English, Spanish, and German, grouped by cognitive distortion type, namely (A) catastrophizing, (B) dichotomous reasoning, (C) disqualifying the positive, (D) emotional reasoning, (E) fortune telling, (F) labeling and mislabeling, (G) magnification and minimization, (H) mental filtering, (I) mindreading, (J) overgeneralizing, (K) personalizing, and (L) should statements. Nearly all time series reveal a universal hockey-stick pattern of recently surging CDS n-gram prevalence levels across cognitive distortion types. The value C indicates the log (base 10) of the total frequency of CDS n-grams in the specific cognitive distortion category as an indication of the order of magnitude of its contribution to our observations.

type. We perform several controls to account for changes in language over time. First, the CDS n-grams consist predominantly of words that have been among the most frequent since 1895 [mean word percentile among all 1-grams $M(P_r) = 99.885$, $SD = 0.346$; *SI Appendix*, Fig. S1]. The CDS n-grams have equally been among the most frequent since 1895 [mean CDS n-gram percentile among all 2- to 5-grams $M(P_r) = 0.946$, $SD = 0.010$; *SI Appendix*, Fig. S2]. Hamilton, Leskovec, and Jurafsky (25) quantify semantic shifts over historical time using word embeddings, showing that frequent words experience the lowest rate of change, scaling with an inverse power law of word frequency. Hence the rate of semantic shift of the words in our CDS n-grams and the CDS n-grams themselves could be among the lowest as well. Second, a trend toward shorter sentences (29) may provide alternative explanations of our observations, but although sentence length did decrease from 1890 to the 1920s in English, it has remained stable since (30). Furthermore, our analysis accounts for changes in sentence length by normalizing n-gram prevalence by the frequency of end-of-sentence punctuation for that year (*Materials and Methods, Time Series: Prevalence and Normalization*). Finally, we previously showed that the prevalence of the CDS n-grams in the language of individuals with depression is not affected by the emotional valence of the n-grams or the presence of personal pronouns (17); hence, a language trend toward more emotional language or use of personal pronouns is not likely to affect our results.

Sampling effects. There are several issues that could arise from our Google Books sample. First, Pechenick et al. (31) show indications of a possible increase in technical writing and non-fiction in the Google Books sample over the past decades. Since our CDS n-grams contain personal pronouns, common verbs, and adjectives that may refer to personal matters, if the amount of technical writing and nonfiction increased, one could hypothesize this could explain a decrease in CDS prevalence. However, we observe the opposite, a significant increase of CDS prevalence.

Second, the choice of CDS n-grams could lead to a “recency bias” in our results, explaining their rise in prevalence in recent decades. We control for this effect with a null model that samples random n-grams more frequently from recent books, due to rapidly increasing publication volume since 1895, thereby inducing a bias toward more recent language. We observe increases of CDS n-gram prevalence well above levels predicted by this null model (Fig. 3). Hence, a recency bias alone may not likely explain

the observed surge in CDS prevalence in recent decades relative to this null model.

Finally, all n-grams in the English (US), Spanish, and German CDS sets occurred in every year from 1895 to 2019, indicating they were in continuous use throughout this period. They were highly frequent from 1895 to 2019, in fact on average more frequent than 94.6% ($SD = 0.0103$) of all n-grams in the Google Books data (*SI Appendix*, Figs. S1 and S2). We furthermore bootstrap our prevalence estimates to gauge the sensitivity of our findings to random changes in the set of CDS n-grams over time (*Materials and Methods, Bootstrapping*). The narrow 95% CI bands (Fig. 3) throughout the period under consideration indicate the stability of our observations over time.

CDS limitations. We caution that although the Google Books data have been widely used to assess cultural and linguistic shifts, and they are one of the largest records of historical literature, it remains uncertain whether CDS prevalence truly reflects changes in societal language and societal wellbeing. Many books included in the Google Books sample were published at times or locations marked by reduced freedom of expression, widespread propaganda, social stigma, and cultural as well as socioeconomic inequities that may reduce access to the literature, potentially reducing its ability to reflect societal changes. Although CDS n-gram prevalence was shown to be higher in individuals with depression (17) and our composition of CDS n-grams closely follows the framework of cognitive distortions established by Beck (9), they do not constitute an individual diagnostic criterion with respect to authors, readers, and the general public. It is also not clear whether the mental health status of authors provides a true reflection of societal changes nor whether cultural changes may have taken place that altered the association between mental health, cognitive distortions, and their expression in language.

Discussion

While the differences between the languages are interesting, perhaps the most important point is that the expression of cognitive distortions increases for all three languages in the recent three decades, leading to a distinct hockey-stick pattern indicating a surge of the CDS prevalence levels, which serve as lexical markers of cognitive distortions.

We can only speculate on the possible underlying causes of the observed surge of CDS prevalence for these three languages, since our results do not establish any causal mechanisms. The

strong increases of CDS prevalence in German during World Wars I and II are validating with respect to the ability of our CDS n-grams to signal societal dynamics in times of turmoil and run counter to the hypothesis that our results are caused by a recency bias in our choice of CDS n-grams and the Google Books sample. In fact, the surge of CDS prevalence during and right after World War II may be the product of a detrimental combination of the war experience and National Socialist propaganda. While there was not a separate language of National Socialism (32), the discourse of National Socialism invaded many registers of speech, including everyday language use, and thus normalized the political agenda (33, 34). In particular, the discourse of National Socialism is shaped by a language of identity that emphasizes an us-them divide (35), which relates to several markers of CDS n-grams, e.g., dichotomous reasoning, labeling and mislabeling, mindreading, and fortune telling. The tumultuous period of 1959 to 1962 in Germany cemented the division of East and West when the Berlin Wall was built in 1961. Interestingly, the fall of the Wall in 1989 did not result in higher amounts of psychological distress (36) and also does not register on fluctuations of CDS n-grams prevalence. The German data show a period of stability from 1962 up to the rapid increase after 2007.

Other differences between the dynamics of cognitive distortions in the three language corpora we analyzed might also point to relevant drivers. For instance, in Spanish and English we see a rising trend starting around 1980, whereas in German there is no such rise, only a sharp jump to a higher level in 2007. It is possible that the reunification of Germany in 1990 and the increased integration of the German-speaking countries in the European Union (and the introduction of the Euro currency in 1999) provided resilience to trends recorded in Spanish and English prior to 2007.

It is suggestive that the timing of the US surge in CDS prevalence coincides with the late 1970s when wages stopped tracking increasing work productivity. This trend was associated with rises in income inequality to recent levels not seen since the 1930s (37). This phenomenon has been observed for most developed economies, including Germany, Spain, and Latin America, contemporaneous with the rapid growth of automation and demand for highly skilled labor (38). The great recession of 2007 might have compounded the effects of this decades-long trend that started in the late 1970s. The widespread adoption of communication technologies such as the internet, the World Wide Web, and social media (39–42) may have driven greater societal and political polarization (43, 44) at a global level (45). The language of such polarization may correspond to cognitive distortions (46), in particular us-vs.-them thinking (labeling and mislabeling), dichotomous reasoning, mindreading (47), overgeneralizing, emotional reasoning, and catastrophizing.

We caution that we make no causal claims with respect to the relationship between lexical markers, cognitive distortions, and internalizing disorders, and the above comments therefore constitute speculations that we hope may inspire follow-up research. Regardless of speculation with respect to the underlying cultural, social, or economic drivers, our results indicate historically high levels of the expression of a large set of lexical markers of cognitive distortions in three languages. Given the association between cognitive distortions and internalizing disorders, this points to the possibility that large populations are increasingly stressed by pervasive cultural, economic, and social changes. The rising prevalence of depression and anxiety (3–5) in recent decades seems to align with our observations.

The availability of large-scale historical records of published languages going back centuries may provide a unique opportunity for the quantitative investigation of important cultural and linguistic dynamics (“culturomics”) (21), while acknowledging

limitations with respect to verifying hypotheses and testing the causal mechanisms that underlie any observations from these data. Future work may contribute to a better understanding of how changes in the collective psychology of societies can be observed over time and how these changes are manifested in their language in response to a variety of cultural and socioeconomic challenges, for example from quantitative indicators of semantic shifts in word meaning (25).

Materials and Methods

Google Books N-Gram Data. We used the third version 2019 release of the Google Books n-gram data, which the Google Books team makes freely available online (<https://storage.googleapis.com/books/ngrams/books/datasetsv3.html>). The data span from the 16th century to the year 2019, with increasing coverage of later years as publication volume grew rapidly.

Cognitive Distortion N-Grams. A panel of CBT experts engaged in a collaborative design effort to compile a set of 241 English n-grams (sequences of $n = 1, 2, 3, 4$, and 5 words) that were deemed to indicate the expression of a cognitive distortion of a particular type. These CDS n-grams were designed to consist of simple, frequent, and nontechnical expressions, e.g., “I am a,” “he thinks,” “will be,” etc., designed to be stand-alone expressions of cognitive distortions regardless of their specific context. For example, “I am a [defeated gentlemen]” and “I am a [loser]” both constitute an expression of a labeling and mislabeling captured by the “I am a” 3-gram.

The set of 241 English n-grams was subsequently translated from English into Spanish and German. This translation mainly focused on retaining the cognitive distortion expression of an n-gram in the target language. All translations were collaboratively compared, back translated, and validated by members of our team of CBT experts and native language speakers to ensure consensus. Since CDS n-grams are short expressions of frequent one, two, three, four, or five words, many have nearly literal translations, e.g., “I am a” translates to “Yo soy un” and “yo soy una.” We provide the complete lists of all English, Spanish, and German CDS n-grams in *SI Appendix, Tables S1–S3*.

The number of CDS n-grams is higher in Spanish and German than in English since the former need to capture grammatical variations such as conjugations, cases and inflections, and gender. Some n-grams were translated to regular expressions (RE) to capture succinctly all possible lexical and grammatical variations of the same CDS in Spanish and German. For example, the English “I am a” was translated to the REs “Yo soy un(a),” which matches both the male and female gender of the definite article in Spanish, and “ich bin ein(e,em,er,en,es)” to match all possible grammatical variations in German (including misspellings or errors). Note that in the case of German the operative verb or term is frequently at the end of the sentence. For example, the n-gram “I never” was translated to the regular expression “Ich (.+) nie,” matching any 3-, 4-, and 5-gram that starts with “Ich” (!) and ends in “nie” (never) such as “Ich habe nie” (I never have), “Ich hatte nie” (I never had), and “Ich war nie” (I never was).

All n-grams and REs were matched in a case-insensitive manner against the Google Books data to capture the widest possible lexical variation across time, including all capitalizations. One given CDS, depending on capitalization and grammatical variations, could match multiple expressions. For example, the German regular expression “Ich bin ein(e,es,em, . . .)” could match any of “ich bin ein,” “Ich bin eine,” “ich bin eines”, etc., including some variations that are rare or even grammatically incorrect (e.g., other letters capitalized). All such matches for each individual n-gram were summed into a single compound time series for the specific CDS such that the most frequent forms have the highest relative weight in subsequent analysis.

Each match retrieved the complete time series of n-gram frequencies for the specific n-gram and matching RE from the earliest to the latest year provided. The time series values correspond to the number of times the n-grams occurred in the Google Books data in a particular year. Note that the earliest books in the Google Books dataset were published in the 15th century, a period marked by low publication volumes and variances in spelling and grammar. As mentioned, our analysis was limited to the period 1895 to 2019 to capture the end of the 19th century, most of the 20th century, and the past two decades, a period of high publishing volume, relatively stable orthographic standards, and relatively low variance of our CDS prevalence data (*SI Appendix, Fig. S4*). Each n-gram in the CDS set of each language occurred in every year from 1895 to 2019, indicating continuous coverage for all individual CDS n-grams.

Time Series: Prevalence and Normalization. The volume of books published has increased significantly over the past two centuries, punctuated by declines at times of economic collapse and war (*SI Appendix*, Fig. S3). The frequency of occurrence of any specific n-gram will therefore fluctuate accordingly, since it is recorded from a changing sample of books published. We therefore determine yearly n-gram prevalence by normalizing the observed yearly frequency of each n-gram by the total yearly volume published. We estimate the latter by summing the yearly frequency of periods, exclamation points, and question marks (".", "!", and "?"), three punctuation symbols that are used in English, Spanish, and German to mark the end of a sentence. Their frequency indicates publication volume as the number of sentences published (*SI Appendix*, Fig. S4), accounting for possible changes in writing style toward shorter or longer sentences. Although periods, exclamation points, and question marks may express different meanings over time, here we record their frequency only to mark the end of sentences. The ratio of periods vs. all end-of-sentence punctuation remained stable from 1895 to 2019 ($M = 0.9633$, $SD = 0.0103$), with periods approximately 26 times more frequent than exclamation points and question marks.

More formally we determine our prevalence time series as follows. We define a set C of k n-grams $c_i \in C = \{c_1, c_2, \dots, c_k\}$, where the number of words in each n-gram is its length $n \in \{1, 2, 3, 4, 5\}$. We denote the yearly time series of the prevalence of any n-gram c_i as the set $X_j(c_i)$, where j refers to a year in the ordered set (1855, 1856, ..., 2020). Each value $x_j \in \mathbb{N}^+$ of $X_j(c_i)$ represents the n-gram's prevalence, i.e., the total number of occurrences of n-gram c_i in the books published in year j , which we denote $x_j(c_i)$.

Since the raw prevalence $x_j(c_i)$ will fluctuate with the total volume of text published in a given year j , denoted V_j , we normalize the prevalence $x_j(c_i)$ with an estimate of V_j . We use the total number of yearly occurrences of end-of-sentence punctuation to estimate the volume of text published, $N_j = X_j(.) + X_j(!) + X_j(?)$; hence, the volume-normalized time series of n-gram c_i is given by $\bar{x}_j(c_i) = X_j(c_i)/N_j$ for every year j . Note that N_j roughly corresponds to the total number of sentences published, because nearly all sentences are terminated by end-of-sentence punctuation.

However, the magnitude of yearly normalized prevalence values will differ significantly between n-grams of different lengths; e.g., "never" is likely much more prevalent than "they will not believe" for the same volume published, since the former is a 1-gram and the latter a more specific 4-gram. Nevertheless, both may follow a similarly shaped pattern of historical change. Furthermore, the volume of books published increases rapidly over time; hence the variance of the time series of n-gram occurrence may also change over time. To allow comparisons of the patterns of changing prevalence over time between time series of different magnitudes and variance, we subtract the 1895 to 2019 mean from all prevalence time series and divide them by the observed standard deviation over the same period, thus converting all prevalence time series to z scores with respect to their 1895 to 2019 mean $\mu(\bar{x}_j)$ and standard deviation $\sigma(\bar{x}_j)$ as follows: $Z_j(c_i) = (\bar{x}_j(c_i) - \mu(\bar{x}_j(c_i)))/\sigma(\bar{x}_j(c_i))$.

These time series express the fluctuations of the prevalence of all n-grams on a common scale, namely standard deviations from their historical mean, without altering the pattern of their decline or increase of time. Normalized as such we can compare the pattern of changing prevalence for any CDS n-gram time series on a common scale. For example, the individual time series of the "I am a" n-gram that marks a labeling and mislabeling cognitive distortion can have very different magnitudes in Spanish and English, but

similar patterns of change over time. This is revealed when we plot them at the same z-score scale (*SI Appendix*, Fig. S5).

Null Model. We define a null model to compare the observed yearly CDS n-gram prevalence fluctuations against. This null model consists of 10,000 sets of k randomly selected n-grams sampled uniformly across the set of n-grams in the Google Books data. To match the continuity of coverage in the CDS n-grams since 1895, each random n-gram was required to occur in at least 100 of 125 y in our analysis period. Each of the resulting 10,000 random sets of n-grams, denoted $\hat{C}_i \in \hat{C} = \{\hat{C}_1, \hat{C}_2, \dots, \hat{C}_{10,000}\}$, was chosen to replicate the number of n-grams of a given length n as in C (e.g., there are 86 3-grams in C of $k = 241$ total in English [*SI Appendix*, Table S1]), so every \hat{C}_i would also have 86 randomly selected 3-grams of 241 total. We retrieve the Google Books time series for each individual random set of CDS \hat{C}_i and normalize them to prevalence values as described above. This results in 10,000 time series that yield a yearly distribution of z scores. We use the 2.5th and 97.5th percentiles of this yearly distribution as a 95% confidence interval showing the diachronic fluctuations of random n-grams in our data, to which we can compare the empirical fluctuations of our selected set of CDS n-grams (Fig. 3 and *SI Appendix*, Fig. S6).

This null model controls for inherent methodological biases in the normalization of our time series and the Google Books data sample, as well as a possible recency bias in the CDS n-grams since the null model's n-grams are randomly chosen from the Google Books data, which have grown rapidly in volume since 1895 (*SI Appendix*, Fig. S3). Therefore, any recent increase in CDS prevalence (e.g., the observed hockey-stick pattern) is compared against a null model that draws n-grams preferentially from recently published books. In addition, the requirement for each null-model n-gram to have at least 100 y of coverage since 1895 also favors more recent n-grams because more data will be available in recent years.

Bootstrapping. Each CDS n-gram corresponds to a yearly z-score time series from 1855 to 2019, yielding a distribution of z scores for each year for the set of CDS n-grams (*SI Appendix*, Fig. S7). To determine the robustness of our results under random variations of our set of CDS n-grams (e.g., by making different CDS n-gram choices) we calculate the 95% confidence intervals for this distribution by a 10,000-fold random resampling with replacement of the respective set of CDS n-grams (i.e., US English, Spanish, or German). Each such random resample results in a new mean time series for the given random set C_r of n-grams, i.e., $\bar{Z}_{1885,2020}(C_r)$. The resulting yearly distribution of z scores indicates how much our yearly results can vary as a result of random changes to our CDS n-gram set and thereby tests the robustness of our time series results under 10,000 random variations of the set of CDS n-grams. All time series are normalized and converted to z scores before resampling; hence we obtain a distribution of yearly z scores from which the relevant percentiles, including the median, are determined.

Data Availability. Previously published data were used for this work (<https://storage.googleapis.com/books/ngrams/books/datasetsv3.html>).

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Supplementary Information for

Historical language records reveal a surge of cognitive distortions in recent decades.

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Tables S1 to S3 (not allowed for Brief Reports)

Supplemental Tables, p.3-5.

Supplemental Figures, p.6-12.

Table S1. English (US): Cognitive distortion types and corresponding 1- to 5-grams (Cognitive Distortion Schemata). All data are available at: https://github.com/bollen/cognitivedistortions_gbooks.

Category	Cognitive Distortion Schemata
Catastrophizing: Exaggerating the importance of negative events	will fail, will go wrong, will end, will be impossible, will not happen, will be terrible, will be horrible, will be a catastrophe, will be a disaster, will never end, will not end
Dichotomous Reasoning: Thinking that an inherently continuous situation can only fall into two categories	only, every, everyone, everybody, everything, everywhere, always, perfect, the best, all, not a single, no one, nobody, nothing, nowhere, never, worthless, the worst, neither, nor, either or, black or white, ever
Disqualifying the Positive: Unreasonably discounting positive experiences	great but, good but, OK but, not that great, not that good, it was not, not all that, fine but, acceptable but, great yet, good yet, OK yet, fine yet, acceptable yet
Emotional Reasoning: Thinking that something is true based on how one feels, ignoring the evidence to the contrary	but I feel, since I feel, because I feel, but it feels, since it feels, because it feels, still feels
Fortune-telling: Making predictions, usually negative ones, about the future	I will not, we will not, you will not, they will not, it will not, that will not, he will not, she will not
Labeling and mislabeling: Labeling yourself or others while discounting evidence that could lead to less disastrous conclusions	I am a, he is a, she is a, they are a, it is a, that is a, sucks at, suck at, I never, he never, she never, you never, we never, they never, I am an, he is an, she is an, they are an, it is an, that is an, a burden, a complete, a completely, a huge, a loser, a major, a total, a totally, a weak, an absolute, an utter, a bad, a broken, a damaged, a helpless, a hopeless, an incompetent, a toxic, an ugly, an undesirable, an unlovable, a worthless, a horrible, a terrible
Magnification and Minimization: Magnifying negative aspects or minimizing positive aspects	worst, best, not important, not count, not matter, no matter, the only thing, the one thing
Mental Filtering: Paying too much attention to negative details instead of the whole picture	I see only, all I see, all I can see, can only think, nothing good, nothing right, completely bad, completely wrong, only the bad, only the worst, if I just, if I only, if it just, if it only
Mindreading: Believing you know what others are thinking	everyone believes, everyone knows, everyone thinks, everyone will believe, everyone will know, everyone will think, nobody believes, nobody knows, nobody thinks, nobody will believe, nobody will know, nobody will think, he believes, he knows, he thinks, he does not believe, he does not know, he does not think, he will believe, he will know, he will think, he will not believe, he will not know, he will not think, she believes, she knows, she thinks, she does not believe, she does not know, she does not think, she will believe, she will know, she will think, she will not believe, she will not know, she will not think, they believe, they know, they think, they do not believe, they do not know, they do not think, they will believe, they will know, they will think, they will not believe, they will not know, they will not think, we believe, we know, we think, we do not believe, we do not know, we do not think, we will believe, we will know, we will think, we will not believe, we will not know, we will not think, you believe, you know, you think, you do not believe, you do not know, you do not think, you will believe, you will know, you will think, you will not believe, you will not know, you will not think all of the time, all of them, all the time, always happens, always like, happens every time, completely, no one ever, nobody ever, every single one of them, every single one of you, I always, you always, he always, she always, they always, I am always, you are always, he is always, she is always, they are always
Overgeneralizing: Making sweeping negative conclusions based on a few examples	all me, all my, because I, because my, because of my, because of me, I am responsible, blame me, I caused, I feel responsible, all my doing, all my fault, my bad, my responsibility
Personalizing: Believing others are behaving negatively because of oneself, without considering more plausible or external explanations for behavior	should, ought, must, have to, has to
Should statements: Having a fixed idea on how you and/or others should behave	

Table S2. Spanish: Cognitive distortion types and corresponding 1- to 5-grams (Cognitive Distortion Schemata).

Category	Cognitive Distortion Schemata
Catastrophizing: Exaggerating the importance of negative events	va a terminar, terminará, va a ser un desastre, será un desastre, va a ser terrible, será terrible, va a ser imposible, será imposible, va a fracasar, fracasará, va a fallar, va a fracasar, fallará, será una catastrofe, va a ser una catastrofe, será horrible, va a ser horrible, nunca va a terminar, nunca terminara, no va a terminar, no va a pasar, no pasará
Dichotomous Reasoning: Thinking that an inherently continuous situation can only fall into two categories	todo el mundo, toda la gente, todo, todas partes, sólo, solamente, sin valor, siempre, perfecto, perfecta, jamás, nunca, ninguno, ninguna, ni un, ni una, ni el, ni la, nadie, nada, en ninguna parte, el peor, la peor, el mejor, la mejor, cada, todos, todas, blanco y negro, todo el mundo, todos, nadie, esto o
Disqualifying the Positive: Unreasonably discounting positive experiences	no tan bueno, no tan, muy bien sin embargo, genial pero, eso no fue, bueno pero, buena pero, bien pero, aceptable pero, OK pero, no tan, bueno pero, bueno sin embargo, bien sin embargo, aceptable sin embargo
Emotional Reasoning: Thinking that something is true based on how one feels, ignoring the evidence to the contrary	ya que yo siento, ya que se siente, todavía se siente, porque yo siento, como yo siento, porque se siente, pero yo siento, pero se siente
Fortune-telling: Making predictions, usually negative ones, about the future	Yo no voy a, Nosotros no vamos a, Nosotras no vamos a, Tú no vas a, Usted no va a, ellos no van a, ellas no van a, esto no va a, eso no va a, él no va a, Él no va a, ella no va a
Labeling and mislabeling: Labeling yourself or others while discounting evidence that could lead to less disastrous conclusions	Yo soy un, Yo soy una, Yo soy un, Yo soy una, Yo nunca, una mala, un mal, una completa, una carga, un perdedor, una perdedora, un gran, una gran, un completo, completa, Tú nunca, Tú nunca, Usted nunca, tóxico, tóxica, totalmente, total, terrible, sin valor, sin esperanza, desesperanzado, desesperanzada, roto, rota, Nosotros nunca, Nosotras nunca, no amable, indecente, indefenso, indefensa, incompetente, incompetente, horrible, feo, fea, Esto es un, Esto es una, Esta es una, Esta es un, Esto es un, Esto es una, Eso es un, Esa es una, Esa es un, Eso es un, Eso es una, Ellos son unos, Ellas son unas, Ellos son unos, Ellas son unas, Ellos nunca, Ellas nunca, Ella nunca, Ella es una, Ella es una, Él nunca, él nunca, él es, Él es, él es un, Él es un, débil, dañada, dañado, apuesto, absoluto, absoluta, no sirve, chupa, mayor, un completo, una completa
Magnification and Minimization: Magnifying negative aspects or minimizing positive aspects	peor, mejor, no es importante, no importante, no cuenta, no importa, no importante, la única cosa, lo único
Mental Filtering: Paying too much attention to negative details instead of the whole picture	Yo sólo veo, Todo lo que veo, Todo lo que yo veo, Todo lo que puedo ver, Todo lo que puedo ver, Sólo puedo pensar, Nada bueno, Nada bien, completamente malo, completamente mal, completamente equivocado, sólo lo malo, sólo lo peor, Si yo solo, Si sólo yo, Si yo solamente, Si solamente yo, Si eso solo, si sólo
Mindreading: Believing you know what others are thinking	Todos creen, Todas creen, Todo el mundo cree, Todos saben, Todas saben, Todo el mundo sabe, Todos piensan, Todas piensan, Todo el mundo piensa, Todos creeran, Todas creeran, Todo el mundo creera, Todos van a saber, Todas van a saber, Todos va a pensar, Todas van a pensar, Todos pensaran, Todas pensaran, Nadie cree, Nadie sabe, Nadie piensa, Nadie va a creer, Nadie creerá, Nadie va a saber, Nadie sabrá, Nadie va a pensar, Nadie pensará, Él cree, Él sabe, Él sabe, él piensa, Él piensa, él no cree, Él no cree, él no sabe, Él no sabe, él no piensa, Él no piensa, él va a creer, Él va a creer, él creerá, Él creerá, él va a saber, Sabra, él va a pensar, Él va a pensar, el pensará, Él pensará, él no va a creer, Él no va a creer, Él no va a creer, Él no creerá, él no creerá, él no va a saber, Él no va a saber, él no sabrá, él no va a pensar, Él no va a pensar, él no pensará, Él no pensará, Ella cree, Ella sabe, Ella piensa, Ella no cree, Ella no sabe, Ella no piensa, Ella va a creer, Ella creerá, Ella va a saber, Ella sabrá, Ella va a pensar, Ella pensará, Ella no va a creer, Ella no va a saber, Ella no sabrá, Ella no va a pensar, Ella no pensará, Ellas creen, Ellas creen, Ellas saben, Ellas piensan, Ellas piensan, Ellas no creen, Ellas no creen, Ellas no saben, Ellas no saben, Ellas no piensan, Ellas no piensan, Ellas van a creer, Ellas van a creer, Ellas creeran, Ellas creera, Ellas van a saber, Ellas sabran, Ellas van a saber, Ellas sabran, Ellas van a pensar, Ellas van a pensar, Ellas pensaran, Ellas pensaran, Ellas van a creer, Ellas van a creer, Ellas creerán, Ellas creerán, Ellas no van a saber, Ellas no van a saber, Ellas no sabrán, Ellas no van a pensar, Ellas no pensaran, Ellas no pensaran, Nosotros creemos, Nosotras creemos, Nosotros sabemos, Nosotras sabemos, Nosotros pensamos, Nosotras pensamos, Nosotros no creemos, Nosotras no creemos, Nosotros no sabemos, Nosotras no sabemos, Nosotros no pensamos, Nosotras no pensamos, Nosotros vamos a creer, Nosotras vamos a creer, Nosotras creeremos, Nosotras creeremos, Nosotros vamos a saber, Nosotras sabremos, Nosotras sabremos, Nosotros vamos a pensar, Nosotras vamos a pensar, Nosotras vamos a pensar, Nosotras vamos a pensar, Nosotras no vamos a creer, Nosotras no vamos a creer, Nosotras no creeremos, Nosotras no creeremos, Nosotras no vamos a saber, Nosotras no vamos a saber, Nosotras no sabremos, Nosotras no sabremos, Nosotras no sabremos, Nosotras no sabremos, Nosotras no pensaremos, Nosotras no pensaremos, Nosotras no pensaremos, Nosotras no pensaremos, tú crees, usted cree, tú sabes, usted sabe, tú piensas, usted piensas, tú no crees, usted no crees, tú no sabes, usted no sabes, tú no piensas, usted no piensas, tú vas a creer, tú creerás, usted va a cree, usted creerá, tú vas a saber, tú sabrás, usted va a saber, usted sabrá, tú vas a pensar, tú pensará, usted va a pensar, usted pensará, tú no vas a creer, tú no creerás, usted no va a creer, usted no creerá, tú no vas a saber, tú no sabrás, usted no va a saber, usted no sabrá, tú no vas a pensar, tú no pensará, usted no va a pensar, usted no pensará
Overgeneralizing: Making sweeping negative conclusions based on a few examples	Yo siempre estoy, Tú siempre estás, Tú siempre eres, Usted siempre está, Ellos siempre, Ellas siempre, Ella siempre, él siempre, Él siempre, Todo el tiempo, Todos ellos, Todas ellas, Siempre pasa, Siempre sucede, siempre como, pasa siempre, sucede siempre, completamente, nadie ha, nunca nadie, nunca alguien, todos y cada uno de, todos y cada uno de, todos y cada uno de, Yo siempre, Tú siempre, Usted siempre, Ella siempre, Ellos siempre, Ellas siempre
Personalizing: Believing others are behaving negatively because of oneself, without considering more plausible or external explanations for behavior	Yo soy responsable, Yo me siento responsable, Yo causé, Todos mis, Todas mis, Todo mi culpa, Toda mi culpa, Toda mi, Todo mi, Porque yo, Porque mi, Por mi, mi responsabilidad, mala mía, Culpénme a mí, Por mi
Should statements: Having a fixed idea on how you and/or others should behave	tienes que, tiene que, debería, deberías, debo, tengo

Table S3. German: Cognitive distortion types and corresponding 1- to 5-grams (Cognitive Distortion Schemata). The n-grams are in some cases formulated as regular expressions to match a range of relevant expressions.

Category	Cognitive Distortion Schemata
Catastrophizing: Exaggerating the importance of negative events	wird versagen, werden versagen, werde versagen, wirst versagen, werdet versagen, wird schiefgehen, wird nicht klappen, wird nicht funktionieren, wird (schlimm schlecht) (enden ausgehen), ist unm(ö)glich, wird nicht passieren, wird schrecklich sein, wird horrend sein, wird eine Katastrophe sein, wird in eine Katastrophe führen, wird nie enden, werden nie enden, wird nicht enden, werden nicht enden
Dichotomous Reasoning: Thinking that an inherently continuous situation can only fall into two categories	nur, all(e em en er es)?, jed(e em en er es)?, überall, immer, perfekt, ausgezeichnet, der beste, das beste, die beste, nicht ein(e)? einzig(e em en er es)?, kein(e em en er es)?, niemand, nichts, nirgendwo, nie, nimmer, wertlos, das schlimmste, der schlimmste, weder, entweder, schwarz und wei(ss ß), ja b, jemals
Disqualifying the Positive: Unreasonably discounting positive experiences	groß(ss)artig (, .)? ?(allerdings aber jedoch), gut (, .)? ?(allerdings aber jedoch), okay (, .)? ?(allerdings aber jedoch), schön (, .)? ?(allerdings aber jedoch), akzeptabel (, .)? ?(allerdings aber jedoch), nicht so (großartig grossartig), nicht so gut, es war nicht, nicht so sehr
Emotional Reasoning: Thinking that something is true based on how one feels, ignoring the evidence to the contrary	aber ich fühle, weil ich fühle, da ich fühle, aber es fühlt sich, weil es sich so anfühlt, da es sich so anfühlt, es fühlt sich so an
Fortune-telling: Making predictions, usually negative ones, about the future	ich werde nicht, wir werden nicht, du wirst nicht, ihr werdet nicht, sie werden nicht, es wird nicht, das wird nicht, er wird nicht, sie wird nicht
Labeling and mislabeling: Labeling yourself or others while discounting evidence that could lead to less disastrous conclusions	ich bin ein(e em en er es)?, du bist ein(e em en er es)?, er ist ein(e em en er es)?, sie ist ein(e em en er es)?, sie sind ein(e em en er es)?, wir sind ein(e em en er es)?, ihr seid ein(e em en er es)?, es ist ein(e em en er es)?, das ist ein(e em en er es)?, schlecht (bei beim im), ich war nie ein(e em en er es)?, er war nie ein(e em en er es)?, sie war nie ein(e em en er es)?, es war nie ein(e em en er es)?, du warst nie ein(e em en er es)?, wir waren nie ein(e em en er es)?, sie waren nie ein(e em en er es)?, ihr ward nie ein(e em en er es)?, ihr wart nie ein(e em en er es)?, ich bin eine Last, du bist eine Last, er ist eine Last, ihr seid eine Last, sie ist eine Last, sie sind eine Last, wir sind eine Last, es ist eine Last, das ist eine Last, ein(e em en er es)? komplett(e em en er es)?, ein(e em en er es)? riesig(e em en er es)?, ein(em)? Versager, eines Versagers, ein(em)? Verlierer, eines Verlierers, ein(e em en er es)? hochgradige(e em en er es)?, ein(e em en er es)? total(e em en er es)?, ein(e em en er es)? schwach(e em en er es)?, ein(e em en er es)? absolut(e em en er es)?, ein(e em en er es)? ganz(e em en er es)?, ein(e em en er es)? schlecht(e em en er es)?, ein(e em en er es)? kaput(e em en er es)?, ein(e em en er es)? beschädigt(e em en er es)?, ein(e em en er es)? hilflos(e em en er es)?, ein(e em en er es)? hoffnungslos(e em en er es)?, ein(e em en er es)? inkompetent(e em en er es)?, ein(e em en er es)? giftig(e em en er es)?, ein(e em en er es)? h(ä)l(a)e schl(e em en er es)?, ein(e em en er es)? unbedeckt(e em en er es)?, ein(e em en er es)? nicht liebensw(ü)rdig(e em en er es)?, ein(e em en er es)? wertlos(e em en er es)?, ein(e em en er es)? horrend(e em en er es)?, ein(e em en er es)? schrecklich(e em en er es)?, ein(e em en er es)? widerlich(e em en er es)?, ein(e em en er es)? abscheulich(e em en er es)?
Magnification and Minimization: Magnifying negative aspects or minimizing positive aspects	schlimmste, beste, nicht wichtig, zählt nicht, zahlt nicht, unwichtig, egal, die einzige Sache, die eine Sache, aber
Mental Filtering: Paying too much attention to negative details instead of the whole picture	ich sehe nur, alles was ich sehe, alles, was ich sehe(n)?, kann nur denken, nichts gutes, nichts Gutes, nichts richtiges, nichts Richtiges, total (schlecht falsch), komplett (schlecht falsch), nur d(er ie as) (schlechte schlimmste), wenn (ich es) nur
Mindreading: Believing you know what others are thinking	alle glauben, jede(r)? glaubt, man glaubt, alle wissen, jede(r)? wei(ss ß), man wei(ss ß), alle denken, jede(r)? denkt, alle werden glauben, jeder wird glauben, alle werden wissen, man wird wissen, jede(r)? wird wissen, alle werden denken, jeder wird denken, man wird denken, keine(r)? glaubt, niemand wei(ss ß), niemand denkt, niemand wird glauben, keine(r)? wird glauben, niemand wird wissen, keine(r)? wird wissen, niemand wird denken, keine(r)? wird denken, er glaubt, er wei(ss ß), er denkt, er glaubt nicht, er wei(ss ß) nicht, er denkt nicht, er wird glauben, er wird wissen, er wird denken, er wird nicht glauben, er wird nicht wissen, er wird nicht denken, sie glaubt, sie wei(ss ß), sie denkt, sie wei(ss ß) nicht, sie glaubt nicht, sie denkt nicht, sie wird glauben, sie wird wissen, sie wird denken, sie wird nicht glauben, sie wird nicht wissen, sie wird nicht denken, sie glauben, sie wissen, sie denken, sie glauben nicht, sie wissen nicht, sie denken nicht, sie werden glauben, sie werden wissen, sie werden denken, sie werden nicht glauben, sie werden nicht wissen, sie werden nicht denken, wir glauben, wir wissen, wir denken, wir glauben nicht, wir wissen nicht, wir denken nicht, wir werden glauben, wir werden wissen, wir werden denken, wir werden nicht glauben, wir werden nicht wissen, wir werden nicht denken, du glaubst, ihr glaubt, du wei(ss ß)t, ihr wei(ss ß)t, du denkst, ihr denkt, du glaubst nicht, ihr glaubt nicht, du wei(ss ß)t nicht, ihr wei(ss ß)t nicht, du denkst nicht, ihr denkt nicht, du wirst glauben, ihr werdet glauben, du wirst wissen, ihr werdet wissen, du wirst denken, ihr werdet denken, du wirst nicht glauben, ihr werdet nicht glauben, du wirst nicht wissen, ihr werdet nicht wissen, du wirst nicht denken, ihr werdet nicht denken
Overgeneralizing: Making sweeping negative conclusions based on a few examples	jedes Mal, jedes mal, jedesmal, alle von ihnen, immer, passiert immer, immer wie, passiert jedes mal, passiert jedesmal, total, ganz, niemand je, jeder einzelne von, jede einzelne von, ich bin immer, du bist immer, er ist immer, sie ist immer, es ist immer, wir sind immer, ihr seid immer, sie sind immer, ich habe immer, du hast immer, er hat immer, sie hat immer, es hat immer, wir haben immer, ihr habt immer, sie haben immer
Personalizing: Believing others are behaving negatively because of oneself, without considering more plausible or external explanations for behavior	ganz Ich, ganz ich, nur Ich, nur ich, alles mein, weil ich, weil mein(e)?, wegen mein(e em en er es)?, wegen mir, Ich bin verantwortlich, gib mir die Schuld, verursacht habe, Ich fühle mich verantwortlich, meine Tat, meine Schuld, ich bin schuld, ich trage die Schuld, meine Verantwortung
Should statements: Having a fixed idea on how you and/or others should behave	sollte, soll, mu(ss ß), mü(ss ß)te, mue(ss ß)te

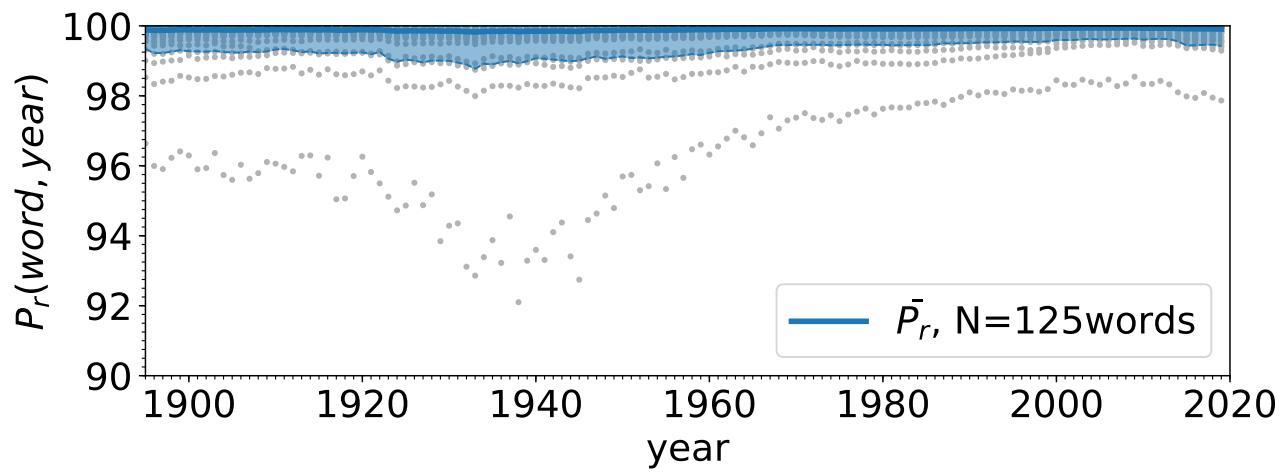


Fig. S1. Graph showing the mean and distribution of the percentiles of the individual words used in English CDS n-grams ($N=125$), e.g. “will”, “I”, and “am”, hence including the CDS 1-grams, over time in the distribution of all 1-grams (single words) in the Google Book data. The blue bands show the 95% confidence interval of the distribution of individual word percentiles. The blue line \bar{P}_r indicates the mean of the percentile scores of the set of words for each year. Gray dots indicate the percentile time series for each individual word. We exclude all Google Books 1-grams that contain non-alphabetical symbols from the distribution of 1-gram frequencies to reduce the inclusion of non-word forms. As shown, the 125 individual words in the CDS n-grams are among the most frequent words in the English language since 1895 (average percentile $M(\bar{P}_r) = 99.885$, $SD = 0.346$). All CDS words are more frequent than 98.0% of the 1-grams in the Google Books data for every year since 1895, with the exception of one word: “unlovable” which nevertheless remained more frequent than 92% of 1-grams since 1895.

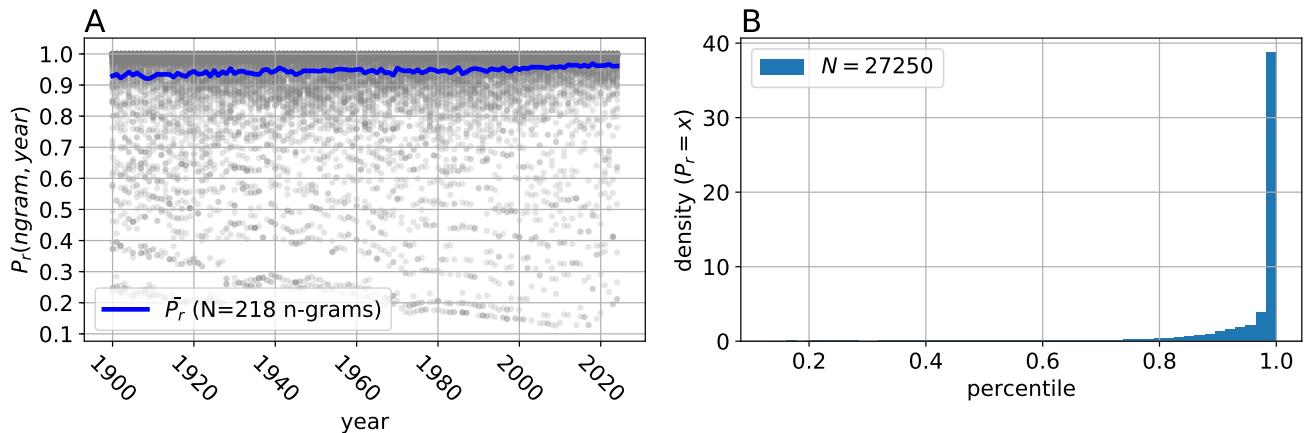


Fig. S2. (A) Distribution of the percentiles of all English CDS 2, 3, 4, and 5-grams ($N = 96, 86, 34$, and 2, respectively), over time in the yearly frequency distribution of all n-grams of equal length in the Google Books data. Gray dots indicate the percentile for each individual CDS n-gram for that year. The blue line indicates the mean percentile value per year for all CDS n-grams. We exclude all Google Books n-grams from the frequency distribution that contain non-alphabetical symbols to reduce the inclusion of non-word forms. As shown, the CDS n-grams are among the most frequent n-grams in the English language since 1895. CDS n-grams are on average more frequent than 94.6% of all n-grams in the Google Books data for every year since 1895 (mean percentile $M(P_r) = 0.946$, $SD = 0.0103$). (B) Distribution of all 218 n-gram percentile values across all years (218 x 125 years) indicates that CDS n-gram percentiles from 1895 to 2019 are concentrated in the highest 5% of the distribution of all n-grams.

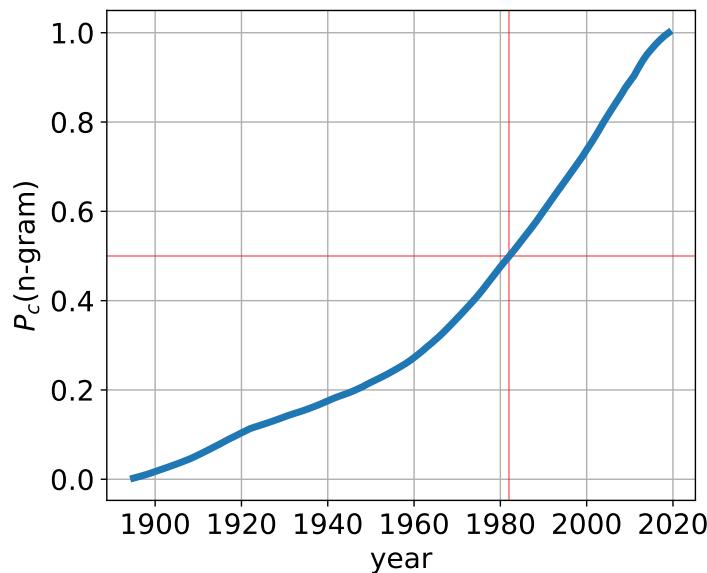


Fig. S3. Cumulative probability P_c of an n-gram being randomly selected from books published in English (US) up to that year. Red lines indicate the point in time (year=1983) at which the probability of an n-gram being chosen from a book published before that time exceeds $P_c = 0.5$. The number of books published in English (US) grew from 1895 to 2019 at an accelerating rate, thus increasing the probability of an n-gram being randomly selected from more recently published books. This causes a bias in our null-model that favors more “modern” language, because n-grams are sampled from more recently published books, proportional to the growth of the number of books published over time. Since the null-model serves as a basis of comparison to our observations, our observations of a recent surge in the expression of markers of cognitive distortion are compensated for a recency bias. Note: our CDS prevalence values are normalized not by number of books published, but by an estimation of publishing volume from the amount of end-of-sentence punctuation (SI Fig. S4).

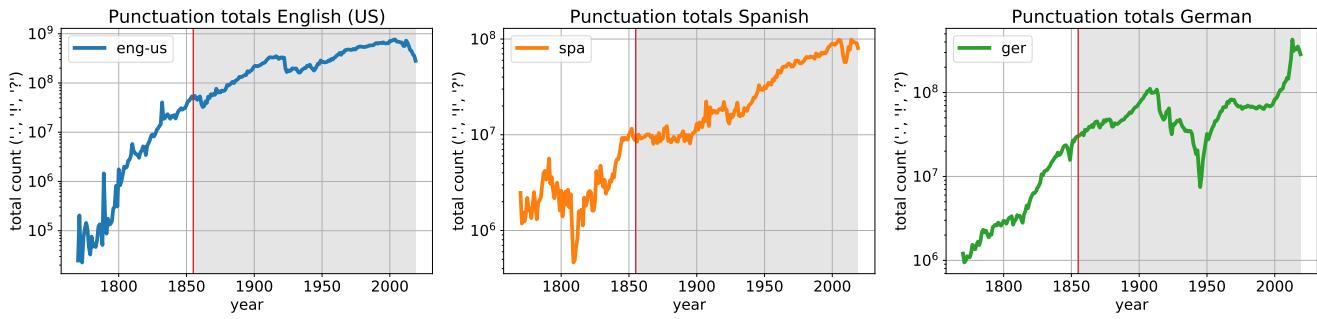


Fig. S4. End-of-sentence punctuation frequencies were used to normalize individual CDS n-gram time series to account for changes in publication volume and sentence length over time. Publication volume increased rapidly since 1770 for English (US), Spanish, and German across several orders of magnitude. The graphs show the time range from 1770 to 2019 to highlight why we select the time period from 1855 to 2019 for our analysis: it represents a period of comparatively high and stable publication volumes for all three languages (starting with red vertical line, marked by gray background). Publication volume drops in German from 1900 to 1946, possibly due to the effects of World War I and World War II.

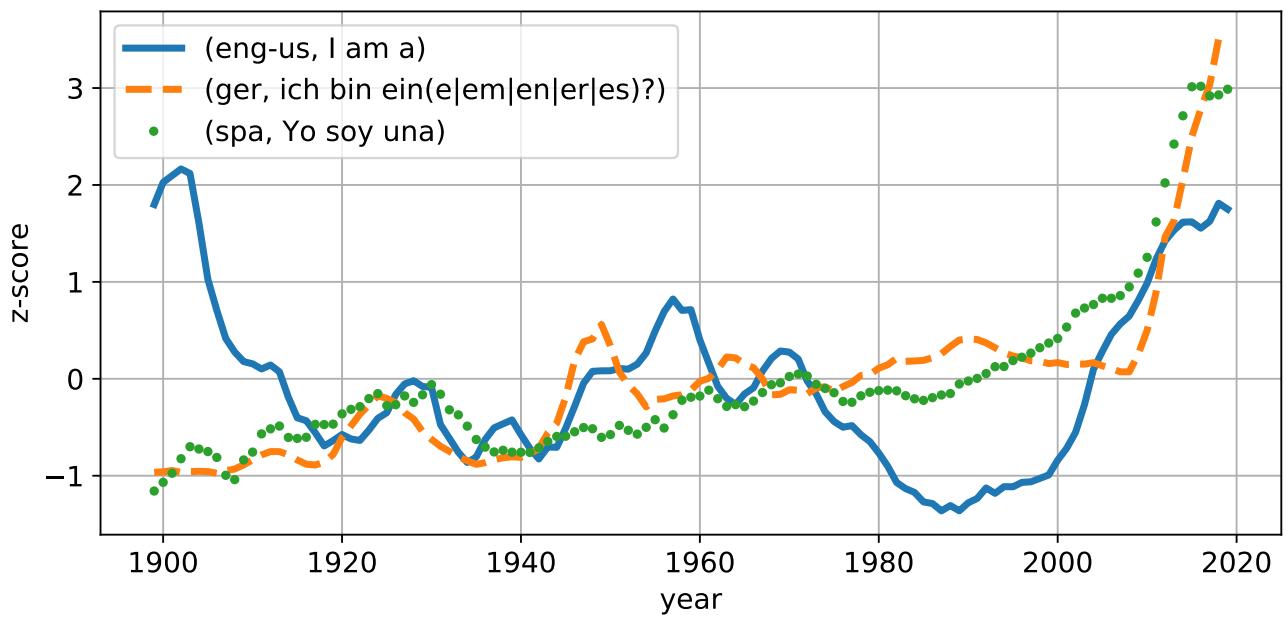


Fig. S5. Example of prevalence time series (yearly frequencies normalized by publication volume and z-score) for “I am a” and its Spanish and German translations. Note that the German and Spanish time series correspond to a regular expression that matches a number of grammatical variations (gender and plural) which have been summed into a single z-score normalized time series.

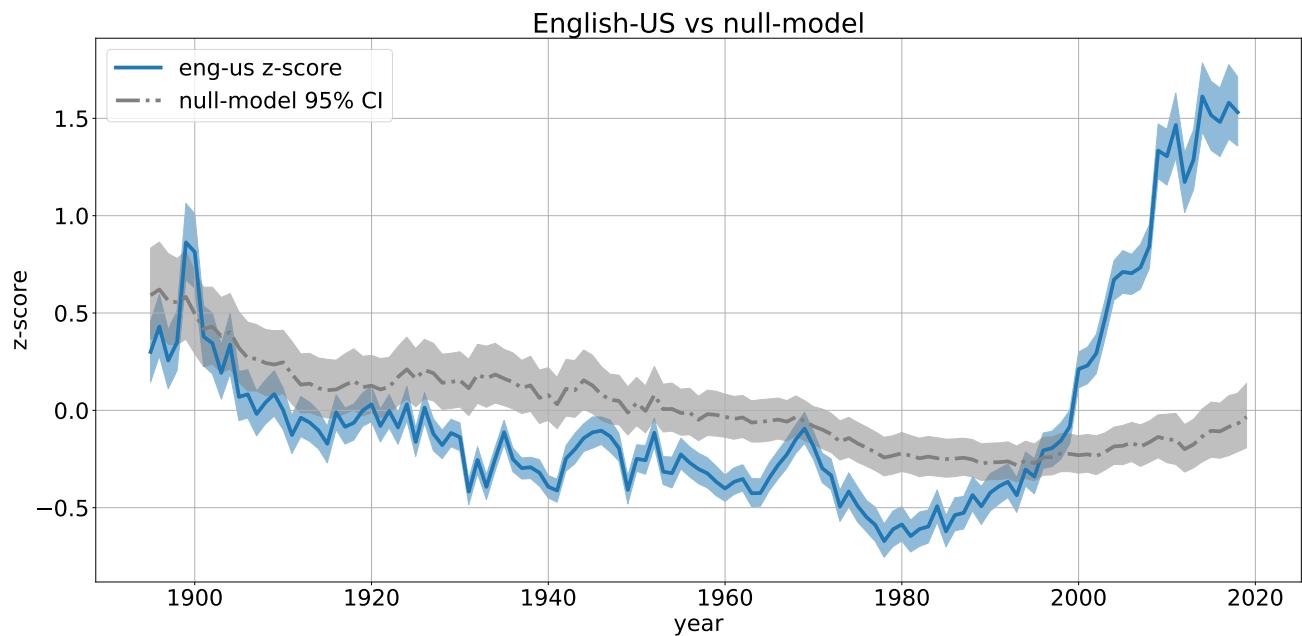


Fig. S6. Time series (z-score) and 95% CI (bootstrapped 10,000-fold) for English (US) CDS n-grams vs a null-model of 10,000-fold randomly selected n-grams (each sample N=241) with the same length distribution as the English (US) set of CDS n-grams. The prevalence of English (US) CDS n-grams deviates significantly from the null-model in two specific periods: it is significantly *lower* than the null-model from approximately 1920 to 1990, and significantly *higher* than the null-model from the late 1990s to 2019.

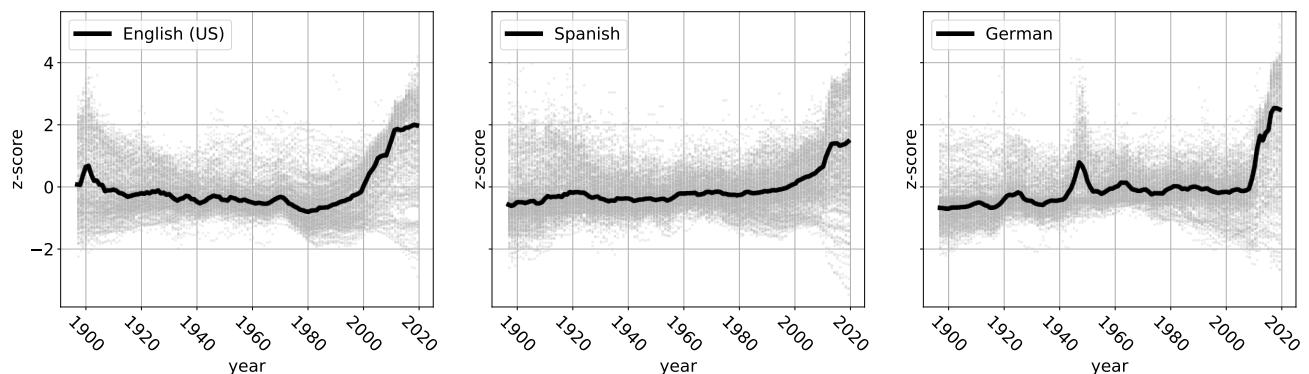


Fig. S7. Individual CDS n-grams prevalence time series (z-score) superimposed with median z-scores (smoothed by 3-year rolling mean) for English, Spanish, and German.