LETTERS
https://doi.org/10.1038/s41562-018-0516-z

nature human behaviour

Corrected: Publisher Correction

The loosening of American culture over 200 years is associated with a creativity–order trade-off

Joshua Conrad Jackson[1*], Michele Gelfand[2*], Soham De[3] and Amber Fox[4]

For many years, scientists have studied culture by comparing societies, regions or social groups within a single point in time. However, culture is always changing, and this change affects the evolution of cognitive processes and behavioural practices across and within societies. Studies have now documented historical changes in sexism[1], individualism[2,3], language use[4] and music preferences[5] within the United States and around the world[6]. Here we build on these efforts by examining changes in cultural tightness–looseness (the strength of cultural norms and tolerance for deviance) over time, using the United States as a case study. We first develop a new linguistic measure to measure historical changes in tightness–looseness. Analyses show that America grew progressively less tight (i.e., looser) from 1800 to 2000. We next examine how changes in tightness–looseness relate to four indicators of societal order: debt (adjusted for inflation), adolescent pregnancies, crime, and high school attendance, as well as four indicators of creative output: registered patents, trademarks, feature films produced, and baby-naming conformity. We find that cultural tightness correlates negatively with each measure of creativity, and correlates positively with three out of four measures of societal order (fewer adolescent pregnancies, less debt and higher levels of school attendance). These findings imply that the historical loosening of American culture was associated with a trade-off between higher creativity but lower order.

Our analysis of cultural change concerns a long-recognized distinction between 'tight' cultural groups with relatively strong norms and little tolerance for deviance and 'loose' groups with weaker norms and more tolerance for dissent. As early as the second century BC, the historian Polybius contrasted Roman discipline, order and rationality with Celtic impetuosity and passion on the battlefield. Many centuries later, the anthropologist Pelto distinguished tight and loose societies in the ethnographic record[7] and, even more recently, cultural psychologists have quantified continuous variation in cultural tightness–looseness across current-day nations[8], US states[9], organizations[10] and social classes.

Case studies and anecdotal evidence suggest that culture has grown less tight (i.e., loosened) in recent centuries—particularly in the United States: free speech and class mobility have risen over the last two centuries[11], whereas forced conscription and prohibition on homosexual relationships have declined[12,13]. Over the same period of time, American fashion norms have become more diverse and permissive, with rigid clothing norms in the nineteenth century gradually expanding to include sportswear in the 1910s and 1920s and non-constraining unisex garments in the 1960s[14]. More recently, the 1964 Civil Rights Act and the US Supreme Court's ruling on *Roe v. Wade* in 1973 have also contributed to less restrictive gender norms[15], and the coverage of the Vietnam War (1965–1973) and of the Watergate scandal in the 1970s encouraged media reporting that directly challenged the authority of the government and military[16]. These historical examples suggest a gradual loosening of norms across American history. However, this has, to our knowledge, not been empirically tested, nor have historical changes in cultural tightness–looseness been quantitatively analysed.

If the United States has loosened over time, this may have important implications for order and creativity. Around the world, the tightest nations have more societal order (for example, a higher presence of police and stricter laws) but less openness and creativity (for example, less open media and less success in creativity contests)[8,17]. A similar pattern exists across US states: tighter states have fewer self-regulation failures (for example, drug abuse and alcoholism) but also less openness and creativity (for example, higher levels of discrimination against minorities and fewer patents and trademarks)[9]. This correlative evidence is also supported by neurobiological differences: people in tighter cultures show more neural reactivity to social norm violations, which mediates the negative association between cultural tightness and creativity and the positive association with self-control[18]. This evidence suggests that a historical loosening of American culture may be associated with less societal order but greater creativity. The goal of the current study was to track cultural tightness–looseness over a long period of time within the United States and formally test whether changes in tightness–looseness are linked to this tradeoff between order and creativity.

Tracking cultural tightness–looseness over a long period of time required a measure that had high temporal resolution and many years available to maximize the power of any conducted analysis in which years were the unit of analysis. We also developed a measure that was not biased by our own conceptions of tightness or looseness. Many past studies have operationalized cultural change through linguistic variation—for example, individualism has been operationalized by some through the usage of personal pronouns (for example, 'I' or 'my') and by words connoting choice and achievement (for example, 'achieve' or 'prefer')[2,3]. Applying these text-based indices in large corpuses has yielded many years of rich data. However, since word lists are chosen at the discretion of researchers, the indices are potentially influenced by the preconceptions of the researchers. They are also sensitive to type-I errors in which a researcher can only select words that change in hypothesis-consistent ways.

In order to avoid bias related to the top-down selection of words, we developed a bottom-up linguistic index of tightness or looseness based on how people actually speak about the strength of norms and tolerance for deviance. To do so, we used the word2vec algorithm, a recently developed computer science algorithm that automatically

[1]Department of Psychology, University of North Carolina, Chapel Hill, Chapel Hill, NC, USA. [2]Department of Psychology, University of Maryland, College Park, MD, USA. [3]Department of Computer Science, University of Maryland, College Park, MD, USA. [4]Department of Medical and Clinical Psychology, Uniformed Services University, Rockville, MD, USA. *e-mail: joshcj@live.unc.edu; mgelfand@umd.edu

Table 1 | Words selected to comprise the final tightness and looseness indices

Tight words	Loose words
Restrain	Allow
Prevent	Freedom
Comply	Create
Constrain	Variability
Uniformity	Autonomy
Adhere	Openness
Enforce	Leeway
Proscribe	Flexibility
Abide	Broadmindedness
Dictate	Transformatory
Circumscribe	Customize
Impose	Subjectivities
Uphold	Modify
Discourage	Limitless
Compel	Empower
Forbid	Adaptiveness
Confine	Pluralism
Govern	Personalize
Prohibit	Encourage
Preclude	Diverse

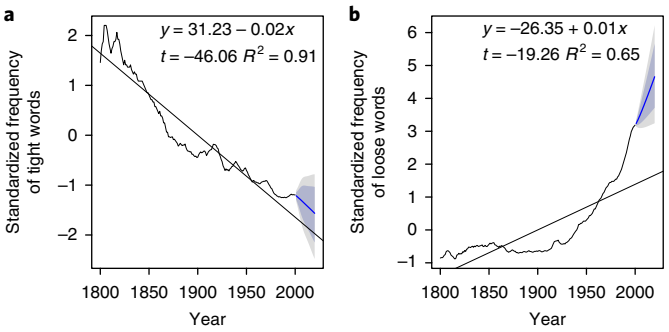

Fig. 1 | Frequencies in tight and loose words in books from 1800 to 2000. **a**, Frequencies of tight words. **b**, Frequency of loose words. Each graph shows the line of best linear fit, as well as forecasts from 2000 to 2020 (blue lines and blue shaded regions) using autoregressive moving-average models. Both measures were transformed using a Box–Cox transformation before forecasts were calculated. Values have been standardized, since some words are used more often than others. The shaded regions correspond to 80% (lighter gray) and 95% (darker gray) confidence intervals.

associates a word or common phrase to a vector (a set of coordinates) in a high-dimensional space[19]. The distance between any two words in this high-dimensional space reflects the probability that these words are used together in a particular corpus. Therefore, clusters of words reflect semantic 'packages' that tend to occur together within written language. Following past projects that have used word2vec to quantify the semantic space of constructs[20], we used word2vec to develop ground-up indices of words that captured how people naturally spoke about tightness and looseness.

We defined these indices using word2vec to map words that appeared in the Google News dataset to a 300-dimensional space. Google News is a corpus of over 1 trillion words from news articles that are published at different points in time, which avoids biases associated with inferring word meanings from how words were used at a single point in time[21]. We identified the coordinates for eight loose words (allow, autonomy, choose, create, freedom, leeway, variability and unique) and eight tight words (comply, conform, constrain, prevent, obey, oblige, restrain and uniformity)—derived from existing long-form and short-form measures of tightness[8,18]—within this space. We next took the vector mean coordinates for all tight words and all loose words and extracted the 50 words that co-occurred most with tight words, and separately, with loose words. Finally, we refined the resulting word lists to a total of 40 words, removing words that had no face valid relationship with tightness or looseness and probably occurred together with loose or tight words for idiosyncratic reasons (for example, 'infantilize' or 'sea lions'). The resulting indices—listed in Table 1—represent linguistic indices that not only showed high face validity, but also captured the way that laypeople talk about tightness and looseness.

After deriving these tightness and looseness indices, we applied them to a new corpus—the Google Books corpus—to identify changes in cultural tightness over time. The Google Books corpus contains over 200 billion books, published between 1800 and 2018, with intent to continue publishing annually for the foreseeable future[22]. Because of the richness of the time-linked dataset, it has become a popular source for measuring the changing frequency[2–4] of certain words or phrases. Furthermore, frequency of word use within the Google Books corpus can be easily adjusted to control for the total number of books published in a given year, meaning that rates of change are not confounded with increasing number of books published in general. To map American cultural change, we analysed the changing frequency of tight words and loose words in books published in the United States between 1800 and 2000. This range is commonly used in analyses of the Google Books corpus, because it prevents confounding associated with cultural change because of the increasing prevalence of eBooks and self-published texts after 2000[2,3]. For example, if loose words in books increased after 2000, this may only be reflective of colloquial language use in self-published books.

Analyses of these temporal trends showed that both tight and loose words tended to occur together over time (α values > 0.92), suggesting that our indices were reliable. Standardized frequencies of tight words and loose words tended to correlate negatively with each other ($\tau = -0.62$, $P < 0.001$), indicating that for years in which tight words were frequently used in books, loose words were infrequently used and vice versa. These relationships supported the notion that tight words and loose words were representative of an underlying construct: cultural tightness–looseness. The R code for these analyses—and all other analyses in the paper—is publicly available at https://osf.io/x2uzn/.

We next analysed historical change in our linguistic indicators of tightness and looseness. We found a general decrease in tightness ($R^2 = 0.78$) and a corresponding increase in looseness ($R^2 = 0.94$; Fig. 1). Linear models can sometimes be misleading when applied to cultural change, as they contain lagged forecast errors and an autoregressive component. For this reason, we calculated optimal autoregressive moving-average models using a forecasting algorithm, which removes the autoregressive and error components of variance[3]. These forecasts (Fig. 1) suggest that rates of looseness are increasing, whereas rates of tightness are decreasing. Notably, rates of change were robust for both tightness and looseness: forecasts coefficients from 2000 to 2020 revealed consistently negative 95% confidence intervals for tightness (upper limit confidence intervals < -0.005) and consistently positive confidence intervals for looseness (lower limit confidence intervals > 2.46). We chose this 20-year forecast window based on past research on changes in individualism and collectivism. We note that different windows

similarly suggested increases in looseness and decreases in tightness over time (see Supplementary Information).

Taken together, these analyses suggest that American norms loosened from 1800 to 2000. People more often used language related to breaking rules and acting against norms over time and used less language related to setting and following rules over time. It should be noted that linguistic trends may not be indicative of cultural trends more generally. Past studies that used multiple measures of cultural change have shown strong convergence between linguistic and behavioural measures[3]. Nevertheless, in the current case, increasing numbers of loose words in books could reflect popular literary trends that do not correspond to actual cultural change. For example, books about breaking rules could have become popular even though cultural tightness–looseness did not otherwise change[20]. The Google Books corpus is also susceptible to problems related to improper scanning and encoding of *n*-grams and increasing publication of scientific literature throughout the twentieth century[23].

To address these limitations, we searched for convergent measures of cultural tightness–looseness that correlate with our linguistic index. We first analysed rates of religiosity in the United States over time. We expected more people to self-report as religious in years with high levels of tightness, as religion is a norm-enforcement system that is strongly correlated with tightness across cultures[8,9]. Our second and third measures were yearly rates of Supreme Court cases and laws passed by the US Congress. We expected years with high levels of tightness to also have high numbers of Supreme Court cases and laws passed, reflecting active societal regulation. Fourth, we analysed yearly execution rates. We expected years with high levels of tightness to have high numbers of executions, reflecting a low tolerance for deviance. Finally, we analysed rates of profanity in American television shows. We expected years with high rates of tightness to have the lowest rates of profanities, which reflect norm violations[8]. We registered each of these predictions at https://osf.io/x2uzn/ prior to gathering data and running analyses. We standardized all variables prior to analyses.

As predicted, cultural tightness (tight words minus loose words) correlated positively with religiosity rates ($\tau = 0.78$, $P < 0.001$), the number of laws passed ($\tau = 0.56$, $P < 0.001$), the number of Supreme Court cases ($\tau = 0.39$, $P < 0.001$) and negatively with the number of profanities ($\tau = -0.83$, $P < 0.001$). Unexpectedly, cultural tightness also correlated negatively with the number of executions, $\tau = -0.16$, $P = 0.001$. This may be because of the rapid and unpredictable nature of temporal data on execution rates because of legislative decisions. For example, rates of executions were extremely high in the years following World War II (1945–1948), but then dropped to 0 after the US Supreme Court's ruling on *Furman v. Georgia* in 1972, only to return to high rates in the 1990s because of the tough stance on crime of the Clinton administration. Of note, all factors but execution rates showed linear trends consistent with the loosening of American culture over time (see Supplementary Information). Together, these analyses suggested that our linguistic index was valid, and that cultural tightness decreased from 1800 to 2000.

We next investigated how the changing tightness–looseness related to order and creativity. As summarized above, existing evidence has tied cultural tightness to higher order—through stricter self-regulation at the societal level—but lower creativity—through less creativity and more conventionality. We therefore sought multiple longitudinal measures of order and creativity to test whether these associations also characterized fluctuations in cultural tightness over time. These measures are described in brief below and more in-depth descriptions are provided in the Methods and in the Supplementary Information.

We measured order using historical reports of household debt, crime, high-school attendance and adolescent pregnancy. These measures had a sufficient number of time points to permit analyses, and have been linked to lowered self-regulation at both the individual and the societal level by past research (see Methods). Of course, fluctuations in each indicator are determined by multiple factors: for example, faster life history strategies could result in earlier pregnancy[1] and more children dropping out of high school to begin careers, whereas more active policing could influence yearly crime rates[24]. Using multiple measures helped to control for these idiosyncratic factors.

Measures of societal creativity were rates of trademarks, rates of patents, feature film production rates and baby-naming conformity. These measures have each been linked to societal creativity and innovation by past literature. However, past studies have operationalized baby-naming conformity as a measure of individualism[3]. Nevertheless, we considered that it could also represent creativity, since an uncreative name would, by definition, represent a conventional and prototypical name. We acknowledge that patent applications, trademark applications and feature films measure the creative input of middle- and upper-class members of society more than lower-class members of society.

We correlated each of these measures of order and creativity with cultural tightness using Kendall correlations, which are non-parametric tests that are appropriate for testing trends over time. To avoid confounding strength of norms with personal wealth, collectivism or the monotonic effect of time, we regressed out variance associated with these factors within our cultural tightness measure and each of our dependent variables. For a longitudinal measure of individualism, we used a previously published linguistic measure[3]. We also controlled for pathogen prevalence in our analyses of baby-naming conformity and adolescent pregnancy, given past associations between these variables[1,3]. Finally, we controlled for unemployment in our analysis of naming conformity[3]. Correlations were similar without these control variables.

With respect to creativity, cultural tightness correlated negatively with patent rates ($\tau = -0.68$, $P < 0.001$, trademark rates, $\tau = -0.62$, $P < 0.001$, feature film production, $\tau = -0.41$, $P < 0.001$, and positively with baby-naming conformity, $\tau = 0.18$, $P = 0.02$. Each of these effects indicated a negative association between cultural tightness and creativity over time.

With respect to order, cultural tightness correlated positively with high school enrollment, $\tau = 0.49$, $P < 0.001$) and negatively with household debt rates ($\tau = -0.65$, $P < 0.001$) and adolescent pregnancy rates ($\tau = -0.40$, $P < 0.001$). Notably, cultural tightness positively correlated with crime ($\tau = 0.44$, $P < 0.001$): years with more tightness had more crime, on average. This trend may have occurred because culturally tighter years featured higher incarceration rates because of more law enforcement presence—a correlation that is observed at the state level[9]. The association between cultural tightness and each indicator is displayed in Fig. 2.

We next analysed whether changes in cultural tightness preceded changes in order and creativity. One method of testing temporal order is through cross-correlations, which display correlations at different lagged intervals. Negative lags indicate that changes in cultural tightness preceded changes in creativity and order. Positive lags indicate that creativity and order preceded changes in cultural tightness. This analysis therefore provides an ideal test of whether cultural tightness changes at the same time as creativity and order, or whether one class of variables temporally precedes the other.

Our first set of analyses focused on the relationship between cultural tightness and creativity. Changes in cultural tightness appeared to temporally precede changes in three of the four measures: naming conformity, feature film production and trademark applications. Changes in patent applications, however, appeared to occur together with changes in cultural tightness, showing less evidence of temporal precedence (see Fig. 3).

Our second set of analyses focused on the relationship between cultural tightness and order. Changes in cultural tightness appeared to temporally precede changes in two of the four measures: crime

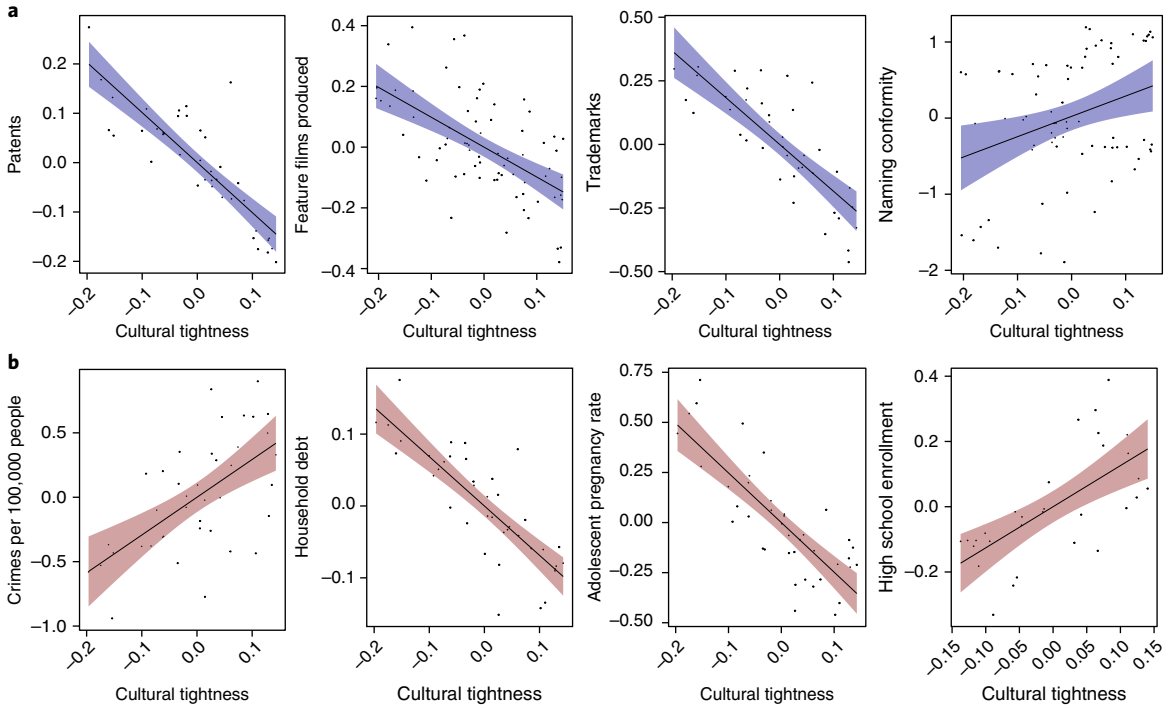

Fig. 2 | Correlations between cultural tightness and measures of creativity and order. a,**b**, Cultural tightness (*x* axes) predicted lower creative output for each of our four creativity measures (**a**) and higher order on three of our four order measures (**b**). Cultural tightness was unexpectedly related to higher crime rates. Best-fit lines represent linear models, and shaded regions indicate standard errors in these models. All variables have been standardized.

and high school enrollment. By contrast, changes in household debt and rates of adolescent pregnancy appeared to occur together with changes to cultural tightness, showing less evidence of temporal precedence (see Fig. 3).

To further investigate temporal ordering, we conducted Granger tests of predictive causality at one-year and five-year lags. Granger tests analyse whether an exogenous variable (for example, cultural tightness) can predict future changes in an endogenous variable (for example, high school enrollment or feature film production) over time, above and beyond earlier values of that endogenous variable. Our Granger tests highlight only one significant result: increases in cultural tightness predicted future reductions in the number of feature films produced. There were also non-significant trends. For example, there were slight increases in crime rates and high school enrollment following increases in cultural tightness. For other measures of order and creativity, there were no significant lagged effects (see Supplementary Table 7).

Taken together, these analyses provide evidence that cultural tightness decreased from 1800 to 2000 in the United States and that decreases in cultural tightness over this time period correlated with decreases in order but increases in creativity. The temporal ordering of these relationships is unclear: in some cases, it seemed that tightness preceded changes in order and creativity, whereas in other cases, changes to cultural tightness co-occurred with changes to creativity and order. Nevertheless, the available evidence still supports the existence of a trade-off in which tightness indicates some benefits to society (for example, lower debt and greater school attendance), but some costs (for example, fewer films and less industrial innovation). The one exception to this rule was a positive relationship between cultural tightness and crime rates, which means that the relationship between cultural tightness and order should be taken with caution.

It is important to note that some of the variables that we tested here have been examined by past studies. In particular, changes in conformist baby names have been predicted on the basis of pathogen prevalence, collectivism and unemployment[3]. Given past research, which has shown that ecological threats such as pathogens increase cultural tightness[8,9], cultural tightness may mediate some of these past findings. Pathogen prevalence, for example, was linked to both tightness ($\beta = 0.28$, $P = 0.002$) and naming conformity ($\beta = .10$, $P = 0.002$) over time in our analyses, even after controlling for the monotonic effect of time. However, when tightness and pathogen prevalence were modelled together, tightness was a significant predictor of naming conformity ($\beta = 2.62$, $P < 0.001$), whereas pathogen prevalence was not ($\beta = 0.03$, $P = 0.60$) and a Monte Carlo simulation confirmed that tightness fully mediated the effect of pathogen prevalence on naming conformity (95% confidence intervals, 6.84–1.93).

The current study also had limitations that should be addressed by future research. The primary limitation was the unavailability of measurable mechanisms: we had no way of statistically accounting for why cultural tightness was correlated with patent applications, adolescent pregnancies or household debt rates. This limitation was particularly acute in the case of crime rates—which, unexpectedly, were positively linked with cultural tightness. This association might be owing to more arrests during culturally tight time periods, but we have no way of confirming or ruling out this potential explanation. To answer more mechanistic questions, we encourage future research that takes a finer-grained approach to examining why tight and loose language might fluctuate over short periods of time, perhaps testing for fluctuations in this language following high-threat events (for example, the attack on the World Trade Centre in New York in 2001 (known as the 9/11 attack) or the Boston marathon bombings in 2013) in newspapers, speeches of politicians and mission statements of organizations[25]. We also encourage future research to test how cultural tightness–looseness may have changed in more recent American history. It may be possible, for example, that cultural tightness has rebounded in more recent years due to

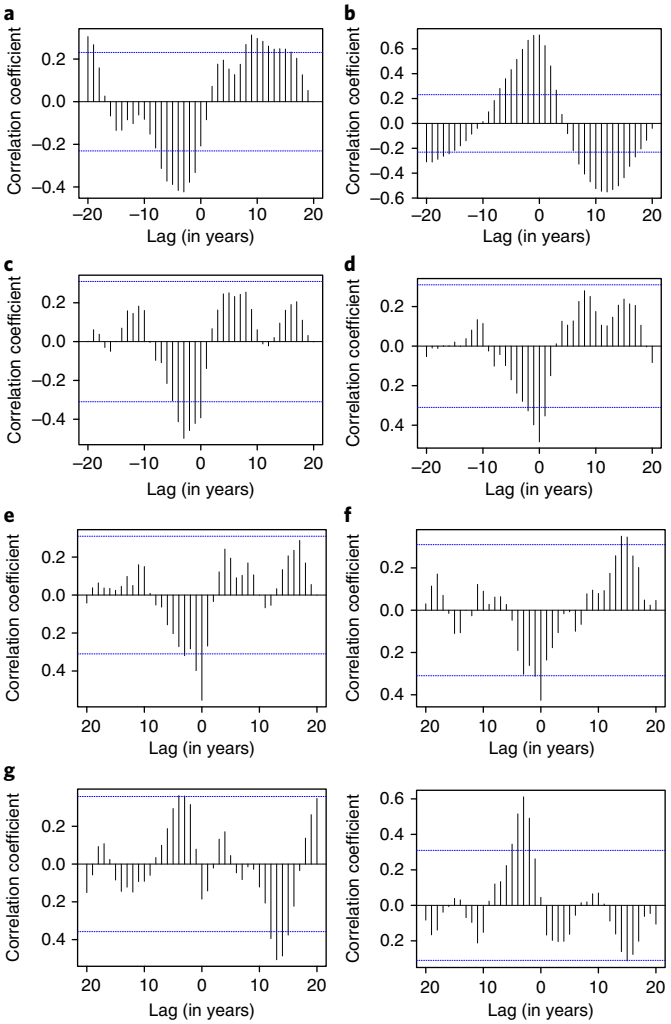

Fig. 3 | Cross-correlations between cultural tightness and measures of creativity and order. a–**d**, Cross-correlation between cultural tightness and measures of creativity. **a**, Correlation with feature film production. **b**, Correlation with baby-naming conformity. **c**,**d**, Correlations with the number of trademarks (**c**) and patents (**d**). **e**–**h**, Cross-correlation between cultural tightness and measures of order. **e**, Correlation with household debt. **f**, Correlations with adolescent pregnancy rates. **g**, Correlations with the rate of high school enrollment. **h**, Correlation with the rate of crime (calculated as the number of crimes per 100,000 people). Each bar represents a correlation coefficient, and the height of the bar represents the direction and magnitude of the correlation. Values outside the dashed horizontal lines are significant correlations at the level of $P = 0.05$. Negative lags (bars on the left side of the plot) indicate that cultural tightness is preceding creativity or order. Positive lags (bars on the right side of the plot) indicate that creativity or order is preceding cultural tightness.

the perceived threat of international terrorism, illegal immigration, and rhetoric from populist politicians.

Our study shows the potential of cultural dynamics as a growing framework for answering age-old questions and resolving contemporary debates. The present research provides insights into the societal implications of tight or loose social norms and addresses the evolution of a cultural distinction that echoes far back in scholarly thought.

Methods

We operationalized a time-series index of cultural tightness–looseness using data from the Google Books corpus[16]. The Google Books corpus provides information on how frequently a word has been used in a given year—indexed by its percentage of all words in books. This percentage metric controls for the total number of words, meaning that rates of change are not confounded by the total number of books published in a given year. As such, increased use of tight words would indicate increased salience of cultural tightness. The timescale of Google Books data (available yearly) and the duration of availability (over 200 years) guaranteed sufficient data for analysis.

We faced a challenge indexing words that are representative of tightness and looseness. One solution would be to draw words from the existing tightness–looseness scales, but we sought an index that reflected how cultural tightness–looseness was conceptualized by non-scientists. To develop a more comprehensive index, we used the recently developed computational framework word2vec[18]. The word2vec framework can automatically associate a word (or a common phrase) with a vector (a set of coordinates) in a high-dimensional space. In this space, the distance between the vectors of two words denotes semantic similarity between those two words in a given corpus. We used a word2vec mapping of words appearing in the Google News dataset in a 300-dimensional space and stored the vector coordinates for eight words that were associated with tightness (comply, conform, constrain, prevent, obey, oblige, restrain and uniformity) and eight words that were associated with looseness (allow, autonomy, choose, create, freedom, leeway, variability and unique) that we developed through discussions between authors and review of the existing tightness–looseness literature and measures[8,9]. Then, after taking the mean vector coordinates for all tightness words and all looseness words, we extracted the 50 words that occurred most often with our tightness word list and the 50 words that occurred most often with our looseness word list.

These word lists were not final products, and each contained some words with little face validity, which most probably occurred together with the chosen tightness and looseness word because some of these words had multiple meanings or were frequently used in multiple different contexts. Therefore, we used an expert in tightness–looseness theory who was blind to our particular hypotheses to refine the word lists to twenty loose words and twenty tight words with high validity (see Supplementary Information). Tight and loose words both covaried reliably across years ($\alpha s > 0.92$) and correlated negatively with each other ($\tau = -0.63$), suggesting a single 'tightness–looseness' construct. We therefore collapsed the indices for our subsequent analyses.

To assess the convergent validity of this linguistic measure, we gathered data on four indicators that we believed to be strongly related to cultural tightness. Our first measure was the yearly rate of people who identified as religious versus non-religious, which was available since 1948 from Gallup (https://news.gallup.com/poll/1690/religion.aspx). Religiosity has correlated strongly with tightness in crosscultural analyses[8], and many have argued that it provides an enforcement system for social norms that is characteristic of tightness[26]. Our second and third measures were number of laws passed by the US Congress—available biannually from GovTrack (https://www.govtrack.us/congress/bills/statistics) since 1947—and number of Supreme Court cases heard—which was available through the US Supreme Court webpage (https://www.supremecourt.gov/). Cultural tightness correlates strongly with governmental activity and regulation[8], and we considered laws and Supreme Court cases to be face-valid measures of governmental activity and regulation. Our fourth measure was profanity in television programs and films, which we considered a face-valid measure of norm violation that should track years with weaker norms. We created a yearly profanity index of eight common curses (motherfucker, cunt, asshole, faggot, damn, shit, fuck and bitch; $\alpha = 0.82$) and stored data on uses of these words since 1931 in the Bookworm film and television database (http://movies.benschmidt.org/), controlling for general rate of television and film production. Each of these terms was popularized as a profanity prior to 1931. Our fifth measure was execution rates, which were available since 1800. Execution indicates severe punishment for defection, so we considered it indicative of strong norms.

We also needed to operationalize order and creativity over time. A more in-depth discussion of how we selected order and creativity variables is provided in the Supplementary Information. We also briefly summarize these variables and their validity here (order: household debt, crime, high school attendance and adolescent pregnancy; creativity: baby-naming conformity, film production, patents and trademarks).

Household debt reflects how well people are spending their money, such that greater debt indicates lower self-regulation. During times of extreme poverty, people may be in debt regardless of their spending habits. However, controlling for gross domestic product in our cultural tightness–debt analyses enabled an analysis of changing debt that was not confounded by fluctuations in societal wealth. For this reason, we indexed debt as an economic measure of self-regulation[27,28] and used it as our first measure of societal order. We collected our data on household debt from The International Monetary Fund, which has been storing information on household debt in the United States since 1960.

Crime is determined by multiple factors, with both systematic and psychological factors influencing crime rates over time. Self-regulation has been repeatedly supported to be one such psychological factor, because individuals with high self-regulation consider the long-term consequences of their behaviour and are less likely to commit crimes[29,30]. We therefore indexed crime as our second

measure of order, gathering data on crime rates from the US Disaster Center, which has been storing these data since 1960. Note that, although the Disaster Center stores data on many types of crimes, we collapsed across specific crimes in this specific study, for the sake of parsimony.

High school attendance is linked to self-regulation, because order influences the likelihood of someone dropping out of school or engaging in disruptive or criminal behaviour that would bar them from the public-school system[31]. High school enrollment is also particularly important, as high school students often exert more control than younger students over their school attendance. High school attendance therefore served as our third measure of order. We gathered data on high school attendance from the World Bank, which has been storing data on high school enrollment since 1970.

Decisions around contraception are subject to a number of influences, including education, availability, religion and life history strategies[32]. Another primary influence, however, is that of self-regulation, and past studies have linked order with high contraceptive fidelity after controlling for other relevant factors[33]. This is especially true in out-of-wedlock adolescent pregnancy, which the US Department of Health and Human Services estimates to characterize 89% of total adolescent pregnancy. Therefore, we indexed the rate of adolescent pregnancies as a measure of self-regulation, with data that the World Bank has been gathering since 1960.

The choice of baby names has previously been treated as indicative of a desire for uniqueness[3]. However, choosing unique versus common baby names is also indicative of creativity, as uncreative baby names would equate to prototypical baby names. In support of this notion, many well-validated measures operationalize creativity through people's ability to generate non-prototypical ideas or representations[34], and the choice of a baby's name is a clear manifestation of this ability. Therefore, we gathered data on baby names from the Social Security Administration, which has been storing these data since 1880.

We indexed the number of American films produced each year as a second measure of creativity, since films are a common form of creative output. Of course, the number of films has been increasing more or less linearly over time, meaning that we were more concerned with how intertemporal fluctuations within this trend would relate to fluctuations in cultural tightness. We gathered data on films from the website IMDb (https://www.imdb.com/), starting in the year 1929, when demand for 'talkies' began to outstrip demand for silent-feature films.

Patents are a popular measure of societal creativity in crosscultural research, because they provide formal recognition of creative output[9]. We therefore measured the number of patents as our third measure of creativity. We collected data on patents from the World Bank, which has been storing these data since 1960. Data on trademarks—also stored by the World Bank since 1960—provided a measure of convergent validity regarding creative output, because they mark the popular establishment of a creative symbol. Therefore, we used trademarks as a fourth measure of creativity.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Code availability

The R code for these analyses—and all other analyses in the paper—is publicly available at https://osf.io/x2uzn/.

Data availability

The data that support the findings of this study are available at https://osf.io/x2uzn/.

Received: 7 September 2017; Accepted: 10 December 2018;
Published online: 28 January 2019

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Acknowledgements

We thank C. Fahmi and A. Veeragandham for research assistance. This study was supported by a National Science Foundation Graduate Research Fellowship to J.C.J., a Thomas S. and Caroline H. Royster Fellowship to J.C.J. and a Humboldt Foundation grant to M.G. No funding agency was involved in the conceptualization, design, data collection, analysis, decision to publish, or preparation of this manuscript, and the views expressed in this manuscript do not necessarily reflect the views of our funding agencies. Language used in this paper does not reflect the opinions of the authors, the funders or *Nature Human Behaviour*.

Author contributions

J.C.J. and M.G. conceptualized and designed the study. J.C.J., S.D. and A.F. acquired and analysed the data. J.C.J. and M.G. interpreted the analysis and wrote the manuscript. All authors approved the final version of the manuscript.

Competing interests
The authors declare no competing interests.

Additional information
Supplementary information is available for this paper at https://doi.org/10.1038/s41562-018-0516-z.

Correspondence and requests for materials should be addressed to J.C.J. or M.G.

Corresponding author(s): Joshua Conrad Jackson

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