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Does Causality Matter More Now? Increase in the Proportion of Causal Language in English Texts

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Abstract

The vast majority of the work on culture and cognition has focused on cross-cultural comparisons, largely ignoring the dynamic aspects of culture. In this article, we provide a diachronic analysis of causal cognition over time. We hypothesized that the increased role of education, science, and technology in Western societies should be accompanied by greater attention to causal connections. To test this hypothesis, we compared word frequencies in English texts from different time periods and found an increase in the use of causal language of about 40% over the past two centuries. The observed increase was not attributable to general language effects or to changing semantics of causal words. We also found that there was a consistent difference between the 19th and the 20th centuries, and that the increase happened mainly in the 20th century.

Keywords

causality, culture, automated text analysis, diachronic analysis, time series, open data

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Does causation matter more for people today than it did for their great-grandparents? Over the past two centuries, there has been a sharp increase in the availability and the duration of formal schooling, more pervasive application of technology in everyday life, and greater familiarity with science and scientific methods. All these cultural phenomena place particular value on cause-effect relations and foster explicit understanding of different levels of causation. Do these cultural shifts correspond to changes in how often we think about causes and effects in general? Such questions are hard to answer empirically because the absence of longitudinal data precludes direct comparisons (Iliev & ojalehto, 2015). One indirect way to address it, however, is to use automated text analysis of historical corpora. In the studies reported here, we used various time-stamped text corpora and the Linguistic Inquiry and Word Count (LIWC) causality dictionary (Pennebaker, Francis, & Booth, 2001) to test whether there has been a historical change in the amount of causal language in English texts. First, we outline the potential role of culture in causal cognition; then, we introduce recent work that has used automated text analysis to study cultural changes. Next, we present a series of empirical studies of the relative frequencies of causal words for the past two centuries. Finally, we discuss theoretical and practical implications.

How people represent, understand, and use causality has been among the central questions in psychology (Ahn, Kalish, Medin, & Gelman, 1995; Cheng, 1997; Gopnik et al., 2004; Kelley, 1973). In one approach to studying these questions, researchers have focused on the universal aspect of human cognition, in which causal learning, representation, and reasoning are not only common among humans but also could be shared with nonhuman animals (Blaisdell, Sawa, Leising, & Waldmann, 2006). Broadly speaking, this approach has been concerned mainly with how the mind connects different objects and events in space and time (Michotte, 1946/1963; Pavlov, 1960/1927), how it accounts for competing cause-effect candidates (Rescorla & Wagner, 1972; Shanks, 1985), or how it distinguishes between observations and interventions (Pearl,

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2000; Skinner, 1938). From this perspective, differences in causal cognition stem from differences in processing capacity, such as those between human and nonhuman animals (Penn & Povinelli, 2007), between children and adults (Piaget, 1927/1930), or between adults with different levels of intelligence (Carroll, 1993).

In contrast, in another broad approach, researchers have emphasized the role of culture in causal cognition. According to this perspective, although the propensity for causal explanations is a panhuman feature (Evans-Pritchard & Gillies, 1976; Shweder, Much, Mahapatra, & Park, 1997), causal cognition is still strongly shaped by culture. It has been repeatedly shown that causal attribution and causal judgments are consistently influenced by culture (Norenzayan & Nisbett, 2000). Depending on their cultural background, subjects in psychological experiments pay more or less attention (a) to the amount of information when making a decision (Choi, Dalal, Kim-Prieto, & Park, 2003), (b) to personal dispositions than to situational circumstances (Nisbett, Peng, Choi, & Norenzayan, 2001), (c) to focal objects than to contextual factors (Peng & Knowles, 2003), (d) to individuals than to groups (Morris & Peng, 1994), or (e) to spatiotemporally close than to far events (Maddux & Yuki, 2006).

Although the role of culture in causal cognition is already a well-established empirical finding, we know little about the historical aspect of such cognitive changes. The initial explanation of observed cross-cultural differences was that they stemmed from differences in ancient Chinese and Greek epistemologies and could be traced back to the work of ancient philosophers (Nisbett et al., 2001). However, this explanation, focused on antiquity, has been recently challenged (Varnum, Grossmann, Kitayama, & Nisbett, 2010) by the findings that East-West cognitive differences are mirrored by socioeconomic differences within the United States (Na et al., 2010) and by geographic differences within Japan (Kitayama, Ishii, Imada, Takemura, & Ramaswamy, 2006). Such results suggest that culture-driven cognitive changes could happen in a relatively short period of time and do not necessarily originate in the ancient past. Accordingly, it is important to determine whether we can detect such cognitive changes in the relatively recent history.

We hypothesized that causality has become more important for Western societies over time and, more specifically, that contemporary Westerners pay more attention to causal relations than their predecessors did. There are two mutually reinforcing paths through which such a process might occur. First, causality has become a key concept in the development of various scientific theories, including the discovery of electricity, the germ theory in medicine, and the discovery of DNA (Kern, 2009). Although some authors have argued against its scientific value (Russell, 1913), causality remains a key concept of science (Woodward, 2016). Second, the Western education system, with its explicit focus on teaching correct forms of thinking (Lipman, 2003; Zimmerman, 2000), has become a hallmark of modernity. School enrollment in the United States, for example, dramatically changed in the 20th century. Snyder (1993) reports the percentage of 5- to 19-year-old Americans enrolled in school: There was a small increase between 1850 (47.2%) and 1900 (50.5%), but by 1950, the percentage was already 78.7%. In 1991, it was 93.1%. Higher education in the United States shows similar trends. During the 1869–1870 school year, only one doctoral degree was granted; in 1899–1900, there were 382; and in 2005–2006, there were more than 56,000 (U.S. Department of Education, 2007). Not only has the general population become more educated, but also it has become more technological; a minimum level of understanding of how different machinery works has become a basic societal requirement (Fourez, 1997).

Even though the hypothesis that Western societies are increasingly concerned with causality is straightforward, testing it presents somewhat uncommon methodological challenges. In other branches of psychology, the presence of longitudinal data has made tracing historical trends relatively easy. Because the same psychological measures have been applied over the years, we now know that Americans are more intelligent than they used to be (Flynn, 1984) and have higher self-esteem than they used to have (Twenge & Campbell, 2001), but they are also less trusting (Putnam, 1995), less empathetic (Konrath, O'Brien, & Hsing, 2011), and more depressed (Twenge et al., 2010). Unfortunately, there are no comparable batteries of shared measures for studying causal cognition. Most studies dealing with causality have been specifically designed to test one theory or another rather than to repeatedly measure causal cognition among the general population. Therefore, to test our hypothesis, we would need to use a method that does not rely on direct measures.

One method for inferring cultural change in the absence of direct psychological measures is to apply automated text analysis to time-stamped text corpora. The most common technique is to assemble a set of words, often referred to as a dictionary, and measure the relative frequency of these words in different texts (for a recent review, see Iliev, Dehghani, & Sagi, 2015). This method has already brought results in various studies on cultural change. For example, Wolff, Medin, and Pankratz (1999) studied historical trends in folk-biological knowledge of English speakers. They found that cultural knowledge about trees had been gradually accumulating between the 16th and 19th centuries, but then it rapidly declined during the 20th century. Another example comes from Greenfield (2013), who tested whether societal changes between the 19th and 20th centuries could

be detected in the language used in English books. Measuring the frequencies of specific terms, such as "obliged," "choose," "get," and "unique," the author found a stable increase in individualism and materialism and a decrease in social belonging, authority, and duties. A similar pattern was observed by Kesebir and Kesebir (2012), who found that terms about morality and virtues (e.g., "decency," "honesty," "compassion") have been in decline in American books.

In this article, we present an empirical test of the hypothesis that the role of causality in Western society has changed. More specifically, because science, education, and technology have become more important now than they were in the past and because all three are associated with a focus on causal explanations and causal mechanisms, we expected an increasing prevalence of causal language in English texts. The approach we took to test our hypothesis is very similar to those used by Wolff et al. (1999), Kesebir and Kesebir (2012) and Greenfield (2013); an important difference is that we used an existing dictionary (Pennebaker et al., 2001) rather than developing our own set of target words. For the advantages of such an approach, see the Supplemental Material available online.

Study 1

Method

Corpora. We used three sources of time-stamped text data:

- *Google Books*: The Google Books database (Michel et al., 2011) is currently the largest time-stamped text corpus. We downloaded the 1-gram (i.e., one-word) data sets for American English and British English, which contain word frequency data from more than 4 million books. In addition, a subset of these frequencies labeled by Google as fiction was analyzed separately. Because the number of older books in the data set is very small, which leads to unstable patterns, we followed the common practice of using the year 1800 as a starting point (Greenfield, 2013; Michel et al., 2011). Because the data contained many nonwords, we reduced the size by filtering it through the standard Unix English dictionary.
- *The New York Times: The New York Times* has built a Web service (http://nytlabs.com/projects/chronicle.html) that presents historical trends similar to the ones provided by Google. One important difference is that *The New York Times* returns the proportion of articles per year containing a given word instead of the proportion of a given word relative to all words. This information alone was not sufficient, because the length of articles might vary from one period to another, and consequently we would not know whether an apparent increase in the number of articles containing a word reflected greater frequency of this word or increased average length of the articles. To overcome this caveat, in addition to our causality dictionary, we used a normalizing dictionary based on the 5,000 most frequent English words (Corpus of Contemporary American English, 2012). Instead of looking at the total number of articles containing causality words, we compared how often causality words appeared relative to the subset of common English words. The final data were based on 14.8 million articles published from 1851 to 2015.
- *Scientific American*: The journal *Nature* provides online access to the archive of the *Scientific American* (http://www.nature.com/scientificamerican/archive/index.html). We assembled a corpus based on Volumes 1 to 291, which correspond to the years 1845 to 2004. Because the automatic conversion from PDF to text format resulted in various errors, we again filtered out the words that were not part of the Unix English dictionary. The final corpus included 497 million words.

Causality dictionary. We used the "cause" category from the LIWC (Version 2007), which contained 108 words and stems. The dictionary included words such as *because, since, hence, how, why, depends*, and *implies*. When stems were used instead of complete words, such as in *influenc**, we searched for all word forms in the Unix dictionary, and included the forms *influence, influences, influence's, influenced*, and *influencing*.

Results

First we looked at the Google Books data (Fig. 1). For each year, we measured the frequencies of causality words relative to the total number of tokens for that year. Then, for each of the three types of books (i.e., American, British, and fiction), we tested whether this proportion changed over time. A linear regression with word proportions as the dependent variable and time as the independent variable revealed a significant increase of the proportion of causal words over time for the American and British books and a weak but significant decrease for fiction (Table 1). Further, visual inspection of the patterns (Fig. 1, bottom) revealed a sharp difference between the 19th and 20th centuries. Additional tests showed that for the 19th century, causal language reliably declined in all three groups, yet afterward it reliably increased. Next, we analyzed the data from *The New York Times* using the

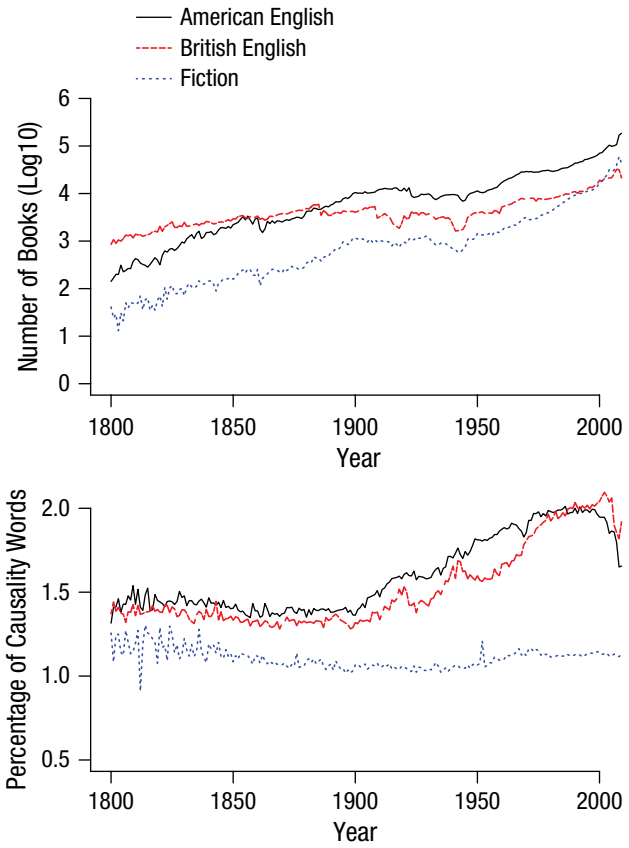

Fig. 1. Google Books data. The top panel shows the number of American English and British English books, along with the number of all fiction books from both corpora, that were printed each year from 1800 to 2009. In the bottom panel, the frequency of causality-related words in each of these three sets of books, expressed as a percentage of all words in the Google Books data set for a given year, is graphed across the same time period.

same method. There was an overall increase for the whole data period. Separate analyses revealed a nonsignificant positive trend for the 19th century and a significant positive trend afterward. The same pattern was observed for the *Scientific American* corpus: a significant overall increase for the whole time period, consisting of nonsignificant increase during the 19th century followed by a significant increase. The trends for the two periodicals are depicted in Figure 2, and the statistical details are presented in Table 1.

Two conclusions could be drawn from these analyses. First, we found converging evidence for an increasing role of causality in the English language, confirming our hypothesis. Four of the five corpora showed a significant increase, whereas fiction showed a weak but significant decrease. Second, we observed a clear difference between trends in the 19th and 20th centuries. The three Google Books corpora showed a significant decline of causal language during the 19th century, followed by a significant increase in the 20th century. The two periodicals showed a weak, nonsignificant positive trend for the 19th century, followed by a much stronger positive trend. Although the results for the 20th century converged for all five corpora, the results for the 19th century were less conclusive; the three books corpora and the two periodicals corpora had directionally opposite trends. Some difference between the 19th and 20th centuries might be expected given the higher rates of education noted earlier, but the decreasing trend for the 19th-century books was not predicted. It is possible that the observed negative trend was a statistical artifact due to the small sample size at the beginning of the period. For example, the average number of fiction books per year in the data set was 28 for the first 5 years of the 19th century, but was 995 for the last 5 years of the 19th century.

Alternatively, the observed negative trend might reflect a genuine cultural phenomenon. One speculation is that the early-19th-century authors might have had greater education than later authors or might have been writing for a more selective audience. It is also possible that interest in causality early on was in decline, and the tradition of correspondence between scientific progress and literature started at a later period. For example, Kern (2009) suggested that causality started to become a culturally significant concept around the 1830s, but his estimate was based on the analysis of specific emblematic books, which might predate the broader trend by decades.

Study 2

In Study 1, we found a reliable increase in causal language over time, but it is possible that these results might be a methodological artifact. The LIWC dictionaries were assembled in the 1990s, so it is possible that we observed an increase because contemporary words became more frequent for periods closer to the present. To test this alternative explanation, we ran another study, in which we compared the historical trend of causality-related words with the trends of the other categories in LIWC. If the causality trend is not distinguishable from the overall trend of the other LIWC categories, our interpretation of the results from Study 1 does not hold.

Method

We used the three Google Books corpora from Study 1. We measured the relative frequency of all dictionary-based categories from the LIWC for the period from 1901 to 2009. Both subordinate and superordinate categories were included; however, categories not based on specific dictionaries (e.g., "long words") were excluded. The total number of included categories was 64.

Table 1. Regression Results From Study 1: Year as a Predictor of the Percentage of Causal Language

Period of analysis and data source	Years covered	Slope of change (*b*)	*t*	R^2	*p*
All years					
Google Books (American English)	1800–2009	0.0030	$t(208) = 24.88$	.74	< .001
Google Books (British English)	1800–2009	0.0030	$t(208) = 21.48$	.69	< .001
Google Books (fiction)	1800–2009	−0.0003	$t(208) = -4.30$	.08	< .001
The New York Times	1851–2015	0.0050	$t(163) = 13.39$	.52	< .001
Scientific American	1845–2004	0.0050	$t(156) = 16.72$	.64	< .001
Before 1901					
Google Books (American English)	1800–1900	−0.0008	$t(99) = -6.74$	.31	< .001
Google Books (British English)	1800–1900	−0.0009	$t(99) = -9.93$	.49	< .001
Google Books (fiction)	1800–1900	−0.0020	$t(99) = -9.57$	.47	< .001
The New York Times	1851–1900	0.0030	$t(48) = 1.26$	.03	0.21
Scientific American	1845–1900	0.0010	$t(54) = 1.16$	.02	0.25
1901 and later					
Google Books (American English)	1901–2009	0.005	$t(107) = 19.65$	.78	< .001
Google Books (British English)	1901–2009	0.007	$t(107) = 34.35$	.91	< .001
Google Books (fiction)	1901–2009	0.001	$t(107) = 13.14$	.61	< .001
The New York Times	1901–2015	0.006	$t(113) = 9.83$	.46	< .001
Scientific American	1901–2004	0.006	$t(102) = 8.46$	.41	< .001

Results

For each of the 64 categories, we computed the Pearson product-moment correlation between time and the relative frequency of the category. Positive coefficients indicate an increasing linear trend, and negative coefficients indicate a decreasing one. The mean correlations across all 64 categories were $r(107) = -.37$ for British English, $r(107) = -.07$ for American English, and $r(107) = .17$ for fiction. The correlations between the causality category and time were $r(107) = .96$ for British English, $r(107) = .88$ for American English, and $r(107) = .79$ for fiction. According to one-sample *t* tests, the causality trends were significantly higher than the combined trends of the other categories: $t(62) = 17.28$ for British English, $t(62) = 16.67$ for American English, and $t(62) = 6.74$ for fiction (all *p*s < .001). The causality category showed the strongest positive linear trend among all 64 categories for the British English corpus, the 4th strongest for the American English corpus, and the 15th strongest in fiction from both corpora. A comparison of the linear trends for all 64 categories is presented in the Supplemental Material.

The results from the current study show that the linear increase observed in Study 1 was not a methodological artifact due to contemporary vocabulary. If the LIWC dictionaries were generally biased toward contemporary words, we would have observed positive linear trends across multiple categories. Although some categories showed a reliable increase, the statistical tests indicate that the positive trends of the causality-related words were stronger than the overall pattern. Therefore, the results from Study 1 cannot be attributed to a general linguistic bias related to the recency of the LIWC dictionaries.

Study 3

We needed to address one final methodological question concerning the validity of our causality measure in historical contexts. The results from Study 2 demonstrated that our findings are not attributable to the modernity of the LIWC dictionaries in general, because most of the LIWC categories did not show the same increase as the causality category did. It is still possible, however, that the vocabulary used to discuss causality has changed but the interest in causality has remained stable. If that is the case, we could witness an increase in causality words, but such an increase would reflect shifting vocabulary rather than increasing interest in causality. Although detailed analysis of such a question would fall into the realm of historical linguistics and go beyond the scope of this work, it was still possible to test whether the LIWC causality measure was sensitive to historical contexts. In Study 3, we compared the causality scores of two groups of historical texts, one of which was written by authors who are known for their interest in causality and the other of which consisted of English language classics.

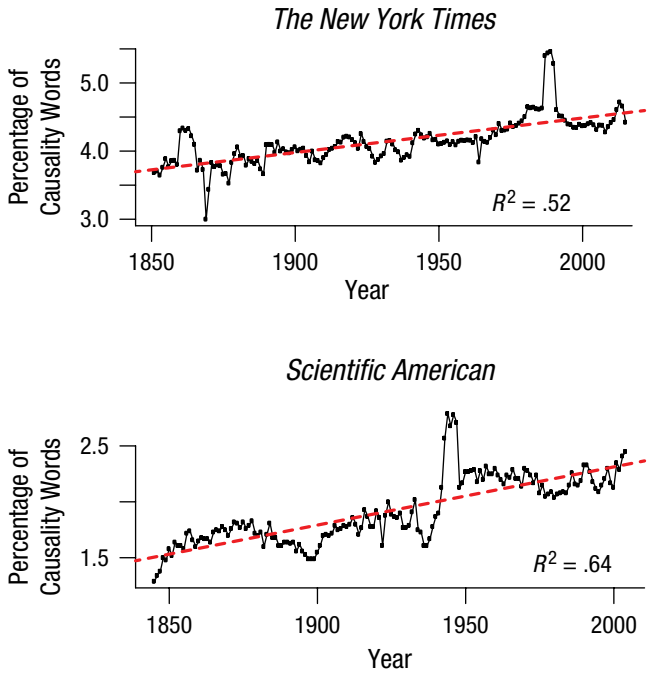

Fig. 2. Time trends for causal language in the archives of *The New York Times* (top) and *Scientific American* (bottom). The graphs show the frequency of causality-related words, expressed as a percentage of all words in the corpus for a given year (for *The New York Times*, 1851–2015; for *Scientific American*, 1845–2004). Also shown are best-fitting regression lines. Although the percentages for *Scientific American* were calculated using counts of all words in the archive for each year, the percentages for *The New York Times* were calculated using a subset of 5,000 frequent words and overestimate the true percentage of causal language.

Method

Causality dictionary. We used the same LIWC dictionary as in the previous studies.

Text corpus. We used data from Project Gutenberg (https://www.gutenberg.org), which provides digital copies of books in the public domain (i.e., books that were never copyrighted or for which the copyright has expired).

Design. We created two groups of authors, which we will refer to as target and control. The target group was derived from a list of the most influential historical thinkers who had worked on causality. To avoid research bias, instead of creating our own list, we used the one assembled by Hulswit (2004). The list included Aristotle, Thomas Aquinas, René Descartes, Thomas Hobbes, Baruch Spinoza, Gottfried Leibniz, John Locke, Isaac Newton, David Hume, Immanuel Kant, and John Stuart Mill. The control group consisted of English-language authors who worked before the 20th century. It included Jane Austen, Lewis Carroll, Rudyard Kipling, Herman Melville, Edgar Allan Poe, Mary Shelley, Robert Louis Stevenson, Harriet Beecher Stowe, Mark Twain, and Oscar Wilde. For each of the authors in the two lists, we searched for the historical texts available in the Project Gutenberg. When more than one text was available, we used the three most popular English texts. For the full list of book titles, see the Supplemental Material.

Results

There were 28 texts (4.3 million words) in the target group and 32 texts (2.7 million words) in the control group. We computed the percentage of causality words for each group. On average, the texts from the control group had 1.04% causal words (SD = 0.21), whereas the texts from the target group had 2.45% causal words (SD = 0.75). The difference was statistically significant, Welch's $t(31) = 9.53$, $p < .001$. Moreover, there was a clear separation between the two groups: Any author from the target group (with the exception of Newton) had higher scores than any author from the control group. The exception might not be surprising given that Newton's main contribution to the work on causality was the rejection of the principle of causality itself.

The results from Study 3 demonstrated that the LIWC causality dictionary could be used to differentiate between historical texts that are a priori known to be more concerned with causality from those that were not. Therefore, the increase in causal language observed in Study 1 cannot be explained by historic changes in the specific causal vocabulary.

Discussion

We hypothesized that the increased role of science, education, and technology in Western society in the relatively recent past should have been accompanied by detectable cognitive changes and, more specifically, by an increased focus on causality. To test this hypothesis, we measured the amount of causal language in historical texts in five corpora. In four of the five corpora, we found an overall increase in causal language. We also found different trends for the 19th and 20th centuries. Although we detected an increase in causal language during the 20th century in all five corpora, the results for the 19th century were less consistent. The three Google Books corpora revealed a reliable decrease, whereas the two periodicals showed a nonreliable positive trend. The decreasing trend in books might be a statistical artifact attributable to the relatively small number of available texts for earlier periods, but it also might be related to the early popularization of nonscientific books, when authors started writing books for the broader masses. The overall trend, however, strongly supported our prediction for an increase in causal language.

We ruled out two alternative explanations for the observed increase. According to the first one, the increasing pattern might be a result of contemporary vocabulary used in LIWC. From this perspective, modern words would become more frequent the closer we get to the present, which would result in an inevitable increasing trend. Study 2, however, showed that there was no overall increasing trend across all LIWC categories, and that the linear trend for the causality category was significantly higher than the average trends of the other categories. According to the second alternative explanation, authors from the past were as concerned with causality as contemporary authors are, but they used different vocabulary, which the LIWC does not capture. To test whether the LIWC causality category was sensitive to an increased attention to causality in historical texts, in Study 3 we compared the language in English classics with the language of historical authors who are known for their interest in causality. The LIWC dictionary allowed us to reliably distinguish between the two groups and to rule out this second explanation.

If we accept that the number of causal words in text corpora from a particular cultural context can be used as a proxy measure for the number or salience of causal inferences that people make, then our results have two important theoretical implications. First, they add to the body of work that links cognitive processing to cultural and societal factors (Vygotsky, 1980). As we suggested earlier, increased attention to causality is not surprising given the increasing role of formal schooling, popular science, and everyday technology. The second implication concerns the origin of current cross-cultural differences. Similar to the changes observed by Greenfield (2013), the changes we observed in these studies have occurred over a relatively short period of time, which suggests that researchers should focus not only on ancient history but also on more recent historical processes within cultures.

With the present research, we have also sought to demonstrate the value of automated text analysis as a tool for within-culture diachronic analysis. We have provided evidence for an increasing role of causality over time, yet some questions remain. First, we used a predefined general dictionary of causality. As described in the Supplemental Material, such a strategy avoids some methodological pitfalls, yet it does not tell us much about historical changes in the usage of different types of causality. For example, we might want to develop separate causality-focused dictionaries that follow the East-West cognitive divide, distinguishing between dispositional and situational causes or between analytic and holistic causes. Further, we might want to distinguish between physical and social causality (Morris & Peng, 1994), between causal notions based on covariance and those based on mechanisms (Ahn et al., 1995), as well as among causing, enabling, and preventing (Wolff, 2007). In addition to dictionary-based methods, another fruitful approach might be an analysis of historical changes based on word co-occurrences or on feature-extraction methods (see Iliev et al., 2015).

The second direction for continuing the current work is to extend the analysis to causality-focused cross-language comparisons (e.g., Beller, Bender, & Song, 2009; Wolff & Ventura, 2009). Although the richest corpora are currently those containing American English, Google has also assembled time-stamped corpora for other major Western languages, as well as for Chinese, Russian, and Hebrew. Combining within-culture historical trends with between-culture comparisons will help us better understand linguistic and historical patterns related to cultural differences in causal cognition. Developing multiple dictionaries and applying them to several languages will undoubtedly be a laborious task, yet one that is well worth the potential insights to be gained and that will enable us to take advantage of data that have been already collected. As this report shows, automated text analysis can rapidly test theoretical intuitions with precise and transparent measures across an expansive range of data, presenting a promising new analytic perspective for cultural research.

Action Editor

Marc J. Buehner served as action editor for this article.

Author Contributions

R. Iliev and R. Axelrod created the study concept and developed the research design. R. Iliev conducted the studies, wrote the computer script, and ran the statistical analyses. R. Iliev and R. Axelrod wrote the manuscript.

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The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at http://pss.sagepub.com/content/by/supplemental-data

Open Practices

All data have been made publicly available via Open Science Framework and can be accessed at https://osf.io/m7sdz/. The complete Open Practices Disclosure for this article can be found at http://pss.sagepub.com/content/by/supplemental-data. This article has received the badge for Open Data. More information about the Open Practices badges can be found at https://osf.io/tvyxz/wiki/1.%20View%20the%20Badges/ and http://pss.sagepub.com/content/25/1/3.full.

References

Ahn, W. K., Kalish, C. W., Medin, D. L., & Gelman, S. A. (1995). The role of covariation versus mechanism information in causal attribution. *Cognition*, *54*, 299–352.

Beller, S., Bender, A., & Song, J. (2009). Weighing up physical causes: Effects of culture, linguistic cues and content. *Journal of Cognition and Culture*, *9*, 347–365.

Blaisdell, A. P., Sawa, K., Leising, K. J., & Waldmann, M. R. (2006). Causal reasoning in rats. *Science*, *311*, 1020–1022.

Carroll, J. B. (1993). *Human cognitive abilities: A survey of factor-analytic studies*. New York, NY: Cambridge University Press.

Cheng, P. W. (1997). From covariation to causation: A causal power theory. *Psychological Review*, *104*, 367–405.

Choi, I., Dalal, R., Kim-Prieto, C., & Park, H. (2003). Culture and judgment of causal relevance. *Journal of Personality and Social Psychology*, *84*, 46–59.

Corpus of Contemporary American English. (2012). *Word frequency data*. Retrieved from http://www.wordfrequency.info/free.asp

Evans-Pritchard, E., & Gillies, E. (1976). *Witchcraft, oracles and magic among the Azande*. Oxford, England: Clarendon Press.

Flynn, J. R. (1984). The mean IQ of Americans: Massive gains 1932 to 1978. *Psychological Bulletin*, *95*, 29–51.

Fourez, G. (1997). Scientific and technological literacy as a social practice. *Social Studies of Science*, *27*, 903–936.

Gopnik, A., Glymour, C., Sobel, D. M., Schulz, L. E., Kushnir, T., & Danks, D. (2004). A theory of causal learning in children: Causal maps and Bayes nets. *Psychological Review*, *111*, 3–32.

Greenfield, P. M. (2013). The changing psychology of culture from 1800 through 2000. *Psychological Science*, *24*, 1722–1731.

Hulswit, M. (2004). A short history of 'causation.' *S.E.E.D. Journal* (*Semiotics*, *Evolution*, *Energy*, *and Development*), *4*(3), 16–42.

Iliev, R., Dehghani, M., & Sagi, E. (2015). Automated text analysis in psychology: Methods, applications, and future developments. *Language and Cognition*, *7*, 265–290.

Iliev, R., & ojalehto, b. (2015). Bringing history back to culture: On the missing diachronic component in the research on culture and cognition. *Frontiers in Psychology*, *6*, Article 716. doi:10.3389/fpsyg.2015.00716

Kelley, H. H. (1973). The processes of causal attribution. *American Psychologist*, *28*, 107–128.

Kern, S. (2009). *A cultural history of causality: Science, murder novels, and systems of thought*. Princeton, NJ: Princeton University Press.

Kesebir, P., & Kesebir, S. (2012). The cultural salience of moral character and virtue declined in twentieth century America. *The Journal of Positive Psychology*, *7*, 471–480.

Kitayama, S., Ishii, K., Imada, T., Takemura, K., & Ramaswamy, J. (2006). Voluntary settlement and the spirit of independence: Evidence from Japan's "Northern frontier." *Journal of Personality and Social Psychology*, *91*, 369–384.

Konrath, S. H., O'Brien, E. H., & Hsing, C. (2011). Changes in dispositional empathy in American college students over time: A meta-analysis. *Personality and Social Psychology Review*, *15*, 180–198.

Lipman, M. (2003). *Thinking in education*. Cambridge, England: Cambridge University Press.

Maddux, W., & Yuki, M. (2006). The "ripple effect": Cultural differences in perceptions of the consequences of events. *Personality and Social Psychology Bulletin*, *32*, 669–683.

Michel, J. B., Shen, Y. K., Aiden, A. P., Veres, A., Gray, M. K., Pickett, J. P., & Aiden, E. L. (2011). Quantitative analysis of culture using millions of digitized books. *Science*, *331*, 176–182.

Michotte, A. (1963). *The perception of causality* (T. Miles & E. Miles, Trans.). New York, NY: Basic Books. (Original work published 1946)

Morris, M. W., & Peng, K. (1994). Culture and cause: American and Chinese attributions for social and physical events. *Journal of Personality and Social Psychology*, *67*, 949–971.

Na, J., Grossmann, I., Varnum, M. E., Kitayama, S., Gonzalez, R., & Nisbett, R. E. (2010). Cultural differences are not always reducible to individual differences. *Proceedings of the National Academy of Sciences, USA*, *107*, 6192–6197.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001). Culture and systems of thought: Holistic vs. analytic cognition. *Psychological Review*, *108*, 291–310.

Norenzayan, A., & Nisbett, R. E. (2000). Culture and causal cognition. *Current Directions in Psychological Science*, *9*, 132–135.

Pavlov, I. P. (1960). *Conditioned reflexes: An investigation of the activity of the cerebral cortex* (G. V. Anrep, Trans.). Mineola, NY: Dover Publications. (Original work published 1927)

Pearl, J. (2000). *Causality: Models, reasoning, and inference*. London, England: Cambridge University Press.

Peng, K., & Knowles, E. D. (2003). Culture, education, and the attribution of physical causality. *Personality and Social Psychology Bulletin*, *29*, 1272–1284.

Penn, D. C., & Povinelli, D. J. (2007). Causal cognition in human and nonhuman animals: A comparative, critical review. *Annual Review of Psychology*, *58*, 97–118.

Pennebaker, J. W., Francis, M. E., & Booth, R. J. (2001). *Linguistic inquiry and word count: LIWC 2001*. Mahwah, NJ: Erlbaum.

Piaget, J. (1930). *The child's conception of causality* (M. Gabain, Trans.). London, England: Kegan Paul, Trench, and Trübner. (Original work published 1927)

Putnam, R. D. (1995). Tuning in, tuning out: The strange disappearance of social capital in America. *Political Science & Politics*, *28*, 664–683.

Rescorla, R. A., & Wagner, A. R. (1972). A theory of Pavlovian conditioning: Variations in the effectiveness of reinforcement and nonreinforcement. In A. H. Black & W. F. Prokasy (Eds.), *Classical conditioning* (pp. 64–99). New York, NY: Appleton-Century-Crofts.

Russell, B. (1913). On the notion of cause. *Proceedings of the Aristotelian Society*, *13*, 1–26.

Shanks, D. R. (1985). Forward and backward blocking in human contingency judgment. *The Quarterly Journal of Experimental Psychology*, *37*, 1–21.

Shweder, R. A., Much, N. C., Mahapatra, M., & Park, L. (1997). The "big three" of morality (autonomy, community, divinity) and the "big three" explanations of suffering. In A. Brandt & P. Rozin (Eds.), *Morality and health* (pp. 119–169). New York, NY: Routledge.

Skinner, B. F. (1938). *The behavior of organisms*. New York, NY: Appleton-Century-Crofts.

Snyder, T. D. (Ed.). (1993). *120 years of American education: A statistical portrait*. Washington, DC: U.S. Department of Education, Office of Educational Research and Improvement, National Center for Education Statistics Publishing. Retrieved from http://nces.ed.gov/pubs93/93442.pdf

Twenge, J. M., & Campbell, W. K. (2001). Age and birth cohort differences in self-esteem: A cross-temporal meta-analysis. *Personality and Social Psychology Review*, *5*, 321–344.

Twenge, J. M., Gentile, B., DeWall, C. N., Ma, D., Lacefield, K., & Schurtz, D. R. (2010). Birth cohort increases in psychopathology among young Americans, 1938–2007: A cross-temporal meta-analysis of the MMPI. *Clinical Psychology Review*, *30*, 145–154.

U.S. Department of Education. (2007). Historical summary of faculty, students, degrees, and finances in degree-granting institutions: Selected years, 1869-70 through 2005-06. In *Digest of Education Statistics*. Retrieved from http://nces.ed.gov/programs/digest/d07/tables/dt07_178.asp

Varnum, M. E. W., Grossmann, I., Kitayama, S., & Nisbett, R. E. (2010). The origin of cultural differences in cognition: The social orientation hypothesis. *Current Directions in Psychological Science*, *19*, 9–13.

Vygotsky, L. S. (1980). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Wolff, P. (2007). Representing causation. *Journal of Experimental Psychology: General*, *136*, 82–111.

Wolff, P., Medin, D. L., & Pankratz, C. (1999). Evolution and devolution of folkbiological knowledge. *Cognition*, *73*, 177–204.

Wolff, P., & Ventura, T. (2009). When Russians learn English: How the semantics of causation may change. *Bilingualism: Language and Cognition*, *12*, 153–176.

Woodward, J. (2016). Causation in science. In P. Humphreys (Ed.), *Oxford handbook of philosophy of science*. Oxford, England: Oxford University Press. doi:10.1093/oxfordhb/9780199368815.013.8

Zimmerman, C. (2000). The development of scientific reasoning skills. *Developmental Review*, *20*, 99–149.