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Review

The role of epistemic drift in online civic discourse about science

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Our societies are experiencing an epistemic drift, that is a changing understanding of what it means to be "honest" and how to arrive at "truth". This drift has increasingly replaced reliance on evidence and facts during truth-seeking with reliance on beliefs, feelings, and intuitions alone. This is especially important in civic discourse about science, which by its very nature relies on evidence over intuition and feelings. We posit that the role of epistemic drift in civic discourse about science is observable in online discussions and can be analyzed through their digital traces. Building on observational and experimental work, we propose a model in which epistemic drift fuels low-quality information sharing through its interplay with emotions. In this view, epistemic drift also drives online toxicity, which creates apparent polarization and erodes the quality of online civic discourse on scientific topics like health and climate change.

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Introduction

When the Soviet empire crumbled in 1989 and liberal democracy seemingly triumphed across the globe, it did not take much optimism to declare the "end of history"; that is, an era in which liberal democracies and market economies would shape human welfare forevermore [1]. A few decades later, such optimistic language has been replaced by concerns with multiple simultaneous crises, from climate change to the threat of future pandemics, increasing inequality and polarization, and democratic backsliding in countries previously thought to have stable democracies, to name but a few. The end of history has turned into a permacrisis and polycrisis — that is, a long-lasting state of multiple simultaneous crises that may amplify each other and that defy resolution unless their complex causal interactions are understood [2].

We argue that there is a common thread that connects several contemporary crises. We characterize this common thread as an epistemic drift; specifically, we argue that there has been a persistent and ongoing change in what it means to be "honest" and how to arrive at "truth", in particular among politicians in western democracies. We show that this drift is associated with indicators of other crises, from inequality to polarization. We argue that this drift also contributes to online toxicity and polarization, which may in turn explain the erosion of public discourse surrounding scientific topics such as climate change or public health.

The drift from evidence to intuition

Democracy relies on citizens sharing a common body of knowledge [3,4]. Accordingly, citizens in liberal democracies prioritize honesty in their representatives over other attributes [5] and the perceived integrity of U.S. presidents was linked to their approval ratings in the closing decades of the previous century [6,7]. The repeated election of Donald Trump to the U.S. presidency seems to contradict the public's desire for honest politicians, given Trump's long-established record of false and misleading statements— more than 30,000 during his first term in office.[1] The conundrum deepens when one considers that Trump's voters—by a three to one margin in most surveys—thought of him as "honest" throughout his first term.[2]

One way in which this seeming paradox can be resolved is by examining in more detail what is meant by the term "honest". This examination has identified two distinct ways in which honesty—and its closely related companion, truth—can be understood [8–11]. One

[1] http://www.washingtonpost.com/politics/2021/01/24/trumps-false-or-misleading-claims-total-30573-over-four-years.
[2] e.g., http://www.nbcnews.com/politics/politics-news/poll-republicans-who-think-trump-untruthful-still-approve-him-n870521.

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understanding of honesty and truth mainly considers sincerity and intuition. On this view, when Donald Trump claims that vaccines cause autism, if the audience perceives that claim to express his sincere belief (however mistaken), then they may consider Trump to be honest even while he is uttering a clear falsehood [12]. The alternative understanding of honesty and truth mainly considers factual accuracy and evidence. On this view, the audience would consider Trump's claim about vaccines to be dishonest or false.

Our work to date has focused on operationalizing and measuring those two understandings of honesty and truth at scale. Specifically, we developed and validated pairs of dictionaries that captured the two different understandings of honesty and truth.[3] For example, we used words such as "feel", "guess", or "seem" to capture a sincerity- or intuition-based understanding, and we used words such as "determine", "evidence", or "examine" to capture a fact- or evidence-based understanding. The words in each dictionary were converted into vector representations known as embeddings [13]. Embeddings are typically obtained from a co-occurrence matrix of all tokens encountered in a large corpus of text (e.g., several billions of tokens obtained by web crawling; see https://commoncrawl.org). A co-occurrence matrix captures the meaning of a word by recording the frequency with which other words are immediately adjacent in natural language (e.g., "ice" co-occuring with "water" more frequently than with "fashion" [13]). Co-occurrence matrices are unwieldy data structures and become useful only after application of mathematical dimension-reduction methods (e.g., singular value decomposition, which is best understood as a generalized version of factor analysis [14]), which yields a matrix in which each row represents a word *embedding* using a far smaller number of columns (usually in the order of a few hundred). In our case, embeddings were averaged across words to arrive at a single numeric representation of the understanding of truth captured by each dictionary. This approach is known as a distributed dictionary representation (DDR) [15] and has the advantage that instead of counting word occurrences in the text of interest, the core meaning of the entire dictionary can be compared to the text of interest—which is similarly converted into averaged embeddings—using a graded similarity measure (i.e., the cosine between vectors). An important implication of the DDR approach is that any text, even if it is seemingly unconcerned with honesty or truth, can be analyzed with respect to the underlying tacit view of honesty or truth that it embodies.

[3] Although honesty and truth are distinct concepts, with the former referring to a person and the latter to the state of the world, here we consider them interchangeably for brevity. The conceptual distinction between honesty and truth was mapped out in Ref. [11].

We applied our dictionaries of truth (i.e., one for evidence-based and one for intuition-based approaches to truth) to 8 million transcripts of speeches in the U.S. Congress between 1879 and 2022. We measured the relative salience of evidence-based language over intuition-based language by computing a similarity score between each speech and the two dictionaries [16]. For simplicity, the similarity scores were combined into a single number, called the EMI (evidence-minus-intuition) score, by subtracting the intuition-based similarity from the evidence-based similarity. The analysis revealed that the reliance on evidence (reflected in a positive EMI score) reached a peak in the mid 1970s, which was followed by a continuous and ongoing decline (see Figure 1). For the most recent years considered (2020–2022), speeches in Congress were primarily involving intuition-based rhetoric rather than relying on evidence. For illustration, Table 1 provides snippets of speeches of each type.

The overall trend in Figure 1 was observed for both houses of Congress and for both parties (although the decline was particularly steep for Republicans during the last few years). The trend was also observed for nearly all topics of discussion when speeches were classified into 20 distinct policy areas (the one exception was international affairs, which did not exhibit a evidence peak in the 1970s but showed a nearly continuous decline since the 1880s). The epistemic drift from evidence to intuition among American politicians shown in Figure 1 is thus of considerable generality, transcending topics as well as partisanship. The drift turns out to be more than an intriguing observation because it is associated with a number of other indicators of various crises, including the fate of democracy.

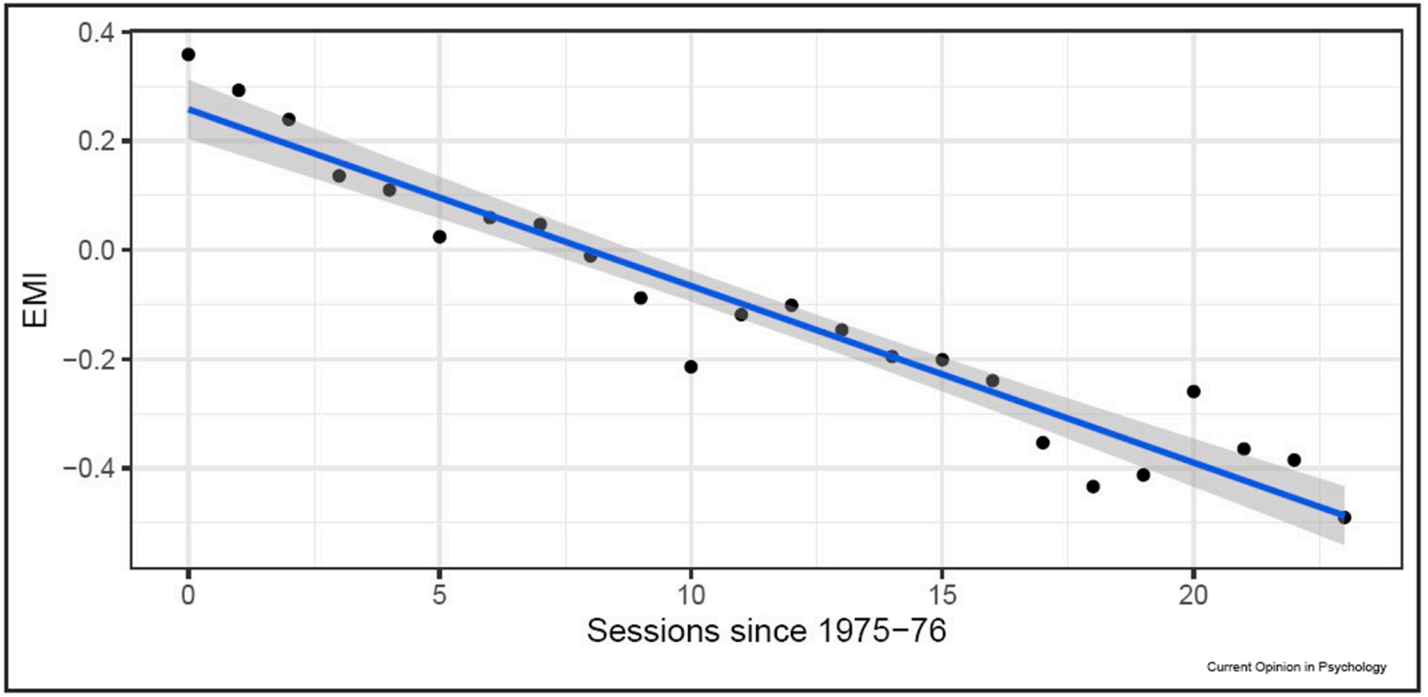
The consequences of epistemic drift

Polarization

A variety of adverse consequences have been found to be associated with the epistemic drift. First, the EMI score for congressional speeches was strongly associated with polarization in Congress, as measured through the DW-NOMINATE database of congressional votes [17]. The more speeches relied on intuition rather than evidence, the greater on average the polarization between parties observed in the same session of Congress [16]. Although congressional polarization is frequently greater than polarization of the public [18], during the last two decades affective polarization of the public has been increasing in the United States (and is outpacing polarization in many other countries) [19]. High elite polarization has been identified as a risk to democracy [20], and it also decreases the public's satisfaction with democracy [20–22].

There is evidence that elite polarization can be directly transmitted to the public in conversations on Twitter. An analysis of tweets by members of the U.S. Congress

Figure 1



Decline of EMI scores in congressional speeches after the peak in 1975–76. Speeches are from both houses of Congress and both parties. The line shows a linear fit and the shaded area shows the standard error of the predicted EMI values based on the regression model. Figure reproduced from Ref. [16] under Creative Commons license.

Table 1

Excerpts of congressional speeches with high and low EMI score.

Sample of evidence-based speeches (high EMI score)
"Yes. The Senator can get them in detail I am sure from the report of the Federal Trade investigation. Before I conclude I shall give some figures as to some of the holding companies and subsidiaries, and some figures applying to all of them showing the fictitious capital stocks and bonds which have been floated and sold to an innocent public, for which absolutely no real value existed."
"If the distinguished and honorable Senator has not read the report of the committee, which was prepared for the information of Senators, he must not charge the committee with any dereliction of duty in not supplying him with information."
Sample of intuition-based speeches (low EMI score)
"I can give the Senator an illustration. I had some ancestors who were very smart people. But fought for the Stuarts in Great Britain against Puritanism and the Commonwealth and the Parliament. They were wise men individually. But historically they were asses. Does the Senator understand the illustration? Their successors partially in my person have confessed that they were asses."
"Oh. Yes. Your howl about the farmers of the country and the destruction of the price of wheat is nothing but the wail of the old standpatter. Who sees the mountain of protection giving way under ceaseless and constant hammering on the part of the people."

showed that more affectively polarized tweets by a politician (as measured by application of dictionaries of polarization; [23]) elicit more polarized replies from members of the public on Twitter/X [24]. Moreover, when controlling for polarization in the politicians' tweets, it was found that tweets that relied more on intuition and sincerity elicited more polarized responses from the public than tweets that used evidence-based language [24]. Thus, the overall association between long-term epistemic drift and increasing polarization can also be observed on a moment-by-moment basis during conversations between politicians and members of the public.

Misinformation

A survey of 1500 experts by the World Economic Forum in 2024 nominated misinformation as the most significant short-term global risk, capable of disrupting elections and exacerbating societal polarization [25]. There is little doubt that misinformation can undermine democracy in a number of ways [4,26–28], including by leading some people to consider politicians to be honest despite their widespread record of misrepresentation and falsehoods, as we noted at the outset.

To examine the potential link between the view of honesty expressed in political speech and quality of the information being shared, we examined a sample of nearly 4 million tweets by members of Congress between 2011 and 2022 [29]. The text in each tweet was again characterized by computational means, using a pair of dictionaries, and the quality of information being shared (i.e., via link in a tweet) was assessed using NewsGuard scores. NewsGuard publishes "nutrition labels" for news domains based on journalistic criteria by professional fact checkers and journalists. NewsGuard scores can distinguish between reliable and unreliable sites, without however identifying individual news items as accurate or false. The analysis revealed that the more a politician relied on language of sincerity and intuition, the more likely they were to share poor-quality information. This association was small in magnitude for Democrats but accentuated for Republicans. Conversely, for both parties, the more a politician's tweet relied on language representing accuracy and evidence, the more likely it was to contain high-quality information [29]. When honesty is seen as a matter of sincere expression of belief, rather than a reflection of accuracy, this rhetorical approach can serve as a gateway to misinformation.

Inequality

Political rhetoric can also have ramifications for the broader welfare of society. Specifically, the analysis of congressional speeches revealed an association between EMI and income inequality, such that more evidence-based rhetoric was followed by lesser societ al. inequality (and conversely, intuition-based rhetoric was associated with greater inequality). Although inequality is just a single variable, it is a good proxy for a society's welfare overall [30]. More unequal societies tend to have lower population health compared to more equal societies, and the same association holds for many other social indicators, including mental illness, level of violence, imprisonment, teenage birth rates, obesity rates, and prevalence of drug abuse [31]. Inequality may also damage democracy more directly because individuals in highly unequal environments tend to project individualistic norms onto society [32]. Imposing those norms fosters greater competition and reduces cooperation, which, in turn, may damage democracy [33].

Association or causation?

We have reported several associations between political rhetoric and democracy-relevant outcomes. The direction of causality must be considered unresolved for all of those outcomes, given the challenges of establishing causal pathways without detailed knowledge of micro-level underlying cognitive processes [34]. Nonetheless, there is suggestive evidence that rhetoric may play a causal role in some of those associations. Specifically, the association between the EMI scores of congressional speeches and societ al. inequality was maximal when the two time series were lagged by two session—that is, the EMI from two congressional sessions ago predicts inequality today. The presence of the lag is compatible with the idea that legislation passed by Congress takes

time to exert its effects and be reflected in society-wide indicators. Given that EMI was also found to be strongly associated with congressional productivity in the same session, a causal chain from evidence-based rhetoric to legislation and from there to reduced inequality is entirely plausible but must remain inconclusive for now.

Moreover, the association between how a politician communicates with the public and the style in which the public responds has been identified as causal. In addition to observing the text of tweets "in the wild", as reported above, we also conducted an experiment in which participants were instructed to respond to (synthetic) tweets on a variety of controversial topics. Unbeknownst to participants, the tweets emphasized either sincerity or accuracy in their rhetoric. The study found that people responded to the tweets in a like manner: sincerity-based language elicited sincerity and evidence-based language elicited facts [24].

Epistemic drift and discourse about science

The importance of science in solving global crises is self-evident. It is therefore of particular concern that the epistemic drift we just described appears to extend to public discourse about science, although the evidence to date has been sparse. Politicization of scientific discussions does not have to be a sign of epistemic drift, for example when discussing how policymaking should be informed by science. However, in the attention economy of social media, politicization of scientific discussions more often leads to rejection of evidence or reliance on misinformation and conspiracist thinking to support partisan arguments. Text analysis of Twitter data on COVID-19 and climate change shows that both types of politicization coexist on X/Twitter, with evidence rejection linked to right-wing politics and conspiracy politics [35].

A recent analysis of medical preprints during the COVID-19 pandemic revealed the interconnections between the dissemination of preprints on social media—which had become the public's main avenue into scientific debate—and the politicization of COVID-19-related discourse [36]. From that analysis, it stands out how with the onset of the pandemic, preprints were identified as "study" rather than "preprint", thereby subtly omitting that results were not peer-reviewed yet. Furthermore, there was a shift from preprints being shared in scientific contexts to being shared in political discussions, in particular by users who identified as Republican and who used politically-charged terms. Beyond that, another analysis of tweets about COVID-19 found patterns of politicization and of selective exposure where users consumed content that aligned with their pre-existing views [37]. A similar politicization and polarization has been observed concerning discourse on climate change on social media [38]. Polarization was low between the COP20 and COP25 meetings, that is between 2015 and 2020, but then increased rapidly for COP26 in 2022, driven mainly be growing right-wing activity. The political affiliation of one's contacts is correlated with how scientific information is received: In addition to an individual's political affiliation, the composition of the political affiliation of their close social contacts is predictive of their confidence in vaccines [39]. Beyond social media, text analysis of US newspapers over three decades shows how references to politicians on the topic of global warming greatly increased in comparison to references to scientists [40]. A similar pattern of politicization appeared in newspapers during COVID-19, but was weaker in network news [41].

Epistemic drift creates linguistic traces in which the language used by different groups and political actors becomes increasingly different, leading to "linguistic echo chambers" and polarization visible in news and social media text. An analysis of the language used in the US Congress when discussing climate change detected an increasing divergence of the language used by Democrats and Republicans, commencing in 2011, that signals a new level of polarization in the way politicians express themselves [40].

A similar pattern was detectable in newspaper coverage during COVID-19, although it was weaker in network news [41], suggesting that polarized news content might have contributed to polarization in attitudes about COVID-19 in the wider public. Embedding models further allow measuring the polarization among US politicians when they discuss climate change on X/Twitter. A recent analysis found that climate change is not as polarized as other contentious issues like abortion, gun rights, or migration. Notably, this kind of linguistic polarization is higher in regions with lower vulnerability to climate change and with lower education levels [42].

The politicization of science and the erosion of a shared language makes social media an ideal channel to spread misinformation on topics that otherwise are informed by science. An analysis of tweets related to the EAT-*Lancet* report in 2019, a landmark article on sustainable and healthy diet recommendations, shows the existence of a new pro-meat community that is using the #yes2meat hashtag to share conspiracy theories about the origin of the study [43]. Similarly, topic modelling of tweets about COVID- 19 vaccines reveals the presence of conspiracy theories about population control in the run-up of the 2020 presidential election [44]. Social media content consumption is associated with vaccine hesitancy. A preregistered study collected Twitter and survey data and identified a correlation between following conservative accounts and lower confidence in the COVID-19 vaccine [45]. Morevoer, sharing links to

low-quality news sources, identified through the Newsguard list, was associated with an increased likelihood of refusing the vaccine. [45]. This is in line with a wider pattern across social media, as reviewed by Ref. [46], where social media content consumption shapes attitudes towards the COVID-19 vaccine. Beyond vaccination, social media also played a role in shaping attitudes towards masks during the COVID-19 pandemic. Tweets critical of mask mandates contained misinformation and conspiracy theories, and the time series of the volume of this type of content led the time series of the number of COVID-19 cases [47].

Discussion

We set out to show that there is a common thread, which we call epistemic drift, that connects several contemporary crises. We have shown that this drift from evidence-based to intuition-based political rhetoric is associated with various indicators of societal welfare and the integrity of democracy, such as polarization and inequality. We also examine this drift in the rhetoric surrounding scientific issues. We cannot pin down the causality behind those associations, although we have established that political rhetoric has downstream consequences in shaping the public's style of debate. One important open question is why this epistemic drift has been observed in the first place. At present, we cannot settle this question empirically, but we can draw attention to several societal trends and one political event that coincided with the onset of the drift. Longitudinal research on social capital in the United States has uncovered inflection points in several indicator variables at about the same time (i.e., the mid 1970s) [48,49]. These include trust in others and confidence in institutions [49], and a shift in adolescents' life goals from discovering a philosophy of life to being well-off [48]. The decline in social capital has previously been linked to the slow emergence of a "post-truth" world [50], and the epistemic drift considered here may be another manifestation of the decline of social capital, although this linkage must remain speculative for now.

An alternative account focuses on specific political events and notes the temporal coincidence between the onset of the drift in the late 1970s and the rise to prominence, and subsequent election to president, of Ronald Reagan. Reagan was widely seen as a great and transformative communicator [51] who introduced a new, "folksy" style of rhetoric into politics that used narratives and anecdotes to mythologize America [52]. His rhetorical style was not modeled on political high culture, but the homely storytelling of traditional American folk culture [53], and this by itself may have constituted the onset of the epistemic drift in political rhetoric. Another factor may be Reagan's decision to rescind the "fairness doctrine" during his second term in 1987, which from 1949 onward had forced broadcasters to devote time to contrasting views on issues of public importance.[4] The removal of the fairness doctrine gave rise to a more fractionated media landscape, exemplified by the emergence of "shock jocks" on talkback radio and highly partisan broadcasters (e.g., Fox News) that catered to a subset of the population. The fractionation, in turn, created an incentive for politicians to become more extreme because they could preferentially address their own partisans—thus gathering more votes at the extreme margins than they would lose in the center by becoming more extreme [54]. The conjunction of those factors— Reagan's own rhetoric, the emergence of more radical news media after revocation of the fairness doctrine, and the incentive for politicians to become more extreme as a result—may help explain the origins and continuation of the epistemic drift we have observed. This hypothesis is awaiting empirical examination.

A final pressing question is whether, and how, this epistemic drift can be reversed. It is far from clear whether a reversal is achievable, but there are small signs of encouragement. In a field experiment involving U.S. state legislators, candidates standing for reelection were found to become more accurate if they were advised of a possible reputational threat arising from fact-checking (in comparison to a control group without such intervention) [55]. In a recent study involving members of the public, participants who were reminded of the importance of accuracy (as opposed to sincerity) as a marker of honesty became less tolerant of violations of democratic norms by politicians [56]. Whether these effects can be scaled to reverse a decadal political trend remains to be seen.

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S.L. produced a first draft of the paper which was jointly edited and revised by both authors.

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Declaration of competing interest

There are no competing interests to disclose.

[4] https://www.reaganlibrary.gov/archives/topic-guide/fairness-doctrine.

Data availability

No data was used for the research described in the article.

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* of special interest
** of outstanding interest

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Further information on references of particular interest

11. ** An explanation and overview of the different views on honesty that are at the heart of the epistemic drift described here.

16. ** The foundational paper that examined the evidence for epistemic drift through a computational linguistic analysis of speeches on the floor of the U.S. Congress.

35. * A mixed-methods analysis of the convergence of COVID-19 and climate topics on Dutch-speaking Twitter that shows that politicization of science on social media can both be political contestation or ideological rejection of science.

42. ** An application of word embeddings to US congress members on Twitter that allows the measurement of linguistic differences between parties as a measure of polarization. This allows to compare the party divide across topics and the correlates of linguistic polarization on climate change with district carbon emissions and climate vulnerability.