Topic modeling reveals distinct posting patterns within an online conspiracy forum.

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Abstract

Conspiracy theories play a troubling role in political discourse, yet the motivations of conspiracy endorsers can be obscure to outsiders. Online forums provide a valuable window into the day-to-day discourse of conspiracy theorizing, but one that is difficult to quantify. We used non-negative matrix factorization to create a topic model of the `r/conspiracy` forum on Reddit.com. This subreddit provides a large and unique corpus which spans many years and numerous authors. We show that within the forum, there are multiple sub-populations distinguishable by their topic loading. Further, these differences are readily interpretable as differences in background beliefs and motivations. These groups regularly interact with one another by commenting; hence topic modeling reveals subgroups that would not be revealed by simple network analyses. The diversity of the distinct subgroups places constraints on theories of what generates conspiracy theorizing: neither simple irrationality nor common preoccupations of topics seem to fit the bill. Instead, we suggest, conspiracy theorizing seems to be primarily driven by higher-order preoccupations with evidence and argument, along with rhetorical strategies which allow diverse groups to each address any particular theme.

Introduction

Alexis de Tocqueville wrote that the American commitment to freedom of association prevented the formation of conspiracies [1]. Considering recent political discourse, this is perhaps optimistic; indeed, conspiracy *theorizing* has long been a part of American politics [2]. The free association promoted by online forums forms a key mechanism for the spread of misinformation, including conspiracy theories [3–5]. Conspiracy theories are not socially innocuous: aside from obvious political effects, endorsement of conspiracy theories is associated with rejection of science and unwillingness to donate to prosocial causes [6].

Numerous psychological accounts purport to explain the attraction of conspiracy theories. Conspiracy endorsers are said to favor a ‘monological’ belief system, in which every event is connected to every other event [6, 7]; to be driven by feelings of powerlessness and lack of control [8]; to crave explanation in a fundamentally confusing world [9]; to be motivated by background political beliefs [10]; to seek social individuation [11]; or to be misled by the ‘echo chambers’ of online opinion [5, 12].

Experimental studies [13] give some insight into the personality structure of conspiracy endorsers. Yet most such studies use a convenience population of students and artificial tasks with questionable ecological validity. Examination of online comments to news stories [14] gives more insight into

the public arguments of committed conspiracy theorists, but it is unclear how widely this generalizes. Only the most vocal and colorful conspiracy theorists are likely to come to public attention, obscuring the larger but more circumspect population who merely *endorse* conspiracy theories.

Finally, many studies assume that ‘conspiracy theorist’ picks out some kind of relatively homogeneous group whose behavior is driven by the same principles. So for example researchers ask ‘who tends to believe [conspiracy theories], and why’ [15] or inquire into the ‘psychological origin’ of conspiracy theories [16], or what ask about the ‘similar underlying psychological processes’ that are common to conspiracy believers [17]. In each case the implication is that there *is* a common psychological factor which characterizes conspiracy endorsers and distinguishes them from others.

Yet as Wood et al [14] have noted, there are serious disagreements and arguments even within conspiracy communities. Conspiracy theorists debate every aspect of (e.g.) the 9/11 attacks, with the only point of agreement being that the official story is (somehow) false. This heterogeneity can be difficult to quantify. Yet accounting for diversity as well as similarity is vital for any account that wants to show the underpinnings of conspiracy endorsement.

This study presents a novel way to investigate and quantify heterogeneity within a large group of conspiracy endorsers. We used a large publicly available collection of online comments from the **r/conspiracy** forum on the website **reddit.com**. Reddit is a collection of online forums (‘subreddits’), most of which are user-run and moderated. Reddit is a popular site, with web traffic consistently ranking in the top 10 US sites. While most forums are comparatively anodyne, Reddit’s historical commitment to freedom of speech has allowed fringe communities to flourish. Reddit makes its comments available to researchers through a public API, and a comprehensive dataset covering nearly 8 years of comments is available.

Topic modeling is a method for representing each document in a corpus as being generated by a variety of distinct topics, each of which consists of a weighted set of words. Topic modeling techniques have become popular because they allow unsupervised dimensionality reduction: much of the variability in a large corpus like the **r/conspiracy** comments can be captured by a relatively small number of topics. The topics generated tend to be easily interpretable by experimenters. Documents (in our case, collections of posters’ comments) are represented as a mix of different topics, allowing for fine-grained categorization and analysis.

As topic modeling has its roots in automated information retrieval, most uses focus on the categorization of individual documents by sorting them into semantically similar clusters for later retrieval and analysis. However, one can equally well use topic modeling to explore the psychological motivations of the authors who make the comments [18]. That is our approach:

having fitted a topic model to `r/conspiracy`, we propose to interpret it as an (abstract and idealized) model of the underlying psychological processes of the authors involved. Topic modeling, combined with detailed descriptive statistics about posting patterns, can thus reveal something about the underlying motivations and belief formation processes of conspiracy endorsers. We thus predicted that `r/conspiracy` would contain subgroups that differed in meaningful ways on their topic loadings and other measures of interest.

Materials and methods

Dataset and preprocessing

We used a publicly available dataset containing 1.7 billion comments and associated metadata spanning from October 2007 to May 2015. This includes nearly 2.25 million comments to `r/conspiracy`, made by nearly 130,000 distinct authors. Reddit posts consist of an initial ‘link’ post—typically just a link to another website—followed by nested comments underneath. Only comments are included in the dataset and the analysis. Comments outnumber link posts by roughly 12:1, and link posts rarely contain more than a URL; of the top 10 most commented-upon links in the dataset, only one contained substantial original text.

We removed high-posting bots, pre-processed the text to remove common words and non-linguistic data, and combined each author’s comments into a single document [19–21]; S1 Appendix contains full details. The result was a term frequency-inverse document frequency (tf-idf) representation of each author’s combined contributions to the `r/conspiracy` forum.

Topic modeling

To analyze the linguistic structure of the data, we constructed a topic model, using the combined author comments as the documents of the target corpus. We used non-negative matrix factorization (NMF), an algorithm developed to find common parts of pictures and which is well-suited to corpus analysis [22–24].

The overall choice of topic number depends on one’s theoretical concerns [25]. Our goal was to find common themes hidden among a group of superficially similar commenters. This argued for a comparatively small number of topics compared to uses which seek to make fine-grained classifications of documents. Choosing too small a topic number tends to result in topics that overlap and run together different themes. To optimise between these two demands, we examined a quantifiable measure of the similarity of the derived topics to one another for a range of topic models.

We constructed an NMF model for $t = 12, 15, \dots 90$ and then calculated the mean cosine similarity between each pair of topics in the generated model. We chose $t = 48$ as the point where the mean cosine similarity began to flatten out (see S1 Fig). The full 48-topic NMF model used for subsequent analyses is shown in S1 Table.

Subgroup clustering and statistics

We predicted that **r/conspiracy** would contain subgroups of authors whose posts differed in meaningful ways in their loadings on the extracted topics. To test this hypothesis, we categorized the authors in **r/conspiracy** into subgroups by using authors' loadings in the document-topic mapping as the basis for a k-means clustering. Authors who made only one or two posts were eliminated from the set, as preliminary analysis showed that they only added to noisy clusterings. To chose a number of clusters, we then performed kmeans clustering from $n = 2..30$ and calculated the percentage of variance explained (PVE) for each. The improvement in PVE begins to level out around $n = 12$ (see S2 Fig. To further ensure that $n = 12$ was a reasonable cluster solution, repeated Linear Discriminant Analysis (LDA) was used to verify cluster discriminability. Data and labels were shuffled and an LDA model fitted on half and tested on the other half. This procedure was repeated 100 times. The resulting mean classification accuracy of 89% (SD .002) is significantly different from expected chance performance of $1/12 \approx 8\%$ ($p < .001$) suggesting that the derived subgroups do pick out stable clusters in topic space.

For the entirety of **r/conspiracy** and each of the 12 subgroups, we calculated number of comments, number of authors, mean number of comments by author, and the *post concentration*, which we define as the percentage of authors who were responsible for the top 50% of comments. In addition to basic descriptive statistics, we examined four other measures to characterize the posting patterns of the subgroup relative to the whole.

First, we compared the posts that each author made in other subreddits versus the number of posts they made in **r/conspiracy** (the *external to target* (E:T) *ratio*). The lower the E:T ratio, the more authors tend to concentrate on the target forum alone. Second, to examine the degree to which authors tend to post with others in their group, we calculated the *mean link diversity* (MLD) for each subgroup. MLD measures how many authors from other subgroups, on average, post to threads in **r/conspiracy** that authors in a subgroup post to. MLD can range from 1 (authors in the subgroup post only with authors in their own subgroup) to 12 (authors post in threads with representatives from every other subgroup.) A low MLD would suggest that subgroups with different language use patterns self-segregate within the forum, while a high MLD suggests the opposite.

Third, to characterize the posting patterns of the subgroups relative to the whole, we examined loadings by topic for each of the subgroups. In test for variation between subgroups, we selected by determining the standard deviation of the loadings by subgroup and then choosing the 15 with the highest standard deviation. For topic loadings, significance level of $p < 0.01$ (uncorrected) was determined by a Monte Carlo method. The full document-topic mapping was shuffled and subgroups the size of the smallest subgroup were randomly selected. This was repeated 1000 times for each topic, and used to create upper and lower bounds for significance per topic.

Fourth and finally, we examined the correlation between a users' loading on topics and the logarithm of each users' combined overall comment length (by character count, which correlates highly with both word count ($r=0.99$) and number of comments made by the author ($r=0.91$)). The logarithm was used as comment length varies over several orders of magnitude. Because NMF fits the tf-idf representation rather than absolute word counts, a positive correlation between a topic and length should indicate that an author uses the words in the topic more *frequently* and *distinctively* the more they write. However, there is also a general correlation between topic loading and length across all topics (due in part to general properties of the tf-idf matrix, and in part to the fact that NMF picks words that tend to be more frequently represented in larger topics). To account for this general trend, we generated 10,000 pseudo-topics by randomly selecting one of the 48 loadings for each author, and used this to calculate the mean and 95% uncorrected confidence interval for the correlation between loading and log length ($r = 0.21 \pm 0.005$). Observed correlations above or below this were considered significantly different.

Aggregate comments and tags

To facilitate discussion, we assigned each subgroup a short name based on their distinctive posting patterns. In order to create a representative but anonymous sample comment, we chose comments from the top 2-4 posters in each subgroup, aggregating representative comments. We altered the grammar and word choice enough that a search would not reveal the original posters. Each poster has considerable variability in their own posts, but the quotes are representative of the whole.

Subgroup 11, the 'uncategorized' group, contains a mix of low-posting contributors, missed bots, and other difficult-to-categorize posts. There is undoubtedly further structure in this group which might be pulled out with further analysis, but much of it is clearly a noise cluster.

Results

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Topic loadings

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The top of Fig 1 shows the mean loadings by subgroup on the 15 most variable topics. Mean topic loadings reveal substantial between-subgroup differences, as well as differences between individual subgroups and **r/conspiracy** as a whole. The bottom of Fig 1 shows a descriptive tag and aggregate comment for each group. The descriptive tags will be used in what follows, placed in small caps to emphasize that they are convenience labels.

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In general, three patterns are seen. First, there are the two sets of TRUE BELIEVERS, which load highly on most topics. Members of these subgroups also tend to be frequent and enthusiastic posters, as shown by the posting statistics. Comment inspection suggests differences between these subgroups—very roughly, group 3 cares more about historical events while group 7 is willing to entertain more speculative conspiracies involving things like UFOs—but we will consider them together.

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Second, there are groups who are distinguished by very high loadings on a single topic and average/low loadings on the others. Some of these are what we will call traditional ‘thematic’ concerns: ANTI-SEMITES are concerned with Jews and Israel; PATRIOTS by constitutional issues, and especially gun control; TRUTHERS by conspiracy theories around the 9/11 attacks; ANTI-AUTHORITARIANS by police use of force against civilians, and ANTI-IMPERALISTS by the consequences of American power more generally.

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Also of note in this pattern are the PSEUDO-SCIENTISTS, who are concerned with quasi-scientific topics such as anti-vaccination advocacy or chemtrails. This subgroups brings up an important point: topic modeling does not distinguish between those who endorse a conspiracy and those who argue with conspiracy theorists. Further, there is considerable debate even among TRUE BELIEVERS about which conspiracy theories are worth endorsing. While this is an important caveat, it is a minor one. For one, comment inspection reveals that most subgroups are primarily composed of endorsers: those who are generally unimpressed by conspiracy theories are lumped by the algorithm into the SKEPTICS. For another, the fact that there are linguistically separable patterns of argument is itself interesting.

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The third and final pattern was less expected. There are groups who are distinguished by more ‘rhetorical’ topics. The most notable among these are the INDIGNANT, which are distinguished by high loading on a topic consisting of angry invective. What distinguishes the INDIGNANT in other words, is not what they talk about but how they talk about it. Similarly, REDDITORS are marked by discussion of Reddit itself and associated social drama, rather than particular themes.

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Turning to the topics themselves, topics like 3, 5, 14, and 17 also

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appear to be primarily rhetorical in nature. Loadings on these topics vary across groups, albeit less dramatically. These topics seem to contain words that play an important role in mediating ingroup identification along with agreement and disagreement, suggesting that such mediation is differentially important for different groups.

Topic correlations

Fig 2 shows the correlation between topic loadings and log comment length. (Raw numbers can be found in S2 Table). This shows which topics become more important the more people post. These results largely dissociate from the picture provided by the pure topic loadings. Consider, for example, the ANTI-SEMITES, who load heavily on the two topics having to do with Judaism. The correlation with log length and these two topics is only slightly above average, as you might expect: group membership is defined in part by placing a high importance on these topics no matter how often one posts. On the other hand, ANTI-SEMITES show a high loading with (e.g.) topic 13, suggesting that 9/11 conspiracy theories become more important for this group the more they write. Conversely, the opposite pattern is also shown—most subgroups are slightly *less* likely than average to talk about gun control the more they write.

Along the rows, two striking patterns emerge. Topic 0, which concerns evidence, belief, and argument, has the strongest correlations of the group, ranging as high as 0.75 in the subgroups and 0.73 overall (numeric scores are depicted in S2 Table). Topic 34, concerning American military power and foreign policy, has a similarly high pattern of correlation (as does topic 35, not pictured here).

Posting statistics

Table 1 shows basic statistics for number of authors and posts by subgroup and for the whole. These vary quite widely: the TRUE BELIEVERS are only 5% of the authors in *r/conspiracy* but responsible for 64% of the total comments.

Table 2 shows data about the External/Target statistics and the Mean Neighborhood Diversity for both the group as a whole and each subgroup. Two important trends are worth noting. First, there is wide variability in E:T ratios, with posters in the most enthusiastic subgroups showing a relatively low E:T. That said, even the group with the lowest average E:T still makes on average 9 comments in other forums for every one they make in *r/conspiracy*.

Second, table 1 shows that the MLD for each group and as a whole is relatively high. On average, people post in threads with representatives from at least 6 other subgroups. MLD ranges only slightly higher or lower.

Table 1. Basic Descriptive statistics.

Group	Posts	P/T	Authors	A/T	P/A
r/Conspiracy	2253494	1.00	129829	1.000	17.36
Skeptics	21131	0.01	2003	0.02	10.55
Anti-Imperialists	111601	0.05	7625	0.06	14.64
Anti-Authoritarians	34700	0.02	2311	0.02	15.02
True Believers 1	531056	0.24	3650	0.03	145.49
Patriots	13986	0.01	880	0.01	15.89
Truthers	57907	0.03	1268	0.01	45.67
Pseudoscientists	163217	0.07	6523	0.05	25.02
True Believers 2	910116	0.40	2324	0.02	391.62
Anti-Semites	92532	0.04	1453	0.01	63.68
Indignant	47196	0.02	3011	0.02	15.67
Redditors	45091	0.02	3108	0.02	14.51
Uncategorized	124299	0.06	19146	0.15	6.49

Descriptive statistics for **r/conspiracy** and each subgroup. P/T = posts by group as percentage of total posts in **r/conspiracy**. A/T = authors as percentage of total authors., P/A posts per author.

Table 2. Descriptive statistics for External posts versus target posts.

Group	E:T	MLD
r/Conspiracy	85	7.2
Skeptics	195	7.3
Anti-imperialists	129	7.4
Anti-authoritarians	121	8.4
True Believers 1	21	6.4
Patriots	135	8.2
Truthers	51	7.7
Pseudoscientists	81	6.9
True Believers 2	9	5.9
Anti-Semites	30	7.3
Indignant	126	7.7
Redditors	140	7.2
Uncategorized	254	7.1

E:T = Mean external to mean target ratio, MLD=Mean link diversity by group. **r/Conspiracy** = overall means, subgroups labels from figure 1.

This suggests that subgroups identified on the basis of topic modeling are not formed because a single forum hosts non-interacting sub-communities.

Despite diversity of interests and language use, it appears that everyone
talks to most everyone else.

Discussion

Posting patterns

We began with the claim that conspiracy forums are characterized by important diversity among posters, and that it would be rash to over-generalize from the behavior of the most frequent or enthusiastic posters. Our data provide support for this hypothesis. First, and most obviously, we have shown that commenters in **r/conspiracy** fall into meaningful subgroups with distinctive patterns of language use that appear to correspond to distinct concerns.

One would come away with a very different picture if one focused on comments rather than users. As noted before, TRUE BELIEVERS are responsible for a disproportionate number of comments. The top author of the TRUE BELIEVERS wrote a staggering 896,337 words (post-processing) across over 18,000 posts—roughly twice the combined length of the *Lord of the Rings* trilogy. Posters in this group may come closest to the classic picture of a ‘monological’ belief system.

However, TRUE BELIEVERS represent only about 5% of the authors in **r/conspiracy**; as the descriptive statistics show, they also tend to post voluminously elsewhere on Reddit, suggesting a commitment to *posting* rather than to conspiracy theories as such.

Most posters in **r/conspiracy** do not appear to post obsessively within the forum: most post more elsewhere, including the high-volume posters. The sheer number of authors in the dataset should also give pause to anyone proposing simplistic explanations: the posts and volumes in our dataset are roughly comparable to those in other subreddits such as **r/makeupaddiction** and **r/wow**, subreddits devoted, respectively to makeup tips and the popular videogame ‘World of Warcraft.’ Further, this includes only users who have taken the time to make a comment: many more passively follow the forums. By the posting standards of Reddit, therefore, **r/conspiracy** is comparable to forums discussing topics of broad mainstream interest rather than a tiny and isolated group.

Language use: four interpretations

Our study showed both commonalities and differences between subgroups posting in **r/conspiracy**. What, if anything, can one say about conspiracy believers as a whole? We evaluate four classes of theory about conspiracy endorsement in light of these findings.

Irrationality

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It is common to suppose that conspiracy endorsement is a sign of *prima facie* irrationality. The idea of a ‘monological belief system’ is typically introduced as the idea that belief in one conspiracy predicts belief in different, apparently unrelated theories [13,26]. Many have noted the power of conspiracy theories to give broad, unifying explanations at the expense of plausibility [9]. This suggests a particular picture: the conspiracy theorist is one who believes that *everything* is connected.

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Yet we think that a move to attribute pathological irrationality would be hasty. First, as we noted above, it is easy to overgeneralize from committed posters. But second, and importantly, the strong correlation between length and topic 0 suggests that posters are concerned above all with evidence and argument. Contrary to the unflattering picture presented by many authors, on which conspiracy endorsers are merely gullible or deluded, we note that conspiracy theorists in fact spend an inordinate amount of time discussing *why* they believe what they believe [2].

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Here we enter into delicate territory. There is a widespread assumption that the content of conspiracy theories is—perhaps by definition—irrational to believe. Yet it cannot be irrational *tout court* to believe that the CIA meddles in international affairs, or that scientists are experimenting on vulnerable populations without their consent, or that the US government secretly monitors the activities of dissident groups. As TRUE BELIEVERS are fond of pointing out, these things have all happened. The best one can say is that a given event is not part of a conspiracy.

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Further, as one of our sample quotes for the TRUE BELIEVERS suggests, even voluminous posters often see themselves as discerning, rejecting as many conspiracies as they accept. Tanya Luhrmann [27] noted a similar phenomenon among practitioners of modern witchcraft, suggesting that among marginalized communities internal debate is as important as agreement.

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First-order content

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Another possibility is that conspiracy believers are distinguished by particular sets of common beliefs. This is arguably the everyday picture—a conspiracy theorist just is someone who believes in conspiracy theories, and there is little more to say.

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The diversity in our dataset makes it difficult to maintain this view, at least if the relevant beliefs are meant to be ones shared by *all* conspiracy theorists. The best candidate might be found among topic 34, concerning US foreign policy, which correlates highly with comment length in all subgroups. It is difficult to know which way the order of explanation goes, however. The US is a powerful country; it may simply be a convenient touchstone for a variety of otherwise different interests.

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Noteworthy is the ability of our method to distinguish between groups like ANTI-AUTHORITARIANS and PATRIOTS. Both are concerned, in some broad sense, with government violence and abuse of power. But they show different patterns of topic loading and different correlation patterns, suggesting important distinctions between groups who may well discuss the same events for superficially similar reasons.

Second-order content

Another (not exclusive) possibility is that conspiracy theorizing is driven largely by what we will call *second-order* concerns: that is, concerns about how one arrives at first-order conclusions. Wood et al [26] suggest that learning about one conspiracy may encourage belief in others because ‘Even though the perpetrators may be different in each case, the fact that one massive, sinister conspiracy could be successfully executed in near-perfect secrecy suggests that many such plots are possible.’ The conspiracy theories so endorsed need not bear any particular relationship to one another. Indeed, it is possible that they might be mutually inconsistent. Wood et al. [26] note a positive correlation between endorsing the statement that Osama Bin Laden was dead before US soldiers arrived and endorsing the statement that he is still alive. One might have thought those to be difficult beliefs to hold simultaneously. However, this correlation is mediated entirely by a more general belief that officials are engaged in a cover-up of some sort or other.

The idea that some sources of information are unreliable cannot be an intrinsically irrational belief. As recent discussions of ‘fake news’ emphasize, everyone believes that at least some media sources are systematically distorted, and that epistemic responsibility thus involves keeping track of which are reliable. Indeed, we find substantial evidence that posters in *r/conspiracy* are concerned with general problems about epistemic responsibility. Recall that topic 0—dealing with evidence and argument—correlates strongly with log comment length for all subgroups. This suggests that the more authors talk, the more they care about evidence, belief and argument.

Rhetorical features

The above mostly concerns what endorsers believe. Yet as Hofstadter’s [2] classic work put it, ‘It is the use of paranoid modes of expression by more or less normal people that makes the phenomenon significant.’ A fourth possibility, therefore, is that conspiracy endorsement is a function of *style* as much as substance.

The most obvious example of this are the INDIGNANT, who write short, profanity-heavy posts. Indeed, the INDIGNANT raise an interesting pos-

sibility: some posters might *endorse* a conspiracy theory without fully believing it, as a way to express their background commitments. Someone might endorse the statement ‘The US was behind 9/11,’ not because they have positive beliefs about what happened, but as a way to vent their anger about US domestic policy. Racist conspiracy theories may play a similar role. Similarly, the REDDITORS seem to be as much concerned with interpersonal drama on the site as they are with any particular conspiracy theory.

Finally, rhetorical topics may play a moderating role. Our methods are relatively coarse-grained, and within groups such TRUTHERS, there can be considerable disagreement [14]. Among our TRUTHERS, topics such as 4, 5, 14, and 17 correlate well with topic length *and* load higher than average. These topics contain words that involve (among other things) moderating inter-group disagreement, providing evidence that such groups are diverse even internally.

Limitations and future directions

Several features and limitations of the present study are worth noting.

Topic analysis does not distinguish between people who endorse a conspiracy (in any sense) and those who argue with conspiracy theorists. Automated methods such as sentiment analysis for teasing out agreement and disagreement would be a useful addition to the present method.

More broadly, we formed subgroups solely by looking at language usage. Other groupings are possible with the reddit dataset: one might look at network structure both within and outside of `r/conspiracy`, for example, by looking at relationships of mutual commenting. Examination of the network structure of other forums [3–5] has given important insight about the dynamics of problematic beliefs as they spread through social networks, and would be a useful compliment to the current investigation. Similarly, one might look at other places in which authors post, as an index of their overall interests outside `r/conspiracy`.

That said, it is also worth noting as a strength of the current study that it is able to distinguish structure without relying on network considerations; the high mean neighbor diversity of each subgroup also suggests that different subgroups can find much to say to each other.

Compared to other methods, NMF has a reputation for creating topics with more diverse quality [24]—the best topics are quite coherent and consistent, while other topics are more diverse. However, we think that the present study offers a more nuanced view. Many ‘rhetorical’ topics are distinguished not by the pre-existing semantic similarity of the words to one another or their co-occurrence per se, but rather by the fact that they distinguish similar ways of talking *about* other topics. Topic 44 (for

example) contains a set of words pertaining to reading articles both in
print and online. These need not co-occur, and may even partially exclude
one another, while still representing an intuitively cohesive way of talking
about evidence. That said, some of the topics have clear intruders (e.g.
topic 10, which mixes words about faked pictures and videos with those
about actual incidents of fakery). More work is needed to distinguish low
from high-quality topics, keeping in mind the compositional nature of NMF
topics.

Conclusion

We have emphasized the degree to which conspiracy endorsers differ. We
suspect that this diversity continues down to the level of motives as well.
Theorists have suggested a wide variety of different motivations for belief
in conspiracy theories, including the need for explanations, the desire
for control in a complex world, political extremism, the desire for simple
explanations, and so on. Some of these do not appear to be especially
problematic motives *per se*. Indeed some form of low-grade conspiracy
theorizing is widespread (consider the kvetching that academics do about
the nefarious plans of administrators and granting bodies).

If we were to take **r/conspiracy** as a whole as a single author, that
author would undoubtedly seem monological and paranoid. Yet very few
authors within conspiracy fit a clearly monological pattern. We suggest that
r/conspiracy looks monological in part because there are many different
authors with different sets of concerns, each interacting with one another.
Consider a thread about (e.g.) secret CIA prison camps. One person
might care about its relationship to 9/11, another might use it to fuel their
antisemitism, a third to make a point about gun control. Each gets what
they need, and each contributes to the larger whole.

Ultimately, we doubt that there needs to be any particular set of psy-
chological motivations which characterize conspiracy theorists. Some are
irrational. Some are irate. Some are epistemically unlucky. Some are
racist. Some are skeptical. We should not say that conspiracy theorists
have overarching belief systems that encompass and unify a wide variety
of different narratives. Instead, it may be the other way around: it is
conspiracy *narratives* that are all-encompassing, pulling in a diverse group
of people who may have little in common with one another, each of whom
can find what they need in a fragment of the larger tale.

#	Name	Representative Quote
0	SKEPTICS	"This kind of thing comes up every month. Fuel burns differently when it is atomized than when it is in a puddle. Can someone please explain why you guys keep falling for this conspiracy nonsense?"
1	ANTI-IMPERALISTS	"Boeing can already target anyone, anywhere. The US is a wholly owned and operated subsidiary of the military-industrial complex. In a decade we'll have drones killing any American who disagrees with the slide into fascism."
2	ANTI-AUTHORITARIANS	"No doubt they are dirty cops and the store owner isn't paying up. 'Zero tolerance' is an excuse to shakedown business owners. Police do whatever they want, they're a gang, no different from the Crips and the Bloods."
3	TRUE BELIEVERS 1	"The difference is that the 911 truth movement has evidence on its side. The idea that Obama was born in Kenya is just a Republican plot to distract people from health care reform. There is no evidence for it, and plenty of evidence against."
4	PATRIOTS	"People who call for 'common sense' gun laws won't be happy until guns are banned. I'm sorry, but the bill of rights protects the rights of the PEOPLE; Article 1, Section 8, already authorizes the government to raise a standing army."
5	TRUTHERS	"Sorry guys, but you've clearly never watched the video. Anyone who sees the 'collapse' of WTC7 and still thinks it was caused by fire rather than demolition is blind or a shill for the NIST."
6	PSUEDOSCIENTISTS	"I have read vaccine studies for 20 years. Why do you think they never use a control? It would make it obvious that vaccines themselves spread highly profitable autoimmune diseases."
7	TRUE BELIEVERS 2	"If HAARP technology is indeed the superweapon so many say it is, then war between the superpowers may well have begun in 2010, and is being fought in secret. Fukushima was just another move in the game."
8	ANTI-SEMITES	"Or maybe you don't realize that the 'Arab Spring' was a Mossad/CIA plot from the start. Face it: only one nation is capable of dragging the U.S. back into the Middle East while making it appear that Islam rather than Judaism is the problem."
9	INDIGNANT	"Fuck Israel. Or I maybe I should just keep my racist shit in my pocket – oh wait, it's already fucking full."
10	REDDITORS	"The mods shadowbanned me 3 times in the last month alone. This subreddit is getting nuts."
11	UNCATEGORIZED	"You don't have to 'produce' electricity, it's all around us. That's why it is called electricity."

Fig 1. Subgroup differences. Top: Subgroup loadings on selected topics. Topics represented by the top 15 words per topic. Loadings significantly above the mean are shown in blue ($p < 0.01$ uncorrected). Loadings represented on a 0-1 scale, normalized per topic, with most saturated blue = highest loading for that topic. Bottom: Subgroup, descriptive label, and aggregated quote (see text for details).

Fig 2. Correlations. Correlations between log comment length and loading for selected topics, corrected for overall correlation between mean loading and length. Correlations shown for conspiracy overall ('C') and for each of the 12 subgroups. Correlations significant to $p < .05$ uncorrected around the average random correlation of 0.21.

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Supporting information

S1 Appendix

Ethics Statement

Ethics approval was waived as we used only publicly available comments harvested via the Reddit API. All comments to the `r/conspiracy` forum were publicly available at the time of data collection (first quarter of May 2015). The ‘sample comments’ in the main text were deliberately obfuscated to prevent their attribution to a particular user.

Dataset

We used a dataset made publicly available by the user ‘Stuck_In_The_Matrix’, who used the official reddit API to scrape a set of roughly 1.7 billion comments and associated metadata spanning from October 2007 to May 2015. (For more details see https://www.reddit.com/r/datasets/comments/3bxlg7/i_have_every_publicly_available_reddit_comment/). The set has nearly every public reddit comment made in the time period. This includes nearly 2.25 million comments to `r/conspiracy`, made by nearly 130,000 distinct authors.

Preprocessing

Reddit allows posts by small automated programs known as ‘bots’, which can skew descriptive statistics. To remove account names associated with bots, we first looked at each poster in a target set of subreddits (including `r/conspiracy`) and calculated the number of other subreddits in which they posted (their *forum diversity*). A list was compiled of usernames whose forum diversity was more than 15 standard deviations above the mean. Manual inspection revealed that every member of this list was probably a bot, whereas more aggressive cuts also included posters who were clearly human. This was combined with a list of usernames corresponding to known bots posted on reddit itself. (From https://www.reddit.com/r/botwatch/comments/1xojwh/list_of_320_reddit_bots/) The 466 authors in the set were excluded from subsequent analyses. This procedure erred on the side of including bots rather than eliminating human posters. While the remaining set contains some bots, the combination of forum diversity and known bots eliminates the vast majority of automated posting, and the remaining bots should make for only a minor skew on the descriptive statistics. Of note, the remaining bots (such as there are) seem to be concentrated in the ‘noisy’ subgroup 11, about which we make no specific claims.

After extracting the comments in `r/conspiracy` from the larger dataset, the comment text itself was preprocessed in several steps. Comments with authors or text bodies which had been subsequently deleted were removed. Whole lines which were preceded by markdown quotation indicators were removed, as were URLs and formatting escape codes were also removed. Words were then tokenized and converted to lowercase, and punctuation and non-alphabetic characters were removed.

Words were tagged with part-of-speech using the python Natural Language Toolkit package (`nltk`, [19]). Functional words such as pronouns and determiners were removed, leaving

only nouns, adjectives, verbs, adverbs, and cardinal numbers. What remained was then lemmatized with `nltk` using the wordnet lemmatizer [20]. Any comment fewer than 3 words after preprocessing was eliminated from further analysis. Note that, unlike many studies, we did not eliminate short words, as there were semantically meaningful words of two and three characters that clearly belong in the final topics.

Because we are interested in drawing inferences about authors rather than individual comments, each author’s comments were combined into a single document. The resulting corpus was transformed into a term frequency-inverse document frequency (tf-idf) representation. A tf-idf representation represents individual documents as a collection of normalized word frequencies, each weighted by the overall frequency of the word in the corpus. The weighting means that words which are extremely common are given relatively little weight, while words which distinguish a particular document are weighted more. At this step any remaining common english stopwords and words that appeared fewer than 20 times in the corpus were also eliminated, leaving a final vocabulary of 30,327 words. (This and subsequent steps used `scikit-learn`, [21]).

Data Sharing

Processed data for `r/conspiracy` is available as a 165MB archive at:

<https://cloudstor.aarnet.edu.au/plus/index.php/s/GRjLJxoxN99RIJe>

To ensure anonymity, the processed data contains neither author names nor identifiable comments.

S1 Fig.

S1 Fig.: Mean pairwise cosine similarity for each vector in the topic-word mapping for a range of NMF topic numbers 12, 15, $\dots$ 90. $1/x$ represents the theoretical lower bound of this value. Red circles indicate difference from the theoretical lower bound. Chosen topic number of 48 indicated by dashed line.

S1 Table

0 point evidence mean fact question claim actually information source ask case theory argument reason study
1 post subreddit rconspiracy sub delete mod op account ban remove page facebook thank picture thread
2 fuck fucking stupid retard bullshit shut idiot kid seriously dude asshole cunt hate sick hell
3 people lot care talk group die understand black life white problem person stop hate stupid
4 conspiracy theory theorist subreddit rconspiracy real sub crazy fact true world evidence secret truth nut
5 know dont let tell like maybe talk thanks truth true feel secret mean friend ask
6 video watch youtube fake camera saw footage game film minute explain view release documentary second
7 good bad job idea point luck great thank thanks damn feel movie evil sir stuff
8 guy picture talk hey shoot bomb crazy backpack run black actually lol stuff idiot white
9 police officer state law shoot force arrest car department military crime dog situation protect citizen
10 look picture photo fake image eye pic backpack maybe edit lot face left white bomb
11 government control citizen american federal power law state medium public terrorist corporation secret
protect corrupt
12 gun control shoot law weapon ban rifle firearm arm shooting buy assault carry crime point
13 building plane collapse wtc tower hit fall steel floor crash demolition fly pentagon jet damage
14 say agree talk wrong exactly hear tell true im word dont ask person sorry quote
15 time long year day waste start hear watch spend hour tell ago live old new
16 really wow care stuff hope lot interesting big kind feel bad like watch thanks understand
17 just maybe watch leave little mean curious guess im stupid feel probably sorry troll dont
18 israel palestinian hamas israeli attack palestine gaza state land rocket iran Jewish arab support terrorist
19 read book interesting thank title write great actually thanks story stop stuff sound watch remember
20 cop bad shoot dog car job arrest black pull asshole hate beat wrong officer law
21 right wrong law freedom realize left amendment sound wing leave constitution speech citizen mean free
22 believe tell god truth hard lie story actually alien true religion theory crazy fake idiot
23 need help start stop change new feel page power upvotes dont let attention problem revolution
24 link thanks source click page site google thread provide share thank website info original check
25 make sense feel sick point fun difference statement sound bad decision wonder mistake person sad
26 kill child kid year die shoot innocent death terrorist dog dead murder civilian school family
27 think mean maybe agree exactly joke dont crazy idea probably word honestly big lot thought
28 happen year day actually event story holocaust ago let probably wait week attack remember exactly
29 want live hear exactly dont truth talk ask help change let free watch stop question
30 comment thread delete sub account mod ban edit shill subreddit rconspiracy reply op page user
31 come day mind hear truth hope year true let wait new start tell alien home
32 sure pretty im lot actually probably sound joke big funny talk stuff lol dude hear
33 jew jewish zionist white holocaust black racist hitler control million nazi religion hate christian muslim
34 war world country american america military new power russia fight state live control end start
35 use word water phone weapon google drug force internet site data term technology chemical company
36 vote party obama paul election president candidate ron republican voting change count voter win democrat
37 reddit mod sub ban user account page site admins subreddit new subreddits remove rconspiracy censor
38 thing bad lot kind sort change different hear exact funny probably life stuff important learn
39 yeah oh lol sound mean probably hear totally hell stuff haha dude definitely wait idiot
40 money pay tax bank year company buy dollar debt gold business loan free market spend
41 way feel life change best easy long start let help power agree live possible great
42 man love god oh thank life black great thanks lol live hear white yes real
43 news source story fox medium report watch hear cnn old tv site day page mainstream
44 article year old ago write title source mention author website wikipedia quote original google publish
45 work job day hard year live school company hour great tell kid life week home
46 try nice stop help hard tell start shill let troll understand maybe sound hide figure
47 shit holy fucking piece real stupid bullshit crazy lol oh dont dude dumb im sub

S1 Table: 48-topic NMF model for **conspiracy**. Showing top 15 words for each topic.

S2 Fig.

S2 Fig.: Percent variance explained for a range of kmeans clustering solutions.

S2 Table

Group Topic	C	0	1	2	3	4	5	6	7	8	9	10	11
0	0.73	0.56	0.47	0.62	0.38	0.61	0.75	0.34	0.35	0.64	0.51	0.6	0.41
1	0.23	0.22	0.15	0.2	0.08	0.13	0.3	0.15	0.13	0.25	0.16	-0.01	0.17
2	0.16	0.22	0.17	0.15	0.14	0.15	0.14	0.09	0.14	0.14	0.03	0.22	0.13
3	0.54	0.32	-0.19	0.35	0.14	0.4	0.35	0.25	0.28	0.44	0.4	0.37	0.15
4	0.22	-0.0	0.13	0.12	-0.03	0.15	0.23	0.12	-0.08	0.17	0.18	0.14	0.12
5	0.43	0.16	0.09	0.29	0.2	0.25	0.38	0.11	0.35	0.33	0.33	0.23	0.08
9	0.21	0.21	0.23	0.08	0.25	0.3	0.23	0.21	0.21	0.34	0.2	0.21	0.19
12	0.16	0.18	0.16	0.22	0.18	0.15	0.18	0.11	0.18	0.2	0.23	0.15	0.11
13	0.29	0.22	0.24	0.29	0.28	0.2	0.39	0.26	0.25	0.34	0.21	0.19	0.19
14	0.47	0.28	0.15	0.3	0.18	0.37	0.39	0.11	0.2	0.35	0.31	0.27	0.11
17	0.48	0.28	0.18	0.32	0.22	0.37	0.37	0.13	0.24	0.33	0.41	0.3	0.12
18	0.18	0.17	0.17	0.14	0.29	0.15	0.17	0.17	0.28	0.12	0.15	0.14	0.11
20	0.11	0.07	0.07	0.13	0.11	0.04	0.09	0.08	0.11	0.06	0.15	0.1	0.03
33	0.18	0.16	0.1	0.1	0.23	0.04	0.16	0.11	0.2	0.26	0.15	0.11	0.08
34	0.47	0.3	0.36	0.3	0.46	0.41	0.34	0.41	0.45	0.56	0.4	0.28	0.25

Raw numeric correlations between selected topics and log length; corresponds to Fig. 2 in main text.