Seeded by Hate? Characterizing the Twitter Networks of Prominent Politicians and Hate Groups in the 2016 US Election

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During the 2016 US presidential election, there was considerable debate about the unique appeal of Donald Trump's candidacy to hate groups. Though some vehemently argued for Trump's ability to rile up hateful ideologies, others actively denied such claims. In the present work, we characterize the Twitter networks of both major presidential candidates, Donald Trump and Hillary Clinton, with various American hate groups. We further examined the Twitter networks for Bernie Sanders, Ted Cruz, and Paul Ryan, for 9 weeks around the 2016 election (4 weeks prior to the election and 4 weeks post-election). By carefully accounting for the observed heterogeneity in the Twitter activity levels across individuals, our data revealed that there were significantly more people linked to leaders and followers of American hate groups belonging to six ideologies (Anti-Government, Anti-Immigrant, Anti-LGBT, Anti-Muslim, Alt-Right, Neo-Nazi, and White-Nationalist) concurring with Donald Trump than with the other four politicians. We also found that significantly more individuals in the Twitter network had the fewest degrees of separation simultaneously from Donald Trump and each one of these six hateful ideologies relative to the other four politicians.

Twitter | 2016 US presidential election | hate groups | Donald Trump

The 2016 US presidential election will be remembered as one of the most divisive in recent history with two of the least liked candidates competing for the White House (1, 2). During the election, the mainstream media appeared baffled by the rise of Donald J. Trump, a businessman with no prior experience in government. Two narratives emerged to explain Trump's rise to fame. On the one hand, it was argued that Trump's rise was driven by uncertainty and angst in the American public (3–5) as well as frustration and distrust of a partisan political system (6–8). This first narrative broadly reflects a number of psychological research that commonly demonstrate that uncertainty and angst can catalyze the formation of rigid, nationalistic, and extreme political beliefs; these are supported by research on right-wing authoritarianism (9), uncertainty-identity theory (10), need for closure (11), and motivated social cognition (12). By contrast, a second narrative argued that Donald Trump's rise was driven by a growing sense of threat among White Americans regarding their changing status in America as a result of growing cultural diversity and the improving status of minority groups made salient by the election of Barack Obama. Such changes were argued to promote minority scapegoating and a campaign that pitted 'us' versus 'them' (11–17). Along with uncertainty-identity theory (10), this second narrative is reflected in psychological research on relative deprivation theory (18, 19), intergroup threat theory (20), and recent evidence that ethnic diversity can threaten the status, identity, and distinctiveness of majority group members (21–23).

Though both sets of factors may have collectively played a role in Trump's rise to power, there has been considerable debate within the media and around dinner tables about the latter narrative that Trump was able to capitalize on White Americans' fears about their changing status and social identity in an unstable national landscape. Critics of Donald Trump point toward Trump's own rhetoric on the campaign trail, which often featured insults leveled against Mexicans, Muslims, immigrants, and women (24, 25). Such rhetoric, it was argued, took advantage of the increased appetite for nationalism and outgroup derogation due to perceived threats to status and identity for the majority group. By doing so, Trump was argued to have forged a coalition where normative bigotry was thought to be acceptable (26). As a consequence, Trump's candidacy was openly supported by the Ku Klux Klan (KKK) and Neo-Nazi groups (27, 28). Though Trump's campaign was careful to distance itself from the endorsement of such extreme hate groups (29), critics point to Trump's close ties to individuals like Stephen Bannon and Sebastian Gorka whose roles in the administration have been celebrated by hate groups (30). Critics also point to the rise of hate crimes since the election (31, 32) and the Trump administration's decision to remove government focus on right-wing extremism as evidence of Trump's ties to hate groups (28, 33). Even months after the election, people continue to debate the role of bigotry in Trump's candidacy (34–36).

Significance Statement

During the 2016 US presidential election, there was significant debate on whether Donald Trump's campaign was fuelled by hateful ideologies and bigotry toward minority groups in America. We analyzed the Twitter networks of retweeters of American hate groups and five key American politicians during the late stages of the election (Donald Trump, Hillary Clinton, Bernie Sanders, Ted Cruz, and Paul Ryan). Our data reveals that Twitter users linked to various American hate groups including Anti-Government, Anti-Immigrant, Anti-LGBT, Anti-Muslim, Neo-Nazi and White-Nationalist were significantly linked to Trump more so than any other politician.

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The present research uses online social networks to empirically address this hotly contested issue. Specifically, we examine the following questions: Do people promoting hateful ideologies show strong support for Trump? How does this compare to other Republican and Democratic leaders? Does this vary depending on the type of hateful ideology? Any such linkages do not necessarily imply that Donald Trump (or any other political candidate) personally shares the views of those hate groups, but rather that their candidacy had particular appeal to such hate groups during the election. To investigate these questions, we focused on the social networks of five US political leaders and the networks of American hate groups or hate group leaders that are publicly accessible.

To do so, we focused on social media communications on Twitter, a popular micro-blogging service, that provides a real and observable social network with millions of users (37, 38). Twitter allows users to communicate or update their status in many ways. One can post a message called a *tweet* that is no more than 140 characters in length, *follow* another Twitter user, and receive the status updates of every user they follow. A tweet of someone else shared publicly with one's own followers is known as a *retweet*. Direct retweets represent the most frequent type of communication event and are considered the strongest index of not only interest in a message, but also endorsement and trust in the communicator (39, 40), especially when retweeted multiple times. In the present work, we chose to focus on direct retweets of key American politicians and hate groups (and their leadership) to examine the ties between both.

Twitter has become a major platform for communication between politicians and their followers. Consequently, Twitter activity has been used to gauge political sentiments, predict elections (41, 42) and reportedly influence the 2016 election (43–45) [*]. President Trump uses the platform to directly communicate with the American public (46, 47). Twitter has also become a major avenue through which hate groups spread their ideologies with larger sections of the population (48). For all these reasons, Twitter was chosen as the ideal medium to observe naturalistic relationships between various individuals and groups.

In the present work, we examined the Twitter networks of several key politicians and hate groups or their leadership during the 2016 US Presidential election. The political leaders included in our study were the two major presidential candidates (i.e., Hillary Clinton with mentionable screen-name as @HillaryClinton and Donald Trump as @realDonaldTrump). Additionally, we chose to include Ted Cruz (as @tedcruz) and Bernie Sanders (as @BernieSanders) who were the second most popular Republican and Democratic presidential candidates in the 2016 election. And finally, we chose to include Paul Ryan (as @SpeakerRyan) as he represented a mainstream Republican Party leader and is the Speaker of the House of Representatives. These individuals all possess active Twitter accounts with more than 2 million followers and engage in frequent Twitter activity.

To examine the links between these five US politicians and hateful ideologies, we used the Southern Poverty Law Center's (SPLC) classification of hate groups and hate group leaders in the USA as it represents the most comprehensive database for hate groups and hateful ideologies in the USA for over 40 years (49–52). Although the SPLC has been criticized for including groups and individuals with politically diverging views from their own (53–56), it is the most comprehensive database available to the public. Moreover, our mathematical models, statistical tests, and the data science pipelines are generic and can therefore be used to examine Twitter networks between political leaders and any database of hate groups as long as these have enough activity on Twitter.

The SPLC database does not necessarily consider all groups or individuals on its list as violent or engaged in criminal activities, but rather identifies any group or individual "whose beliefs or practices attack or malign an entire class of people, typically for their immutable characteristics" (57). The database does not include foreign hate groups or extremist groups such as ISIS, Al Qaeda, or Boko Haram, as its focus is on American hate groups. The SPLC database categorizes the activities of individuals and groups into several ideologies including Neo-Nazi (e.g., National Socialist Movement), Black-Separatist (e.g., Nation of Islam), Anti-LGBT (e.g., Westboro Baptist Church), Anti-Immigrant (e.g., American Border Patrol), Anti-Muslim (e.g., ACT for America), Alt-Right (e.g., American Renaissance), Anti-Government (e.g., Oath Keepers), and White-Nationalist (e.g., Aryan Brotherhood). However, these groups sometimes collude across ideologies to reach their common goals (31, 32).

Because only 78% of the SPLC identified hate groups or leaders had a valid Twitter account that we could track, our study is limited to a further subset of 52 user accounts who were active in the Twitter public streams. The number of followers of these ideologies pooled across the 52 accounts are given in Table S1. Thus, our approach is not exhaustive, in terms of being able to track every leader of each hateful ideology, but is nonetheless representative of the public Twitter activity[†].

Using these parameters, we obtained a retweet network representing each retweet between a tweeter (the user who posted the original tweet) and its retweeter (the user who retweeted) from our data in order to examine three specific questions: (Q1) Is Trump preferentially retweeted by hate groups or their leadership when compared to other politicians (i.e., Clinton, Sanders, Cruz, or Ryan) against the null random network model of *apathetic retweeting*? (Q2) What frequency of unique users retweeted both a politician and a hate group or its leadership more than one would expect under the null model? And (Q3) What is the joint distribution of the *degrees of separation*, measured through the lengths of the most retweeted directed paths in the observed Twitter network, to each user from each of the five politicians and the eight most prolific hateful ideologies on Twitter? Such a joint distribution gives insights into the *retweet ideological profiles* of politically active Twitter users.

To answer these questions we used Apache Spark (58), a unified engine for big data processing, to collect, model and analyze our data. First, our custom-designed Twitter-collector gathered nearly 22 million communication events on Twitter

[*] This article is the subject of separate legal complaints on behalf of Cambridge Analytica LLC and SCL Elections Limited, and Sophie Schmidt.

[†] Although the SPLC also identifies ideologies of the Ku Klux Klan (KKK), Neo-confederates, Racist Skinheads, and Holocaust Deniers, within their database, there was not enough activity on the Twitter accounts of the groups or their leadership that we were able to track given just a few thousand followers (see Table S1). It may be that these groups have a smaller online presence, or they simply use a different social media platform (including closed discussion forums; see (36)) making it harder to follow as we focused our analyses only on groups or leaders with public streams.

related to any one of our 5 major politicians and 52 hate groups or their leadership over a 9-week period centered around the 2016 US election (i.e., we focused on data from 4 weeks prior to the election and 4 weeks after the election). Our analyses observed Twitter networks without consciously filtering out bot accounts. As bots may have played a role in influencing the 2016 election (45, 59), we simply observed the public Twitter streams associated with these politicians and hate groups. We do retrospectively study the effect of potential bot accounts with high entropy scores and the accounts identified by Twitter as being Russian trolls (60).

Second, using the observed retweet network we address questions (Q1) and (Q2) by attempting to reject the null hypotheses of *apathetic retweeting* where each user is completely apathetic about who they retweet while preserving the number of times they retweet others and the number of times others retweet them. We formalize this null model as the *apathetic retweet network* from the directed versions of the configuration network model (61, 62) (see (63) and references therein for an overview of models for stochastic social dynamics). Thus, we can preserve the observed innate differences among users' tweet and retweet rates in this null model when we attempt to reject it in favor of its complementary alternative hypothesis of non-apathetic retweeting of one set of users by another set of users. To the best of our knowledge, we are the first to develop a scalable and fault-tolerant Monte Carlo sampling algorithm that can produce independent samples from this null model in order to obtain the null distribution of any test statistic of the apathetic retweet network. Finally, to answer (Q3) we use distributed vertex programs over the empirically estimated *geometric retweet network* model to obtain the degrees of separation from a politician and a hate group or its leadership.

Modeling Retweets.

Communications in Twitter. A tweet of another user that is publicly shared with one's followers is known as a retweet. Retweets are the simplest way to share information and constitute the most frequent type of communication in our Twitter dataset. Direct retweets indicate trust in the communicator and endorsement (38–40). Retweet analysis via random network models as done in this study circumvents the ambiguity and uncertainty associated with statistical algorithms (64) in natural language understanding (NLU) that will be required when working with (a) *quoted tweets* where one is allowed to add a comment to the retweet, (b) *reply tweets* or (c) *reply of quoted tweets* where one can reply in possible disagreement.

Thus, retweets are a simple and natural signal of *directional concurrence*, i.e. concurrence *with* the user who posted the (original) tweet *by* the user who retweeted it (i.e., between the tweeter and the retweeter). This is especially the case when one retweets another multiple times. The number of retweets per day captured from the public stream during the 9 week period reached over 1 million during the day of the third US Presidential debate and the days leading up to the election (Fig. S2).

The proportion of retweets is known to vary greatly depending on the features of the Twitter subnetwork under study (37). There were over 13.7 million retweets (63.1%) of an original tweet and over 2.7 million (12.6%) original tweets in our dataset (Table S2). We ignore the remaining 25% of the events that require further NLU and focus our analysis instead on the retweet network obtained from 75% of all events in our dataset as explained in the next section.

Retweet Network. We allowed the set of users who tweet and retweet, i.e., tweeters and retweeters, to form the nodes of the retweet network. Each retweet was allowed to represent a directed edge or arc from its tweeter to its retweeter, i.e. the tweeter-retweeter pair, as a signal of directional concurrence in the retweet network. Because one can retweet more than one tweet posted by any user, we allowed for parallel or multiple edges between the same pair of users including self-loops, i.e. edges from and to the same user. There were over 4.4 million unique tweeter-retweeter pairs out of 2.5 million unique users representing over 16.4 million tweets and retweets in our dataset with over 21.7 million communication events in Twitter during the 9-week period around the US presidential election (Table S2). Mathematically, the retweets in our dataset are represented by a *directed multi-edged self-looped network*. Thus the *out-degree* (number of outgoing edges) and *in-degree* (number of incoming edges) for a user in the retweet network gives the number of times that the user is retweeted by others and the number of times the user retweets others (including oneself), respectively. Similarly, the number of distinct users who are retweeted by the user is given by their *in-nbhd* and the number of distinct retweeters of the user is given by their *out-nbhd*.

The observed retweet network is highly heterogeneous and largely dominated by the two presidential candidates as depicted in Table 1. Due to our Twitter collector's design with retrospective data-augmentation, as explained in the Methods section, our network forms a single connected component when viewed with undirected edges.

Table 1. Retweet Network statistics of the five politicial accounts

Politician	in-degree	in-nbhd	out-degree	out-nbhd
Donald Trump	40	12	5,952,257	958,262
Hillary Clinton	225	121	2,774,111	943,995
Bernie Sanders	107	62	762,209	356,718
Paul Ryan	769	158	68,973	28,902
Ted Cruz	322	189	49,479	27,663

Apathetic Retweet Network Model. The *configuration model*, originally developed for undirected networks (62, 65, 66) and later extended for directed networks (61, 67) is a random network model that produces samples uniformly from the set of networks that preserve the in-degree and out-degree of each node in an observed network.

By representing each retweet as a directed edge between the author of the tweet and its retweeter, we define the null "apathetic" model for a random retweet network as the *directed, multi-edged, self-looped configuration model*, whereby each user apathetically or non-preferentially retweets another user, by choosing uniformly at random from the set of all users, while preserving their observed in-degree and out-degree. However, the model frees up information on the users involved in retweeting, i.e. who retweets whom, provided the in-degree and out-degree of each user is identical to that of the observed network. This null model thus preserves the innate tweet and retweet rates of each user while modeling complete apathy or indifference for who one chooses to retweet.

Cut, Permute and Rewire Algorithm. CutPermuteAndRewire is a Monte Carlo algorithm to generate independent sample networks from the directed multi-edged self-looped random configuration model, i.e. our null random network model for apathetic retweeting. CutPermuteAndRewire is a distributed, scalable, and fault-tolerant version of the standard construction involving random pairings of out-bound and in-bound half-edges (61, 67) through the following three steps: (i) *cutting* the directed edges representing the retweets in our observed retweet network into out-bound and in-bound half edges, (ii) *permuting* the in-bound half edges by sorting them according to pseudo-random numbers that are generated and associated with them and (iii) *rewiring* the original out-bound half edges with the permuted in-bound half edges using a distributed join. Note that the in-degree and out-degree of each node in the observed retweet network is preserved after the three steps by construction.

By taking advantage of the fastest available distributed sorting and optimized distributed joining algorithms in Apache Spark (58), CutPermuteAndRewire can produce independent sample networks with tens of millions of retweets or edges in a small Apache Spark cluster over six commodity compute nodes. Unlike directed configuration models restricted to simple directed graphs (67), we are not concerned with avoiding parallel or multiple edges and self-loops as they arise naturally in our representation of retweets as directed edges over the nodes representing users.

The null distribution of any test statistic of the retweet network can be directly obtained from applying it to each Monte Carlo sample from our randomized algorithm. By comparing the observed test statistic to Monte Carlo samples from the null distribution, one can directly obtain estimates of the p-value in order to attempt to reject the null hypothesis of apathetic retweeting in favor of the alternative hypothesis of non-apathetic retweeting.

Degrees of Separation in Geometric Retweet Network Model. In order to gain deeper insights into the retweet network beyond the immediate retweet neighborhood of each user, i.e. those retweeted by a user and those who retweet the user, we adapt Milgram's concept of *six degrees of separation* (68) that all people in the world are six or fewer steps away from each other so that a sequence of "a friend of a friend" relationships can be made to connect any two people in a maximum of six steps. We adapt the concept in three major ways.

First, we focus on Twitter users and replace the mutual or undirected relationship of being a friend by the directed relationship of being a retweeter. This adaptation accounts for the main difference between various social and technological networks (69) as well as other communication networks (70) that are characterized by mutually reciprocal relationships, and the directed relationships in Twitter where a path from a user to another may follow several distinct sequences while not existing in the reverse direction (37).

Second, instead of the degrees of separation between every pair of users in an undirected sense, we are interested in the *retweet* degrees of separation in a directional sense, measured by the length of the most retweeted path that originates from a few influential users, such as politicians or hate groups and their leadership, and terminates at each user.

Third, we account for the strength of the retweet relationship when defining the most retweeted path by incorporating $r_{a,b}$, the observed number of retweets between the user who is the source of the original tweets, i.e. the tweeter a, and the user who retweets them, i.e. the retweeter b, through the directed edge-weight given by $\hat{p}_{a,b} = 1/(1 + r_{a,b})$ that is used to specify the probability of an independent geometric random variable giving the number of retweets of user a by user b.

Let G be such a weighted directed retweet network with nodes as users and directed edges with edge-weights,

$$\{\hat{p}_{a,b} = (1 + r_{a,b})^{-1} : \text{for each edge } (a, b) \text{ in } G \text{ with } r_{a,b} > 0\}.$$

The collection of independent but non-identical geometric random variables with probability parameters given by these edge-weights is our empirically estimated *geometric retweet network* model for the joint distribution of the number of retweets of each user by another over the 9-week period of observation.

We derive our estimated geometric retweet network model by recalling the well-known relationship between Poisson, exponential, and geometric random variables. If the random variable $R_{a,b}$, giving the number of retweets of a by b is Poisson distributed with a random mean parameter $\xi_{a,b}$ that is drawn from the exponentially distributed random variable with rate parameter $1/\lambda_{a,b}$, then $R_{a,b}$ is geometrically distributed with probability parameter $p_{a,b} = 1/(1+\lambda_{a,b})$ and expectation $\lambda_{a,b}$. We can estimate the parameters from the observed number of retweets $r_{a,b}$ via the moment estimate $\hat{\lambda}_{a,b} = r_{a,b}$ and model the number of retweets during the 9 week period according to the geometric random variable with probability parameter $\hat{p}_{a,b} = (1 + r_{a,b})^{-1}$ for each directed edge between a tweeter and a retweeter in the retweet network.

A small weight $\hat{p}_{a,b} = (1 + r_{a,b})^{-1}$ corresponds in an inversely proportionate manner to a large number of retweets and the shortest path from user a to user b through this directed weighted network corresponds to the path with a large number of retweets from user a to user b. Thus, the estimated geometric model interpretation of the weighted retweet network G allows us to use a straightforward distributed vertex program in Apache Spark to obtain the shortest path that is composed of a sequence of d tweeter-retweeter pairs of edges, say $E = \{(a, v_1), (v_1, v_2), \ldots, (v_{d-1}, b)\}$, with the lowest sum of edge-weights given by $\sum_{(u,v)\in E} \hat{p}_{u,v}$ among all possible paths between an influential user of interest a and every other user b in G. Crucially, this $\hat{p}$-weighted shortest path is called *the most retweeted path* as it is composed of the same sequence of edges with the correspondingly high sum of retweet counts given by $\sum_{(u,v)\in E} r_{u,v}$. The length d of the most retweeted path from a to b, known as the *(retweet) degrees of separation* from a to b, has a clear interpretation as the length of the sequence of "retweeter of a retweeter" statements along the most retweeted path that is needed to link user a to user b by considering the retweet activities of every user in the network. When we have a set of influential users $A = \{a_1, a_2, \ldots, a_k\}$ of interest, say k leaders of a hateful ideology, we define the shortest path from A to any user b as the minimum of the k shortest paths from each user in A to b.

Table 2. Relative frequency of retweets by any one of the hate groups or their leadership for any original tweet made by one of the politicians

Politician, observed test statistic: marginal interval for the region of acceptance at 0.001 significance level				
Donald Trump	Hillary Clinton	Bernie Sanders	Paul Ryan	Ted Cruz
0.987 : (0.6008,0.6013)	0 : (0.2708,0.2709)	0 : (0.0677,0.0682)	0: (0.00411,0.00413)	0.0131 : (0.0024,0.0028)

Results

Test Statistics. Given the observed heterogeneity in the activity levels of Twitter users, including the most influential user @realDonaldTrump, who was more active than the other four politicians with over twice as many retweets by about the same number of retweeters as the next most influential user @HillaryClinton (Table 1), any hypothesis test needs to control for this heterogeneity. Our novel approach uses retweet networks sampled independently from the null apathetic retweet network model in order to obtain the null distribution of various test statistics while preserving the observed differences in the activity levels, in terms of the observed in-degree and out-degree of each user in the retweet network. Note that we do not have multiple testing issues when attempting to reject the null hypothesis of apathetic retweeting in favor of its complementary alternative hypothesis of non-apathetic retweeting since we obtain independent Monte Carlo samples from the joint distribution of the statistics under the null model to estimate the acceptance and rejection regions at the significance level of 0.001. We conducted the following two hypothesis tests involving frequencies of direct retweets and that of retweeters of politicians and hate groups to address our questions (Q1) and (Q2).

Frequencies of direct retweets of politicians by hate groups. None of the 194,098 retweets of an original tweet by one of the hate group leaders were made by any one of our five political accounts. However, out of the 7,233 retweets made by one of the hate group leaders 151 were originally tweeted by Trump, 2 by Cruz and none by the other three political leaders. These 151 retweets of Trump were split among Neo-Nazi (87), White-Nationalist (55), Anti-Muslim (6) and Anti-Government (3) groups or their leadership, while the 2 retweets of Cruz were from Neo-Nazi and White-Nationalist groups or their leaders.

One of the simplest statistic is the relative frequency of retweets by any one of the hate groups or their leaders of any original tweet made by each of the five politicians. This statistic of relative frequencies is given by five proportions that sum to 1. Given that Trump has more than twice as many retweets as Clinton despite having about the same number of retweeters (see out-degree and out-nbhd in Table 1), one may expect Trump to be retweeted more by hate groups or their leaders even if they were retweeting the five political leaders apathetically without showing any preference for Trump. To control for this effect, we used the CutPermuteAndRewire algorithm to obtain samples from the joint distribution of the relative frequencies under the null hypothesis of apathetic retweeting. As shown in Table 2, the observed statistic lies outside the acceptance region obtained from 1000 Monte Carlo samples from the null model and we thus reject the null hypothesis of apathetic retweeting with a p-value less than 0.001 in favor of non-apathetic retweeting with over 98% of retweets by hate groups preferring Trump well above the upper bound of 60.13% under the null model, while simultaneously avoiding any retweeting of Clinton or Sanders with a relative frequency of 0% that is well below their respective lower bounds of 27.08% and 6.77% under the null model, respectively. The observed relative frequencies for Ryan and Cruz, on the other hand, deviate relatively little from the corresponding marginal intervals of their acceptance region.

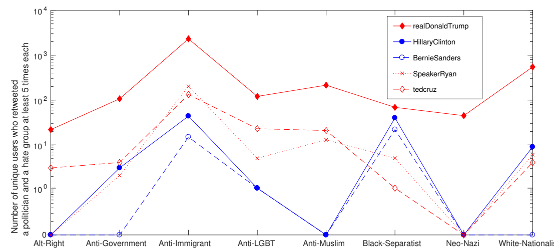


Fig. 1. Number of unique users who retweeted a politician and a hate group at least five times each (Note: The y-axis is in log-scale in powers of 10).

Frequencies of retweeters of politicians and hate groups. In order to explore these Twitter links further, we looked one degree deeper into the retweet network and obtained the number of Twitter users who retweeted both a politician and a specific hate group (or its leadership) at least five times. This provided a more conservative estimate of the number of users retweeting hate groups and their leadership or politicians as it would only include those actively retweeting both. The observed frequency of such users is shown in Fig. 1 and Table 3 along with their 0.1% marginal intervals of the acceptance region for the null hypothesis of apathetic retweeting. Since the observed frequencies jointly lie well outside the acceptance region obtained from 1000 Monte Carlo samples drawn from the null model using the CutPermuteAndRewire algorithm, we reject the null hypothesis of apathetic retweeting in favor of non-apathetic retweeting with a p-value less than 0.001.

When the observed counts are in the rejection region by falling below or above the respective marginal intervals of the acceptance region, we can obtain statistically meaningful insights of the observations under the favored alternative hypothesis of non-apathetic retweeting. However, such insights need further models and tests for a refined and rigorous understanding within the space of alternative hypotheses. In this study we are primarily concerned with rejecting the null hypothesis of apathetic retweeting formalized through the random network distribution conditional on the observed in and out degrees through the configuration model in favor of its complementary alternative hypothesis of non-apathetic retweeting.

In Table 3 the observed frequencies that lie in the rejection region above and below the corresponding marginal intervals for the acceptance region are indicated by * and $^\circ$, respectively. Thus, for example, a statistically significant frequency of users have retweeted Trump, Ryan or Cruz and Anti-Immigrant groups or their leaders at least five times each in a non-apathetic and preferentially approving manner since these frequencies are above their null intervals, i.e. the marginal intervals of the acceptance region for the null model of apathetic retweeting at a significance level of 0.001. These same frequencies are below the null intervals for Clinton and Sanders in favor of the non-apathetic retweeting alternative hypothesis, but in a preferentially disapproving manner. Only Trump has a significant frequency of retweeters who also frequently retweet Anti-Government, Anti-Immigrant, Anti-LGBT, Anti-Muslim, Neo-Nazi, and White Nationalist hate groups or their leadership in a non-apathetic and preferentially approving manner.

Our results are robust to changes in the threshold number of retweets being at least 5, albeit at the expense of fewer observations for larger thresholds. This is because the pattern of user frequencies across hateful ideologies and the five politicians shown in Fig. 1 is largely preserved across other thresholds as shown in Fig. S3. The results are also robust when the test statistic is an expectation of the frequencies taken over all threshold levels greater than 1. We chose the naturally interpretable threshold of at least 5 retweets over the 9-week period of observation in Fig. 1 and Table 3 to select users with more than one retweet per fortnight, on average.

Effect of Bot and Troll Accounts. While we did not actively filter out highly sophisticated bot accounts given the difficulty in their detection (71), we studied the effect of removing retweets related to accounts with very high scores for two types of information entropy based on: (i) the distributions of time lags between successive posts and (ii) the content of words within the posts. This is because accounts that send messages at uniform time intervals or post messages with unusually static or identical text content might be bots or cyborgs with unusual entropy scores. Accounts with more than 10 posts that crossed 2.5 standard deviations from the mean for either entropy score were flagged as potential bot accounts using a scalable variant of a practical approach (72). Additionally, we retrospectively examined our retweet network against the 2,752 now-deactivated Twitter accounts that the company identified as being tied to Russia's "Internet Research Agency" troll farm (60). Out of the 12,984,331 retweets in our dataset, less than 0.1% were related to a troll account (293 were retweeted by and 12,347 were originally tweeted by a troll account) and out of 2,451,081 distinct users in our retweet network, only 172 were related to a troll account. Interestingly, removal of these troll-related retweets from the retweet network did not alter the statistical tests in Tables 2 and 3. The observed test statistics remained the same when we removed the troll related retweets and the acceptance region did not vary enough to alter any of the reported results. Similarly, removal of nearly 1% of all retweets that were affiliated with one of 2045 accounts that were either a potential bot account or one of the troll accounts did not affect the test results. The robustness of the tests to presence or absence of the potential bot and identified troll accounts suggests that our results are independent of the direct influence of these bot and troll accounts, at least with regard to our Twitter study focused around the activities of the five politicians in relation to the 52 hate groups.

Degrees of Separation from Politicians and Hate Groups. For each user node in the estimated geometric retweet network model, we obtained the length of the most retweeted path, i.e. the degrees of separation, from one of the five politicians (DT = @realDonaldTrump, HC = @HillaryCinton, BS = @BernieSanders, PR = @SpeakerRyan, TC = @tedcruz) and eight hateful ideologies (AI = Anti-Immigrant, AM = Anti-Muslim, WN = White-Nationalist, AL = Anti-LGBT, AG = Anti-Govt, NN= Neo-Nazi, BlS=Black-Separatist, AR=Alt-Right). Thus each user had a *retweet ideological profile* or simply a profile given by their thirteen degrees of separation (from the five politicians and eight hateful ideologies). In order to focus on users who were politically active, we excluded (i) unreachable users who had infinite degrees of separation from all five politicians, i.e. those users who were unreachable from any one of the five politicians by a sequence of retweets, and (ii) users whose most retweeted path did not have an average number of retweets greater than 4 per edge.

We thus obtained profiles for 2,137,712 politically active users over the 9 week period (our monitored population) and report in Table 4 the frequencies of users with the same retweet ideological profile given by thirteen numbers along with the corresponding percentage of the overall sample.

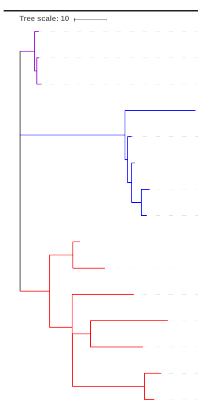
Using the Manhattan distance between profiles, i.e. sum of the absolute value of the differences between the profiles (i.e. the 13 degrees of separation), we clustered the top 15 groups of users with the most frequent profiles constituting 95% of the monitored population as shown by the classification tree (73, 74) in the first column of Table 4. Since this tree is built from the most retweeted path-lengths from influential users promoting various ideologies, we call this the *ideological tree*.

Broadly there are three clades in the tree. First, the politically ambivalent clade is made up of three profiles (with leaf id's 05, 07 and 12) that constitute nearly 3% of the monitored population and is characterized by the smallest possible degrees of separation not only from @realDonaldTrump (DT), but also from either @HillaryClinton (HC) or @BernieSanders (BS). Second, the Democratic-leaning cluster that is characterized by having fewer degrees of separation from at least one of the two Democratic politicians: HC and BS. It is shown by the clade with leaf id's 02, 04, 03, 13, and the more diverged id 11 that is farthest from all hate groups and from the Politicians but relatively closer to HC. The three most populous leaf nodes in the Democratic-leaning clade with id's 02, 03 and 04, constitute about 37%, 11% and 3.5% of the monitored population. Third, the Republican-leaning cluster that is characterized by having fewer degrees of separation from at least one of the three Republican politicians: @realDonaldTrump (DT), @SpeakerRyan (PR) and @tedcruz (TC). It is shown by the larger clade with the following seven leaf id's: 01, 15, 14, 08, 09, 06 and 10 in Table 4. The most populous leaf nodes in the Republican-leaning clade are made up of two of the 15 groups of users with id's 01 and 15, and constitute nearly 38% of the monitored population with distinct profiles that are primarily characterized by the smallest possible degrees of separation of 1 from DT. Similarly, the other two less populous Republican-leaning id's (08, 09, 06 and 10) are primarily characterized by different degrees of separation from DT, PR and TC, whereas id 14, with its own branch, is notable by having the smallest possible degrees of separation from both

Table 3. Observed frequency of distinct users who retweeted a politician and a leader within a hate group at least 5 times each

Ideology	Politician				
	Donald Trump	Hillary Clinton	Bernie Sanders	Paul Ryan	Ted Cruz
	observed test statistic: marginal interval for the region of acceptance at 0.001 significance level				
Anti-Government	*107 : (0, 1)	3 : (0, 3)	0 : (0, 1)	*2 : (0,1)	*4 : (0, 1)
Anti-Immigrant	*2314 : (375, 498)	$^\circ$44 : (373, 492)	$^\circ$15 : (369, 485)	*204 : (47, 95)	*133 : (18, 54)
Anti-LGBT	*121 : (0, 4)	1 : (0, 4)	1 : (0, 4)	*5 : (0, 3)	*23 : (0, 3)
Anti-Muslim	*215 : (0, 3)	0 : (0, 3)	0 : (0, 3)	*13 : (0, 3)	*21 : (0, 3)
Neo-Nazi	*45 : (0, 1)	0 : (0, 1)	0 : (0, 1)	0: (0, 1)	0: (0, 1)
White-Nationalist	*548 : (0, 12)	9 : (0, 10)	0 : (0, 10)	6: (0, 8)	4: (0, 7)
Black-Separatist	$^\circ$69 : (653, 811)	$^\circ$40 : (649, 808)	$^\circ$22 : (645, 801)	$^\circ$5 : (72, 128)	$^\circ$1 : (28, 66)
Alternative-Right	*22 : (0, 0)	0 : (0, 0)	0 : (0, 0)	0 : (0, 0)	*3 : (0, 0)

Table 4. The top 15 groups of users according to their profiles of most retweeted path-lengths from the five politicians (DT = @realDonaldTrump, HC = @HillaryCinton, BS = @BernieSanders, PR = @SpeakerRyan, TC = @tedcruz) and eight hateful ideologies (AI = Anti-Immigrant, AM = Anti-Muslim, WN = White-Nationalist, AL = Anti-LGBT, AG = Anti-Govt, NN= Neo-Nazi, BIS=Black-Separatist, AR=Alt-Right) given by their id, frequency, percentage of population and their classification given by the ideological tree with leaf nodes as the ids.

ideological tree	id	frequency	percentage of population	Politician					Hate Group							
				DT	HC	BS	PR	TC	AI	AM	WN	AL	AG	NN	BIS	AR
	05	42853	02.005	1	1	2	4	4	5	5	7	6	4	7	7	7
	07	11481	00.537	1	2	1	4	4	5	5	7	6	4	7	7	7
	12	5868	00.274	1	1	1	4	4	5	5	7	6	4	7	7	7
	11	5972	00.279	4	2	3	5	7	8	8	9	9	7	10	10	10
	02	791286	37.016	3	1	2	4	6	7	7	8	8	6	9	9	9
	04	74126	03.468	3	1	1	4	6	7	7	8	8	6	9	9	9
	03	232093	10.857	3	2	1	6	6	7	7	9	8	6	9	9	9
	13	5173	00.242	3	1	1	6	6	7	7	8	8	6	9	9	9
	01	811586	37.965	1	4	7	4	4	5	5	7	6	4	7	7	7
	15	3892	00.182	1	4	7	1	4	5	5	7	3	4	7	7	7
	14	4011	00.188	1	4	7	4	4	1	5	3	5	4	5	7	7
	08	10460	00.489	3	5	9	1	3	3	3	5	3	6	7	9	9
	09	8069	00.377	3	3	3	3	1	4	3	3	3	6	5	6	9
	06	29997	01.403	2	3	3	3	3	5	3	3	5	5	5	3	3
	10	6257	00.293	1	3	3	4	4	5	3	3	5	4	5	3	3

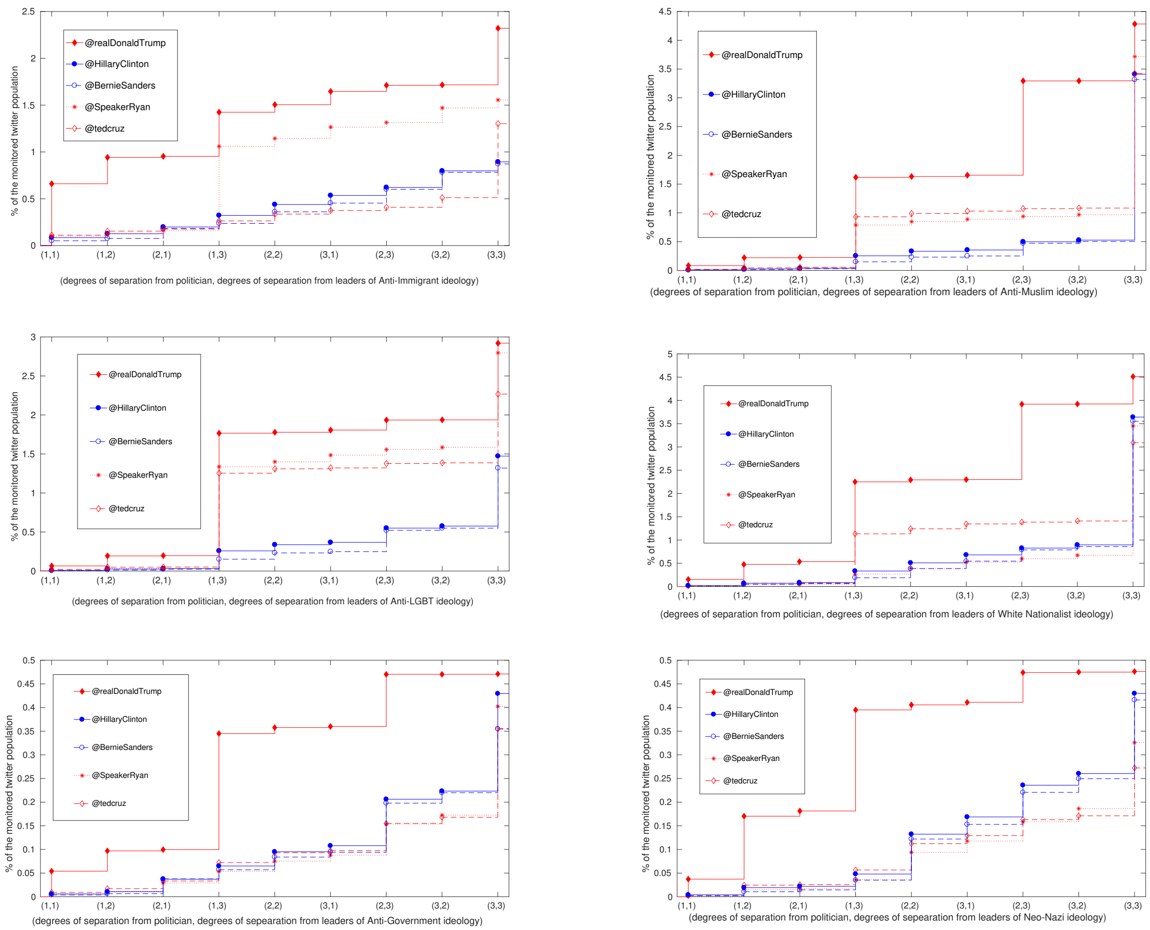


Fig. 2. Cumulative percentage of the monitored Twitter population who are within a given in-degree of separation from a politician and a hateful Ideology.

DT and Anti-Immigrant groups or their leadership.

Note that more than 91% and 95% of users have their degrees of separation from all eight extremist ideologies no smaller than 4 and 3, respectively. This is reflective of little direct influence by leaders of hateful ideologies for over 95% of the monitored population. In order to get insights on users whose most retweeted paths from at least one of the hateful ideologies is within 3 or fewer retweet degrees of separation, we zoomed into the less frequent profiles of the remaining 5% of the monitored population of politically active users. These results are depicted as cumulative percentages of the monitored population for the following nine pairs of retweet degrees of separation from one of the five politicians and a given hateful ideology: $\{(1,1),(1,2),(2,1),(1,3),(2,2)(3,1),(2,3),(3,2),(3,3)\}$ in Fig. 2. For example, over 0.6% and 1% of the population is at 1 degree of separation from @realDonaldTrump and within 1 and 2 degrees of separation from Anti-Immigrant ideologies, as specified by the y-axis values corresponding to the x-axis values of $(1,1)$ and $(1,2)$, respectively, in the top left sub-plot of Fig. 2. Similarly, nearly 2.4% of the population is within 3 degrees of separation from both Trump and Anti-Immigrant ideologies as specified by the y-axis value corresponding to the x-axis value of $(3,3)$ in the same sub-plot. Thus, the cumulative percentage of the politically active monitored population that is within a given ordered pair of degrees of separation (from a politician and a hateful ideology) is depicted similarly by the six sub-plots of Fig. 2.

Although the number of distinct retweeters of @realDonaldTrump and @HillaryClinton are roughly the same at around 950,000 (see out-nbhd column in Table 1), the proportion of the population that is within 1, 2 or 3 degrees of separation from @realDonaldTrump and from any one of the six hateful ideologies (Anti-Immigrant, Anti-Muslim, Anti-LGBT, White-Nationalist, Anti-Government and Neo-Nazi) is consistently higher than that from any other politician (unlike those for the Black-Separatists and Alt-Right ideologies shown in Fig. S4). As mentioned earlier, the null model of apathetic retweeting was strongly rejected using the frequency of users who retweeted both a politician and a hateful ideology more than four times each in favor of the alternative hypothesis of non-apathetic retweeting in which these same six ideologies were found to be retweeted in a preferentially approving manner by those who also retweeted Trump (Table 3).

Recall that the degrees of separation has a clear interpretation as the length of the sequence of "retweeter of a retweeter" statements along the most retweeted path that links a set of influential users to each user by considering the global retweet activities of every user in the network. Thus, this analysis provides global insights into the most retweeted pathways from influential sets of users (politicians and leaders of hateful ideologies), through the joint distribution of the lengths of these paths, to each of the $2,137,712$ politically active users. It further provides an ideological tree to classify users based on the Manhattan distance of these path-lengths that allows one to ask where one lies on a well-defined ideological tree, a mathematically natural generalization (75, 76) of the line giving the usual bi-polar spectrum of left versus right or Democrat versus Republican, a common restriction in social media research (64, for e.g.), and thus allowing us to consider the effects of transmissions of "memes" (77, p. 192)[‡] on social media networks (79) through ideological trees using more sophisticated notions (80, 81).

[‡] See (78).

Conclusion

Using 9-weeks of Twitter data collected around the 2016 US presidential election, the present research examined the Twitter linkages between five major American political leaders (Donald Trump, Hillary Clinton, Ted Cruz, Bernie Sanders, and Paul Ryan) with American hate groups. Using two different approaches to the data, we found converging evidence that Donald Trump possessed unique appeal to a variety of American hate groups. First, utilizing direct retweets, we found that Twitter users who frequently retweeted hate groups and their leadership (i.e., at least 5 times in the span of 9 weeks) were significantly more likely to retweet Trump over any other politician. A significant number of retweeters of nearly all hateful ideologies (except for Black-Separatists) were found in Trump's Twitter network including Anti-Immigrant, Anti-Government, Anti-Muslim, Neo-Nazi, Alt-Right, Anti-LGBT, and White-Nationalists. By comparison, retweeters of only Anti-Immigrant, Anti-Muslim, and Anti-LGBT were significantly linked to Paul Ryan or Ted Cruz, but even these linkages were comparably small relative to Trump. Second, using most retweeted path lengths, we found that a significantly larger proportion of people were within one, two and three degrees of separation from Donald Trump and from Anti-Government, Anti-LGBT, Anti-Muslim, Anti-Immigrant, Neo-Nazi, or White-Nationalist ideologies, relative to the corresponding degrees of separation from Hillary Clinton, Bernie Sanders, Ted Cruz, or Paul Ryan and the same hate groups or their leaders. None of the political candidates appeared to hold particular appeal to users retweeting Black-Separatist hate groups or its leadership. Despite evidence that Donald Trump held unique appeal for a variety of hate groups in the USA, it is important to note that only a small portion of those retweeting Trump are within a few degrees of separation from hateful ideologies suggesting that most of his Twitter network is unrelated to such blatant hate. However, these data also suggest that Trump had unique appeal to these hateful ideologies more so than any of the other key politician examined.

Data Archival. All 21,749,868 Tweet IDs used in this study are available from from https://tinyurl.com/y8lamxzx.

Materials and Methods

Dataset. Our dataset comprises of nearly 22 million communication events in Twitter over a total of 9 weeks centered around the US 2016 election. The dataset was collected in our designed experiment using Twitter's streaming and REST APIs (82) that were extended (83) for Apache Spark (58), a unified engine for big data processing. Each of these communication events were parsed and classified into seven types of events using Spark SQL modules (84) as shown in Table S2. Over 17 million events were collected from Twitter's public streams by directly tracking communications related to the Twitter accounts of the five political candidates and 52 hate group or hate group leaders identified by the SPLC. The remaining 5 million events were obtained retrospectively using the REST API as detailed next.

Retrospective data augmentation. Nearly 7 million of the 10.5 million retweets collected from the public streams happened within the same day of the original tweet and over 98% of the retweets happened within a week of the original tweet. This is due to most retweets being an immediate reaction to publicly share a tweet that one finds interesting or concurs with (37). Furthermore, since our tweet collector is only recording events that are directly related to one of our tracked users, we do not know of any other Twitter interactions by those who retweeted one of our tracked users. Thus, to better understand the recent retweet behavior of at least some of the politically active Twitter users with other non-tracked users on Twitter, we focus on October 19 2016, the day of the 3rd US Presidential debate, and obtain a seed set of users who retweeted either @HillaryClinton or @RealDonaldTrump on this day. As depicted in Fig. S1, the communication intensity reached over 120 events per second around the debate in our custom Twitter collector that explicitly tracked status updates related to any of the political candidates and several hate groups or their leadership.

Our seed set is made up of a random sample of about a third of all users (including all verified and geo-enabled accounts) who retweeted either Clinton or Trump on October 19 2016 and thus constitute an evenly represented sample of politically active Twitter users from the two parties. For each user in the seed set, at the end of the 9 week period, we added all the retweets from their 200 most recent status updates that occurred in the 9 week period as directed edges to our retweet network. This strategy involves a breadth-first expansion about the seed set of users in the much larger retweet network on Twitter as it allows us to expand our 9-week-long retweet network by focussing on the recent retweet timelines of those who retweeted either of the two final presidential candidates during the day of the last debate. Crucially, this augmented data added another 0.3 million users to our network, increased the number of retweet events from 10.5 million to 13.7 million and made the retweet network into a single connected component(when represented by undirected edges). Fig. S2 shows the number of retweets collected each day during the 9 week period.

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Supporting Information: Seeded by Hate? Characterizing Twitter Networks of Political Leaders with Hate Groups in the USA

Supporting Information (SI)

SI Text. Supporting information on Tables and Figures are provided here.

SI Tables. Two supporting Tables S1 and S2 are presented here.

Table S1. The total number of followers for various leaders within each hate group

Ideology of Hate Group	# of Followers
Anti-Govt	470,095
Black-Separatist	463,943
Alt-Right	326,174
Neo-Nazi	249,941
Anti-Muslim	138,053
White-Nationalist	116,558
Anti-LGBT	113,011
Anti-Immigrant	75,837
Christian-Identity	27,994
Neo-Confederate	3,281
Ku-Klux-Klan	1,511
Racist-Skinhead	915

Only a subset of leaders within each group were active in twitter

Table S2. Types of twitter communication events in the dataset

Type of Event	count	percentage
ReTweet	13,713,342	63.1
Reply Tweet	4,154,074	19.1
Original Tweet	2,731,533	12.6
Quoted Tweet	736,042	3.4
Retweet of Quoted Tweet	343,754	1.6
Reply of Quoted Tweet	71,123	0.3
All Types of Events	21,749,868	100

SI Figures. Four supporting Figures S1, S2, S3 and S4 are presented here.

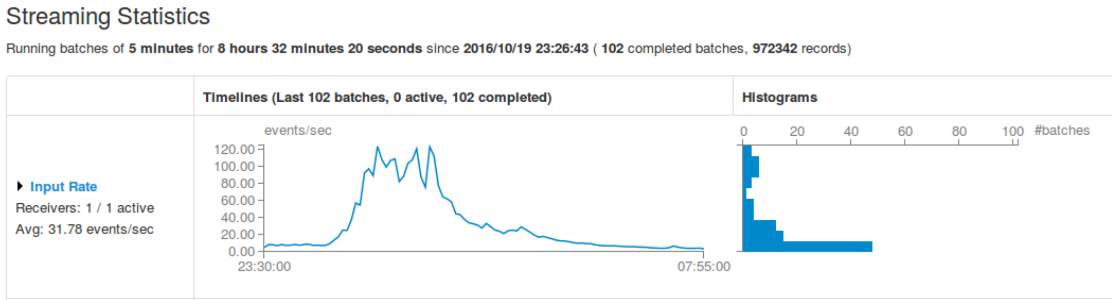

Fig. S1. Streaming statistics for our custom twitter collector during the 3rd US Presidential debate on 2016/10/19.

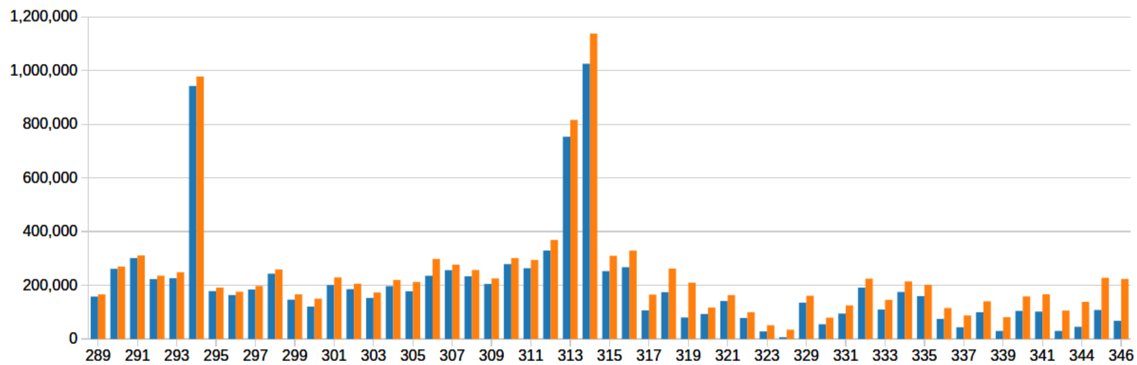

Fig. S2. The number of retweets captured from the public stream (blue) further augmented retrospectively (orange) every day over the 9 week period.

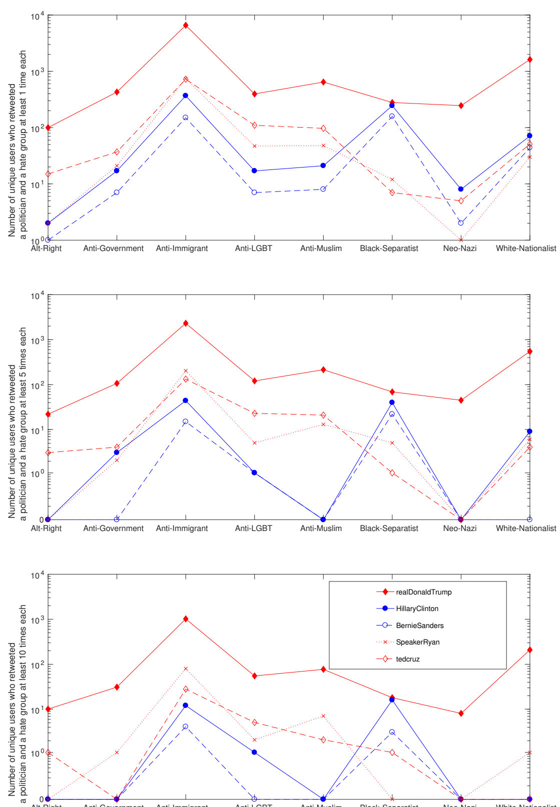

Fig. S3. Number of unique users who retweeted a politician and a hate group at least 1, 5 or 10 times each.

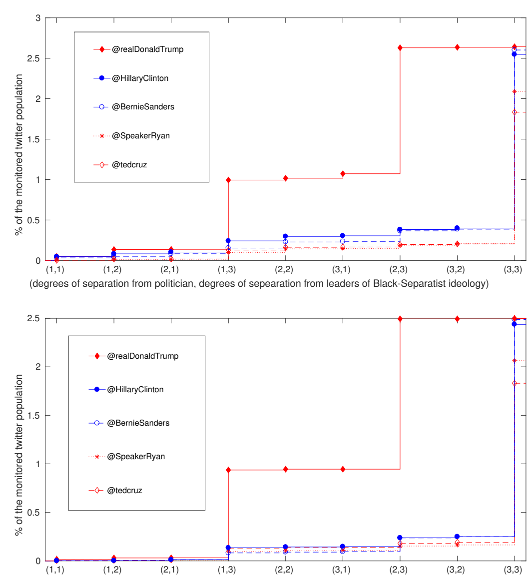

Fig. S4. Cumulative percentage of the monitored twitter population who are within a given in-degree of separation from a politician and a hateful Ideology.