Tracing Twitter Buzz:

Clustering Hashtags and Handles About Mass Shootings and Gun Control

The rise of social media provides great opportunities for researchers to study social behaviors, as well as human thoughts and emotions. Social media data are not only abundant in volume, but are also dynamic and naturally occurring, offering a clear window into public discourse capturing various facets of individual and collective behaviors (Lazer, et al., 2009; Shah, Capella, & Neuman, 2015). Twitter, especially, has been a major public platform for individuals to communicate with each other; an ideal medium from which researchers have gained insights about both the structure of online connections (e.g., Myers et al., 2014) and the content of online communications (e.g., Conover et al, 2011, Hanna et al, 2011).

One particular area of such research focuses on the temporal patterns on Twitter. Time is a salient dimension of Twitter, as the ephemeral quality makes it a digital space that always focus on "the here and now." As things happen real time on Twitter, some studies have capitalized on the instantaneous feature of Twitter stream to examine events and trends on the social network. For example, the temporal, social, and topical features of Twitter messages are capable of identifying events marked by sudden bursts of interest (Becker et al., 2011). Scholars find that trending topics on Twitter usually have a short half-life, and the ones that are persistent are sustained through retweeting or driven by news media (Asur et al., 2015). While those studies provide insights on the macro-level about the temporal patterns of communication on Twitter, we choose to zoom in on a specific topic—gun policy debate in the United States—with a goal to identify specific events surrounding this topic and to trace the sub-topical trends.

Gun-policy debate has been one of the major political issues dividing the United States. National tragedies such as the mass shooting at a movie theater in Aurora, Colorado on July 20,

2012, followed by Sandy Hook Elementary School in Newtown, Connecticut on December 14, 2012, prompted stronger calls for gun-restrictions, igniting heated debates with gun-rights advocates. Social media, especially Twitter, have been useful platforms for constructing and redefining gun-related discourses for individual supporters/opponents, activists, and major political and media elites.

By treating Twitter as a full-blown public arena and a hybrid sphere where individual citizens, organized groups, and journalists interact, we aim to portray the nature and substance of online public discourses related to mass shootings and gun-policy. To be specific, using hashtags as semantic markers and handles as indicators of influential agents, we investigate 1) the patterns and tempos of discourses surrounding mass shootings and gun debate and 2) the major actors who were driving the discourses on Twitter over a 3-year period, from 2012 to 2014.

Literature Review

Issue Attention Dynamics

Issues experience a cyclical process of salience and decline in terms of public interest (Anderson et al., 2012). As social issues fester, significant events spur alarm and enthusiasm, forcing the issue to the forefront for the broader public to grapple with. After realizing the costs of solving these larger societal issues, the public gradually loses interest in the issue, resulting in the issue returning to a dormant state. Since the publication of Anthony Downs's (1972) seminar work on issue-attention cycles, scholars have become increasingly drawn to the framework in studying the volatility of issue attention over time in the social media age. From 1973 to 2012, Downs's yearly citations dramatically took off in the 1990s and early 2000s as the Internet access started to spread, with an acute spike after social media platforms like Facebook and Twitter emerged (Gupta & Jenkins-Smith, 2015: p. 317).

Issues are predisposed to issue-attention cycles if they (1) do not affect the majority as opposed to a sizable minority, (2) demonstrate interest convergence with larger majorities, and (3) the issue itself does not, on its own, sustain popular interest for long periods of time. Others have attempted to explain the causal factors underlying issue volatility, attempting to understand how short public attention spans interact with increased issue diversity in online attention space. In particular, Newig (2004) identified three conditions that make certain problems more likely to capture public attention, the (1) severity, (2) accessibility, and (3) availability of resources. Djerf-Pierre (2012) also added that issues experience amplification and decline through a process of issue fatigue and issue competition. In other words, the history of an issue, and its relationship to other related attention-grabbing issues, augment the issue-attention dynamic by making some issues more likely to reappear on the public agenda compared to others.

Although issue attention dynamics have been mostly focusing on environmental issues, the increasing popularity of the issue attention cycle framework is broadly reflective of the importance of political communication. Anderson et al. (2012) observed different patterns of an issue in online media (e.g. blogs) and traditional media, such that the salience of the issue in online sphere was more persistent and resonant among the online public.

How issues experience oscillating dynamics in social media has been explored less. Social media is prevalent with "inadvertency" (Brundidge, 2010). In the social media environment, people are likely to be exposed to inadvertent differences, or heterogeneity, due to weakened social boundaries. Especially on Twitter, technological affordances such as hashtags, @mentions, or retweets, are easier, less effortful, but powerful tools for engaging and mobilizing public (Karpf, 2012). As a case, analyzing the attention dynamics of gun debate on Twitter may reveal insights about the construction and organization of Twitter-specific discourse.

Hashtags and Mentions: The Building Blocks of Twitter

Hashtag and mentions are part of the Twitter organizational infrastructure and represent different pieces of information that organize conversation. Hashtags curate and annotate content into specific topics, allowing the broader Twitter network to tag and follow tweets that talk about different issues (Boynton & Richardson, 2014; Bode et al., 2014). Hashtags vary greatly in use and lifespan. For example, some hashtags are ephemeral, lasting for only one event or news story, or are used exclusively by a specific audience. Other hashtags can operate as a long-term organizing device, used repeatedly for years as a rallying cry. Because hashtags help organize information in tweets, Twitter users depend heavily on these structural cues to follow Twitter conversations. One particularly unique form of the manipulation in Twitter discourse is "hashjacking," which occurs when users reappropriate (or "hijack") a hashtag that is employed by a different network. Such phenomena are possible only because the discursive structure of Twitter depends on the ability to annotate tweets via hashtags.

Mentions, the other organizational structure analyzed in this study, allow users to tag other relevant individuals in tweets. Users can therefore reply, respond to, or mention other users in the Twitter-sphere. Mentions make user handles referential, thereby organizing conversations by users involved. Logically, users who are frequently @mentioned or retweeted are likely to be at the center of dense networks. In fact, the number of mentions and retweets are often used in tandem with number of followers to measure user influence (Cha, Haddadi, Benvenuto, & Gummadi, 2010). What drives this selection is the assumption that users' interactions on Twitter—be it in form of retweets, @messages, or linked websites—work as a collective curating process. Users that are @mentioned or retweeted often not only have the capacity to influence others, but themselves are important markers in Twitter discourse because other users

have indicated their importance (e.g., by retweeting a post they made). By analyzing tweets that were retweeted the most during a specific time interval, researchers can focus on messages that users deemed most important (Jungherr & Jürgens, 2013).

These structural Twitter affordances, or building blocks (Luo, Osborne, Petrovic & Wang, 2012), are necessary for Twitter users to engage in "Twitter discourse." While there are many semantic Twitter norms (e.g., the use of a number and "/ " to indicate a message separated into multiple tweets), hashtags and mentions are two pivotal conventions embedded early into the Twitter API (Twitter, n.d.). Such early integration made these mechanisms iconic to Twitter discourse, and distinguishes Twitter from other social media. Regular Twitter users will even deploy these Twitter building blocks strategically, such as to invade other people's discussions or ensure a tweet goes viral (Hanna, Sayre, Bode, Yang & Shah, 2011).

Twitter is also a space where news stories and political issues are intertwined and discussed in tandem. Hashtags, memes, and tweets take off beyond the scope of their author's capabilities, and are used by Twitter communities as topic-specific symbols (Brock, 2012). Twitter's building blocks facilitates the creation of many tweeting communities, regardless of how many people are interested in that political issue, or how long that community lives. Among the issues that have gained significant traction on Twitter, mass shootings—and affiliated policy-specific topics related to U.S. gun policy—is among the most prominent and persistent. This can be attributed to a combination of factors, including the pervasive nature of gun policy coverage, the frequency of mass shootings within the past decade, and the active presence of gun policy organizations on Twitter (Merry, 2015). Looking at hashtags and user handles (Twitter accounts used for @mentions and retweets) that have been frequently used in gun-related discourses on

Twitter, this study examines how these specific technological affordances are used in the issue life cycles. Therefore, based on the rationale above, we propose following research questions:

RQ1: What are the defined clusters of (a) hashtags and (b) handles in the mass shootings and gun debate discourses in Twitter?

RQ2: What are the attention patterns of (a) hashtags and (b) handle clusters?

Methods

Mass killings, based on federal statues, involve the death of three or more people killed (Ingraham, 2015). According to LA Times (Los Angeles Times, 2017), there have been 25 mass shootings in the US in the past decade, 10 of which occurred between 2012 and 2014. Among those mass shootings are: the Aurora theatre shooting with 12 killed and 58 injured in 2012, the Newtown school shooting with 27 killed and one injured in 2012, the Washington Navy Yard shooting with 12 killed and 3 injured in 2013, and the Fort Hood shooting with 3 killed and 16 injured in 2014. The plethora of mass shooting in this timespan offer an appropriate context for mapping out how people were paying attention to those shootings and who were driving subsequent discussions of gun policy.

Twitter data were gathered from a running archive that collects tweets through Twitter's streaming API. Our archive consists of a 10% random sample of Twitter's global stream of tweet data between 2012 and June 30, 2015; after then, the sample was bottlenecked to a 1% sample of all tweets. Two steps were taken to optimally retrieve relevant data about mass shootings from the archive. First, general search strings were defined so as to capture as many tweets as possible. The search strings included "gun," "shooter," "shooting," "firearm," "second amendment," "2nd amendment", "nra" and their variations, yielding 13,169,470 tweets. For each

tweet, we downloaded fields such as id string, handle, handle id, handle profile, retweet id, retweet handle, and retweet handle profile. The second step involved noise reduction in the harvested data. Two coders were assigned to produce an exclusion list containing words and phrases that marked irrelevant tweets based on topic modeling results.[1] Then all tweets containing one of the words or phrases were deleted. Foreign language tweets were also removed through the exclusion list. Eventually, 4,971,996 tweets were included in analysis.

Each hashtag and handle within the text of each tweet were extracted and labelled the date of the tweet. The frequency of each hashtag and handle within the three-year span was tabulated and the top 300 hashtags and handles in terms of frequency were selected. Four graduate students coded for the relevance of hashtags and mentions by skimming through the actual tweets, and reached KA inter-coder reliability of 0.78 for hashtags, and 0.81 for handles. Eventually 256 hashtags and 281 mentions relevant to mass shootings and gun regulation were included for subsequent analyses.

To cluster the hashtags/mentions, we ran K-means clustering (MacQueen, 1967), a commonly used unsupervised learning algorithm that solves clustering problem. Each hashtag/mention's daily counts from January 1 2012 to December 31 2014 were tabulated and each hashtag/mention was treated as a vector with 1096 dimensions (1096 days between 2012 and 2014). To account for the fact that hashtags and mentions may vary greatly in total volume, each hashtag/mention vector was standardized into z-scores. Assuming that hashtag/mention has its own cycle or temporal pattern within the three-year span, we can argue that the more similar their patterns, the more likely they are to be in the same cluster.

[1] We applied Latent Dirichlet Allocation (LDA), an effective method of topic modeling, to classifying the tweets (each as a document) into 100 topics. Two graduate student coders went through 50 topics and terms, each, and the corresponding tweets with the goal to further reduce irrelevant tweets by adding words/phrases to the exclusion list.

Mathematically, given a set of hashtags (h1, h2, h3,…hn), where each observation is a 1096-dimentional real vector (x_1,x_2,…x_n), k-means clustering aims to partition the n hashtags into k (k <=n) set S = {S1, S2, …, Sk} so as to minimize the within-cluster sum of squares, which is the variance. The following procedure was followed:

1. Pick k centroids ($y_1, y_2 \ldots y_k$),

   find $\arg\min_j \left\|x_i - y_j\right\|^2$ and set $x_i \in S_j$ (i=1,2…n)

2. Calculate new centroids

   $y_j = \frac{1}{N_j}\sum_{x_i \in S_j} x_i$ where N_j is the size of S_j (j=1,2…k)

3. With the new centroids, relabel all the $\boldsymbol{x}$ vectors as in step 1
4. Recalculate new centroids as in step 2
5. The loop ends when no hashtags (h) moves to a new set ($\boldsymbol{S}$).

To determine the optimal cluster size, we tested 20, 30, and 40-cluster solutions. We found that 30 clusters for the hashtags and 40 hashtags for the mentions yielded the clearest patterns.

Results

Based on the results of the cluster analysis, we aim to map out and trace the nature—the discursive and temporal patterns—of online discourse surrounding mass shooting and the gun control debate on Twitter. To address our research questions, we examine the frequency plots of each cluster and actual tweets of hashtags to gauge distinctive characteristics of each cluster. The results of both cluster analyses are described in this section.

Hashtag Clusters

According to the analysis, the top five most used hashtags are #nra (148,350), #2a (133,314), #guncontrol (106,348), #tcot (top conservatives on twitter) (99,982), and #nj2as (New Jersey Second Amendment 2A Society; 69, 815), four of which are politically conservative in

nature. Among the 30 clusters of hashtags, the top four largest clusters dominate over 60% of the Twitter conversation. The largest cluster (Cluster 5: 20.68%) comes from online discussions surrounding New Jersey gun right resistance. The second largest cluster (Cluster 27: 19.38%), similarly dominated by conservatives, represents online debate surrounding constitutional right and second amendment. Only the third largest cluster (Cluster 16: 10.71%) represents liberal leaning hashtags, such as #demandaplan, #standdownnra, #p2b. The fourth largest cluster (Cluster 8: 10.51%), still composed of conservative-dominated hashtags, is characterized by more substantive policy-based discussion. Overall, two broad categories of hashtag clusters were identified: (1) event-exclusive and (2) persistent discourse clusters.

[Insert Table 1 about here]

Event-exclusive cluster

In event-exclusive clusters, only hashtags related to specific events co-occurred. For some of these clusters, hashtags represent pure account of the event occurrences. For example, clusters of *Navy Yard shooting* (Cluster 20; e.g. #navyyardshootng, #navyyard, #washington), *Fort Hood shooting* (Cluster 3; e.g. #forthood, #forthoodshooting), and the *Sikh Temple shooting* (Cluster 26; e.g. #templeshooting, #sikh) contain hashtags that are directly related to each mass shooting event. These clusters reveal short-lived, ephemeral patterns, indicating that the hashtags were used exclusively to describe the event around the time when it occurred (see Figure 1).

Other event-exclusive clusters, while they are also driven by each mass shootings event, portray different patterns. Cluster 4, *the Aurora shooting* cluster, for instance, is a cluster that includes not only descriptive hashtags (#aurora, #batman, #colorado) but also hashtags of emotional reactions (#prayforaurora, #tragic), specifically related to the Aurora Shooting in mid-2012. There is a clear, single peak in the volume of Twitter discourse among conservatives after

the event. A similar pattern can be seen with the *Newtown shooting* cluster (Cluster 29), where there is one single spike in Twitter conversation right after the incident occurred in the late 2013. This cluster also includes hashtags of emotional reactions to the shooting, such as expressing thoughts and prayers for the victims (#sandyhook, #prayfornewtown, #sad, and #rip). Cluster 8 ("*Gun control debate*") also constitutes hashtags related to the Newtown shooting (e.g. #newtown, #prayfornewtown), as well as gun-policy hashtags (#guncontrol, #gunlaws). This is noticeably different from the purely event-exclusive *Newtown shooting* cluster. The plot of this "*Gun control debate*" cluster reveals that there is a rather stable, continued discourse marked by this cluster, suggesting that while it emerged due to a specific event, gun-policy discussions remain relatively in a persistent manner over time.

[Insert Figure 1 about here]

Persistent discourse cluster

Unlike event-exclusive clusters, the second type of cluster is characterized by its ability to attract and sustain persistent use and attention which, even in the case where they were initiated by external events, are not constrained to a single event's temporal nature. This type of clusters contains hashtags that are used by both sides of the gun debate, or monopolized by one.

Partisan discourse. Cluster 16 is the only identifiable liberal cluster, with hashtags that show a clear liberal lean or gun-control stance (#violence, #demandaplan, #ows, #nomorenra, and #p2b), accounting for 10.71% of the total hashtags. This cluster showed up after the Newtown shooting and remained stable, signaling that the liberal, anti-gun discourses persisted on Twitter. On the other hand, there were a number of clusters with conservative leanings, such as Cluster 18 ("*Pro-gun discourse*"), Cluster 22 ("*Gun control debate*"), Cluster 23 ("*Conservative*"), and Cluster 27 ("Constitutional conservative"). Among these, distinct features

can also be identified, indicating each cluster's different pattern despite their shared ideological leaning. For example, while both Cluster 18 ("*Pro-gun discourse*" #gunsinamerica, #safety) and Cluster 22 ("*Gun control debate*" #gunrights, #2nd, #firearms, #libertarian) consist of hashtags specific to pro-gun discourses, Cluster 23 ("*Conservative*") constitutes more general conservative hashtags that can be used in political discourses outside of the gun debate (#teaparty, #ccot, and #gop).

Another identifiable cluster on the right, Cluster 27 ("Conservative constitutional"), displays a distinct pattern compared to more policy-specific hashtags because it conservative discourse surrounding the constitutional rights. Examples of this conservative constitutional hashtags include #secondamendment, #freedom, and #constitution. This single cluster generates 19.38% hashtagged tweets and sustains a sizable amount of attention and discourse over the time. This speaks to the potentially temporal nature of policy-based discussion, as opposed to discourse surrounding broad rationale or values.

Mixed discourse. Unlike the partisan clusters, Cluster 14 ("*Mixed gun debate*") represents gun policy debate with mixed voices: both liberal and conservative hashtags are a sizeable proportion of this cluster (#nowisthetime, #votegunsense, #protect2a, and #nrastandandfight). This cluster shows a persistent increase after the Newtown shooting and reaches its spike around the early 2013, when a bill to expand background checks was defeated in the Senate, ending federal legislative efforts. The cross-cutting occurrence of partisan hashtags suggests that there were cases where both liberal and conservative hashtags were used in a similar temporal pattern, representing the heated nature of the issue.

Local orientation and broad impact. Among the 30 clusters, two clusters, Cluster 5 and Cluster 10 were specifically related to New Jersey gun laws (labeled as "New Jersey gun right

resistance" for both). These two clusters, however, showed distinct patterns in their attention patterns and visibility on Twitter. Cluster 10 consists of hashtags related to New Jersey legislations, including #newnjgunlaws, #nj, #nj2, and #nj2a. As the pattern shows, this cluster specifically emerged during the period when a heated controversy arose regarding the gun control bill in New Jersey. Despite a local orientation, Cluster 5 shows a different pattern. This cluster, which dominates 20.68% of the total hashtags, remains persistent especially from early 2013. Given the hashtags co-occurred (#2a, #nj2as, #gunsense, #ccw, #life), it is likely that the discussion surrounding New Jersey Second Amendment expanded to broader discourses of gun right resistance in Twitter.

Handle Clusters

The five most frequently used handles in the mass shootings and gun debates in Twitter include the following: @piersmorgan (41,323), @govchristie (36,911), @barackobama (35,433), @nra (32,117), and @ap (29,886). Among the 40 handle clusters, we identified several categories of the clusters, including media, public agents, and ordinary people or popular twitter accounts.

[Insert Table 2 about here]

Media

Cluster 31, labeled the *Major breaking news* cluster, consisted of outlets such as @cnnbrk, @cnn, @usatoday, @breakingnews, and @huffingtonpost. The cluster showed sharp fluctuations over time mainly driven by the mass shootings event, accounting for 8.79% of total handles (see Figure 2).

Other media-related handles, except for *Major breaking news* cluster which is purely news based, were defined by co-occurrences with other public agents in Twitter, such as pundits,

politicians, and celebrities. For example, Cluster 5 ("*News and anger/frustration*"), which accounts for the 11.42% of the total handles, is a combination of major news outlets (e.g. @ap, @cbsnews) and emotional reactions from other media pundits and celebrities (e.g. @piersmorgan, @marmel, @pattonoswalt, @alexalltimelow). To be specific, this cluster indicates a co-occurrence of the news about mass shootings and subsequent expressions of anger and frustrations regarding the mass shootings events. The tweets of the clusters demonstrate that news of mass shootings events ignite emotional reactions of public agents in Twitter. However, such emotional reactions of anger and frustration do not reach high spikes for every events over the three year period. In other words, unlike the *Major breaking news* cluster, which shows extreme fluctuations for each mass shootings event, the *News and anger/frustration* cluster shows somewhat different cycles in terms of peaking due to Newtown, and dropping as attention was diverted to subsequent events.

Cluster 39 ("*Mainstream media and politics*"), which includes @barackobama, @huffpostpol, @whitehouse, @politico, can be characterized as a combination of mainstream politics and media. As seen in the graph, the cluster also appears to be driven by major mass shootings events, but shows more sustained fluctuations especially after the Newtown shooting in the late 2012. It is likely that the Newtown shooting spurred the subsequent gun-related discussions and maintained as an important agenda for both mainstream politics and media.

Partisan media. Clusters of partisan media with co-occurrences of other actors were identified as well. Cluster 19 ("*Mainstream liberal media and public agents*") is characterized as liberal media and liberal pundits (@thinkprogress, @motherjones @ac360 @msnbc) co-occurring in the mass shootings discourses on Twitter. Similarly, Cluster 16 ("*Online liberal media and public agents*") includes @slate, @bradybuzz, @johnfugelsang, and @corybooker,

showing an interaction of liberal online media and liberal public figures. On the other hand, only one conservative-leaning cluster was found (Cluster 4; "*Conservative media agents*"), consisting of media agents such as @breitbartnews, @drudge_report, @realalexjones, and @patdollard. Compared the attention patterns of these partisan clusters, the overall dynamics of *Mainstream liberal media and public agents* cluster and *Online liberal media and public agents* cluster resemble each other, showing more fluctuations and sensitive reactions to mass shootings events than *Conservative media agents* cluster. This indicates that liberal media and public figures generate more gun-related discourses driven by the events than conservative media agents.

Local media. Local news clusters, such as Cluster 3, Cluster 21, and Cluster 33, they tend to show lower frequencies of mass shootings and gun-related discourses (1.83%, 0.95%, 0.28%, respectively). They appear to be be less influenced by the mass shootings event, compared to other major media clusters. These local news clusters show few co-occurrences with other actors as well. This not only suggests their relatively low level of discursive engagement with national tragedies, but shows that these handles are not given as much attention as handles in other clusters.

[Figure 2 about here]

Public agents: activist groups, politicians, and celebrities

The clusters of public agents reflect more contentious, mixed interactions of different actors in mass shootings and gun discourses. Cluster 22 ("*Pro-gun vs anti-gun activist groups*") is one example where pro-gun and anti-gun activists (@demandaction, @votingfemale, @youngcons, @newtownaction) co-occur in one cluster, revealing patterns of a contentious gun debate in Twitter. As described in the graph, the activists' movements began after the Newtown shooting in the late 2012 and remained relatively constant, suggesting sustainability of the

contentious gun debates among activists group after the major shooting event. Cluster 7, the "*liberal activists and conservative people*" cluster, is also composed of handles from both sides of the debate, including @momsdemand, @shannonrwatts, @wallsofthecity, @bikininmaine. Similar to the *Pro-gun vs anti-gun activist groups* cluster, it features a constant exchange between anti-gun activist groups and gun rights supporters, especially after the Newtown shooting. The "*Pro-gun vs anti-gun activist groups*" and "*Liberal activists and conservative people*" clusters account for 1.41% and 7.74% of the total handles, respectively. Cluster 17, labeled "*Liberal celebrity and conservative politician*," reveals an interesting relationship between the liberal comedian @robdelaney and the conservative politician @sarahpalinusa. Despite small percentages of the total handles (0.33%), they were constantly mentioned by each other and together by others in the same tweets because of their political disagreements.

Cluster 10 and Cluster 20 are unique clusters related New Jersey gun legislations, explaining 6.48% and 7.10% of the total handles, respectively. While Cluster 20 involves more handles specific to New Jersey politics and government (@govchristie, @njsendems, and @njgop), cluster 10 is composed of non-governmental handles surrounding New Jersey Second Amendment discourses (@2anow, @ccwinnj, @flamanar, and @3r1tech), largely advocating their support for the gun rights. Patterns of both clusters show two main active moments in the mid-2013 and mid-2014, when the gun control bills were introduced and vetoed by the governor Christie. A graph shows cluster 10 keeps ongoing discussions after the mid-2013, suggesting the sustained activities of non-governmental pro-gun supporters. This differs from cluster 20 which appeared only in two clearly distinct moments when governmental officials and politicians engaged in discussing New Jersey gun laws.

Ordinary people and popular non-verified Twitter accounts

In addition to media and public figures categories, the analysis of handles also highlight distinct clusters consisting of ordinary accounts. For example, Cluster 24, "*Call for thoughts/prayers*," (@frank_ocaen, @daidridgetnt) and cluster 26, "*Call for donations/retweets*," (@realkg5, @c10jones) were frequently retweeted because of their calling for donations and showing respect to the victims, especially after the Aurora shooting in the mid-2012. Interestingly, cluster 15 is characterized as a combination of online and local news (e.g. @tmz, @9news, and @denverpost) and related reactions of thoughts and prayers by other ordinary users (e.g. @instagrvm, @channinngtatum, and @jessicaredfield) around the Aurora shooting. Overall, all of these clusters show rather temporal and highly event-driven patterns, especially and exclusively around the Aurora shooting Twitter spike.

Besides ordinary accountss, other automated accounts were also identified. For example, cluster 18 ("*Non-verified*") consists of handles like @badkidandrew and @stfudustin that circulate information related to shooting events or gun-legislations, repeatedly @mentioning each other. Such non-verified Twitter accounts were observed in some other clusters as well (e.g. @hauzofsam, @fernand0monster). Observations of their actual tweets revealed that those non-verified handles produced high frequencies of tweets within a short period of seconds, tweeting gun-related information and news links. Given these interesting irregularities, it is likely that these handles are a part of non-verified popular accounts, and may be bots.

Discussion

This study conducted two sets of cluster analysis for hashtags and handles that appeared in the mass shootings and gun-related discourses on Twitter. By identifying distinct discourses surrounding both hashtags and handles, we provide useful insights regarding the use of Twitter

building blocks (Luo et al., 2012) in tweets to structure mass shooting and gun control policy discourses.

The cluster analysis for hashtags revealed several distinct groups of conversation. Notably, some hashtag clusters were event-specific, occurring exclusively at specific points in time, especially mass shootings events. Visually, these could be identified as sudden peaks in use. Contrastingly, there were also hashtag clusters with more sustained lifespans (e.g., Cluster 18 "*Pro-gun discourse*," Cluster 22 "*Gun control debate*," and Cluster 27 "*Conservative constitutional*"). These were more likely to be linked to policy discussions. While some clusters had hashtags that were used predominantly in liberal or conservative discourse, other clusters were more mixed. This reflects the ability for hashtags to be used both short-term and long-term and by different groups of actors.

Partisan clusters of hashtags set up a contrast between the right and the left in their use of this mechanism: there are no clearly identified liberal clusters that concentrate gun discussion on based on constitutionality. Among these persistent clusters, a large proportion comes from continued partisan discourse from one particular side: the conservatives or gun-right advocates. For liberal or gun-control discourses, there was only one giant cluster representing hashtags with liberal leaning (Cluster 16 "*the liberal"*). Considering the partisan nature of gun debate hashtags on Twitter, there is clear asymmetry in the diversity and concentration of hashtags use among both sides. While conservative-leaning clusters seemed to dominate a large proportion of gun-related online discourse on Twitter, the liberal-leaning cluster seemed to be only reactive to shooting events.

The cluster analysis for handles was typologies into three broad groups: media, public and social actors, and everyday individuals. Among the three clusters with media handles—

specifically mainstream (not local) media—were the largest actors in Twitter gun discourse. This suggests that media operate as opinion leaders in the Twitter discourse on gun control. Media was found to co-occur with other public actors, as well as emotions (i.e, anger/frustration and thoughts/prayers). One explanation for this may be the pervasive role of media as the main driver of information during big events and national tragedies. Early in the timespan of a mass shooting, people are more likely to seek out information from sources like news media. Given the brevity of tweets themselves, it is possible that people are retweeting media in an effort to "get the word out" about a particular shooting.

Within our cluster analysis, we were also able to identify clusters of ordinary people, as well as activist groups (though no cluster was dominated by activist groups). Sometimes, handles in these clusters would encourage others to donate or retweet. This mechanism is similar to that of connective action (Bennet & Segerberg, 2012), but the temporal nature of mass shooting suggests that connective action-like tendencies may occur more ephemerally, reactionary to bursts of event. Some additional unique features of our cluster analysis include the identification of a "New Jersey gun law cluster" composed mainly of second amendment supporters and having a consistent presence on Twitter and a possible bot cluster.

In terms of partisanship, clusters of both hashtags and handles varied in their "partisan purity" (i.e., the degree to which a cluster exclusively contained handles or hashtags belonging to one side of the American left-right political spectrum). Qualitative assessments of each cluster analysis show that liberals and conservatives tend to use hashtags and handles (@mentions and retweets) in the gun debates, but in different ways. For handles, more liberal-oriented handles were identified in clusters which included a smattering of politicians, policy experts, celebrities, and other social agents, suggesting a variety of sources of information. On the other hand, only

one powerful conservative handle cluster emerged, implying that the handles in this cluster are intimately related. But when examining hashtag clusters, conservatives had a greater variety of hashtags clusters, particularly those with persistent use (e.g. #tcot, #ccot, #gunrights, and #goa). The ability to specify types of conservative hashtag clusters (e.g., Cluster 10 and 20, which are specific to "New Jersey gun legislation" or Cluster 27 "Constitutional debate") confirms the internal-cohesiveness of these clusters; at face value, they make sense. This suggests that liberal Twitter discourse may rely on a greater variety of sources, but will unite less around hashtags, while conservative Twitter discourse was more organized around hashtags, and homogenous in terms of handle references.

Speaking more broadly to the methodological contributions of this analysis, we argue that our method can trace both the events and trends surrounding the gun policy topic. Through K-means clustering of hashtags and handles based on their daily frequencies, we were able to identify both particular moments of interest and general longitudinal trends of specific thematic discussions. Hashtags are particularly indicative of the sudden increase of interest, providing a valuable source of information to retrieve past events. Additionally, both hashtags and handles enable us to trace and map out the back-and-forth conversations on Twitter about gun policy and mass shootings over time. Through validating against actual tweets, we find that homogeneous clusters did represent the interest of a group longitudinally, while heterogeneous clusters signify contestation among actors or shared topical focus between different groups of actors.

One limitation of this study is the reduction of Twitter discourse analysis to the use of these Twitter building blocks, mainly hashtags and the use of handles in retweets and @mentions. While there is obviously semantic information that is lost by doing this, our paper was more interested in the structural mechanisms of these markers than in discursive practices on

a whole. However, the analysis of content in relation to these Twitter building blocks would be another valuable future contribution. Another limitation may be the dependence on human interpretation in cluster analysis. Several trained coders' performed qualitative observations of hashtags, mentions, and retweeted tweets in terms of the content and their overtime flows increased the validity of our findings and interpretations. Finally, given the significance of news media on Twitter, it may be worthwhile to explore news discourse more specifically. One way to do so is by comparing news articles and the accounts of those news outlets on Twitter, looking at the interactions between traditional media and related online discourses. Future research could also expand on this analysis by performing a deeper dive on the use of hashtags and mentions in tandem. This will advance our understanding of who are the major actors (handles) in different online discourses (hashtags).

Nonetheless, this study provides novel contributions to the field for mapping out the online discourses surrounding mass shootings events over the three-year period, specifically focusing on unique affordances on Twitter, hashtags and handles (retweet and @mention). Using the Twitter sphere as an important platform that reflects how people allocate attention and engage in conversations, this study identified the nature and flow of different discourses and key drivers in the online discussions. In addition, portraying Twitter clusters gives practical insights for legislators and policy makers by documenting salience and dynamics of specific issues circling around hashtags and handles, beyond public opinion data. Therefore, we can conclude that understanding hashtags and handles use is critical to unpack gun discourse on Twitter.

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Table 1. 15 out of 30 hashtag clusters

ID	Category	Cluster label	Cluster size	Total # of hashtags	% of hashtags	Examples
3	Event-exclusive (Descriptive)	Fort Hood shooting	2	3315	0.21	#forthood, #forthoodshooting
4	Event-exclusive (Emotional)	Aurora shooting	11	49096	3.15	#theatershooting, #aurora, #colorado, #batman, #prayforaurora
5	Persistent discourse (Partisan - Conservative)	New Jersey gun right resistance	10	321783	20.68	#2a, #nj2as, #gunsense, #pjnet, #gunfail, #ccw, #stopatt, #firearm
8	Persistent discourse	Gun control debate	9	163618	10.51	#guncontrol, #gunlaws, #newtown, #prayfornewtown
10	Persistent discourse (Partisan-Conservative)	New Jersey gun right resistance	7	30960	1.99	#newnjgunlaws, #nj, #dgu, #nj2, #nj2a
14	Persistent discourse (Mix)	Mixed gun debate	7	21279	1.37	#votegunsense, #protect2a, #backgroundchecks #merica
16	Persistent discourse (Partisan- Liberal)	Liberal	10	166585	10.71	#demandaplan, #nowaynra, #violence, #ows, #nomorenra, #standdownnra, #p2b
18	Persistent discourse (Partisan- Conservative)	Pro-gun discourse	2	4487	5.83	#gunsinamerica, #safety
20	Event-exclusive (Descriptive)	Navy Yard shooting	6	44173	2.84	#breaking, #navyyardshooting, #breakingnews, #navyyard, #washington
21	Persistent discourse	Gun right advocacy	2	2382	0.15	#nraam, #indygunsense

	(Partisan - Conservative)					
22	Persistent discourse (Partisan - Conservative)	Gun control debate	19	90689	5.83	#gunrights, #uniteblue, #goa, #gunsafety, #cto
23	Persistent discourse (Partisan - Conservative)	Conservative	6	82858	5.32	#teaparty, #tlot, #gop, # ccot, #lnyhbt, #ocra
26	Event-exclusive (Descriptive)	Sikh Temple shooting	3	4861	0.31	#templeshooting, #sikh, #wisconsin
27	Persistent discourse (Partisan - Conservative)	Conservative constitutional	26	301542	19.38	#2ndamendment, #constitution, #nobama, #conservative, #tco
29	Event-exclusive (Emotional)	Newtown shooting	19	60277	3.87	#prayfornewtown, #rip, #sandyhook, #sad, #heartbreaking

Table 2. 18 out of 40 handle clusters

Id	Category	Cluster label	Cluster size	Total # of handles	% of handles	Examples
3	Media	Local news outlets	4	17049	1.83	@abc7chicago, @6abc
4	Media	Conservative media agents	11	38303	4.12	@breitbartnews, @theblaze, @drudge_report, @patdollard
5	Media	News and anger/frustration	17	106203	11.42	@ap, @cbsnews, @ pattonoswalt @alexalltimelow

7	Public agent	Liberal activists and conservative people	15	71925	7.74	@momsdemand, @shannonrwatts, @petefrt, @bikininmaine
10	Public agent	New Jersey gun law	12	60217	6.48	@2anow, @ccwinnj, @3r1tech, @janknepper
15	Media	News and thoughts/prayers	11	25636	2.76	@denverpost, @9news, @instagrvm, @channinngtatum
16	Media	Online liberal media and public agents	7	43746	4.71	@slate, @bradybuzz, @chrislhayes, @corybooker
17	Public agent	Liberal celebrity and conservative politician	2	3033	0.33	@robdelaney, @sarahpalinusa
18	Non-verified	Non-verified	2	4486	0.48	@badkidandrew, @stfudustin
19	Media	Mainstream liberal media and public agents	16	57517	6.19	@thinkprogress, @motherjones, @mikebloomberg, @ac360
20	Public agent	New Jersey gun law	15	66024	7.10	@govchristie, @njsemdems, @nj2as, @njgop
21	Media	Local news outlets	6	8876	0.95	@wwltv, @wsvn, @kiro7seattle
22	Public agent	Pro-gun vs anti-gun activist groups	8	13097	1.41	@demandaction, @votingfemale, @youngcons, @ofa
24	Ordinary people	Call for thoughts/prayers	3	7061	0.76	@frank_ocaen, @daidridgetnt, @theliluminati

26	Ordinary people	Call for donations/retweets	2	11947	1.29	@realkg5, @anonymousfm
31	Media	Major breaking news	12	81756	8.79	@cnnbrk, @breakingnews, @bbcbreaking
33	Media	Local news outlets (Houston)	2	2578	0.28	@khou, @abc13houston
39	Media	Mainstream media and politics	14	62568	6.73	@barackobama, @whitehouse, @politico, @huffpostpol

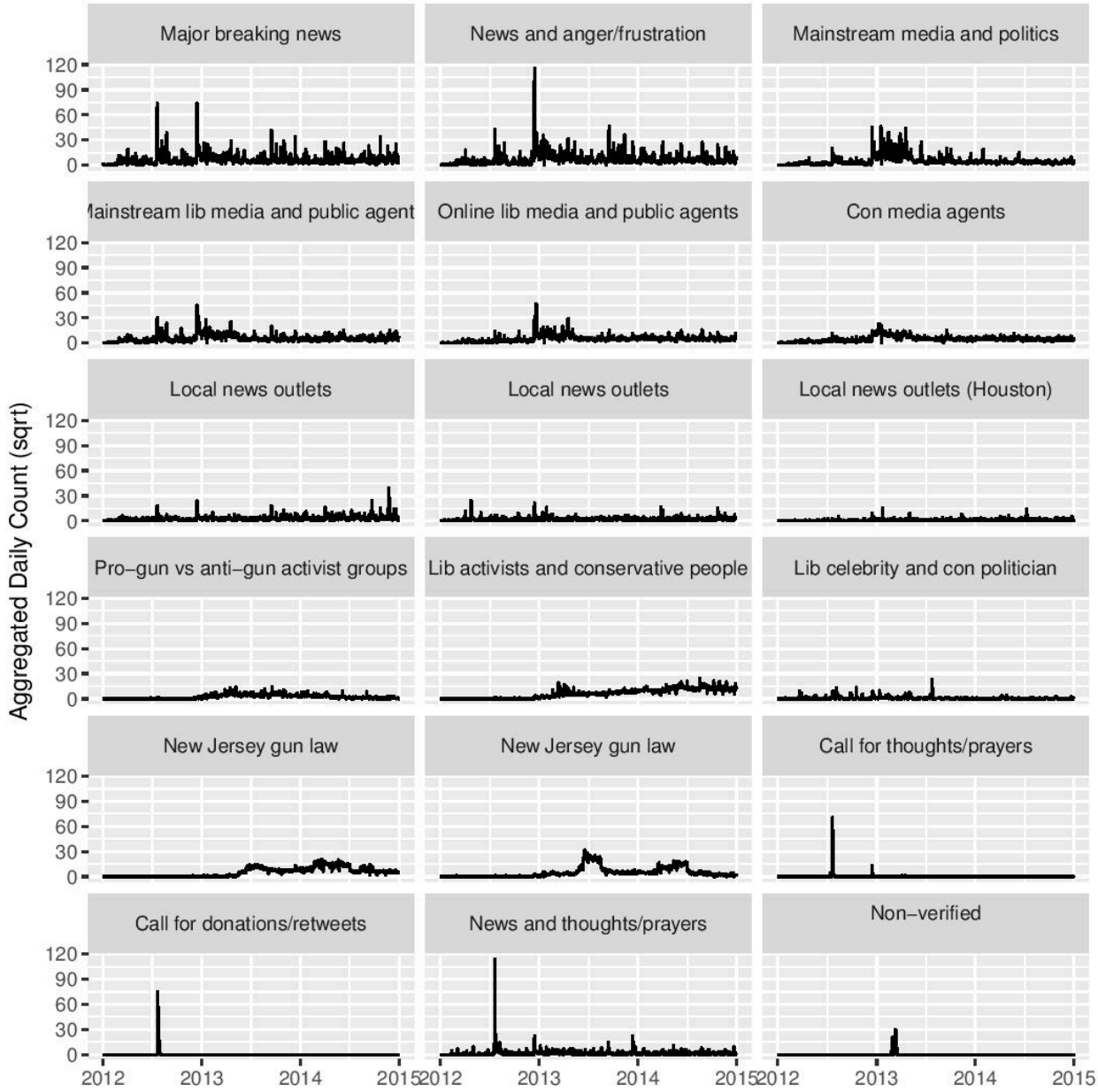

Figure 1. Aggregated daily counts of selected hashtag clusters from 2012 to 2014

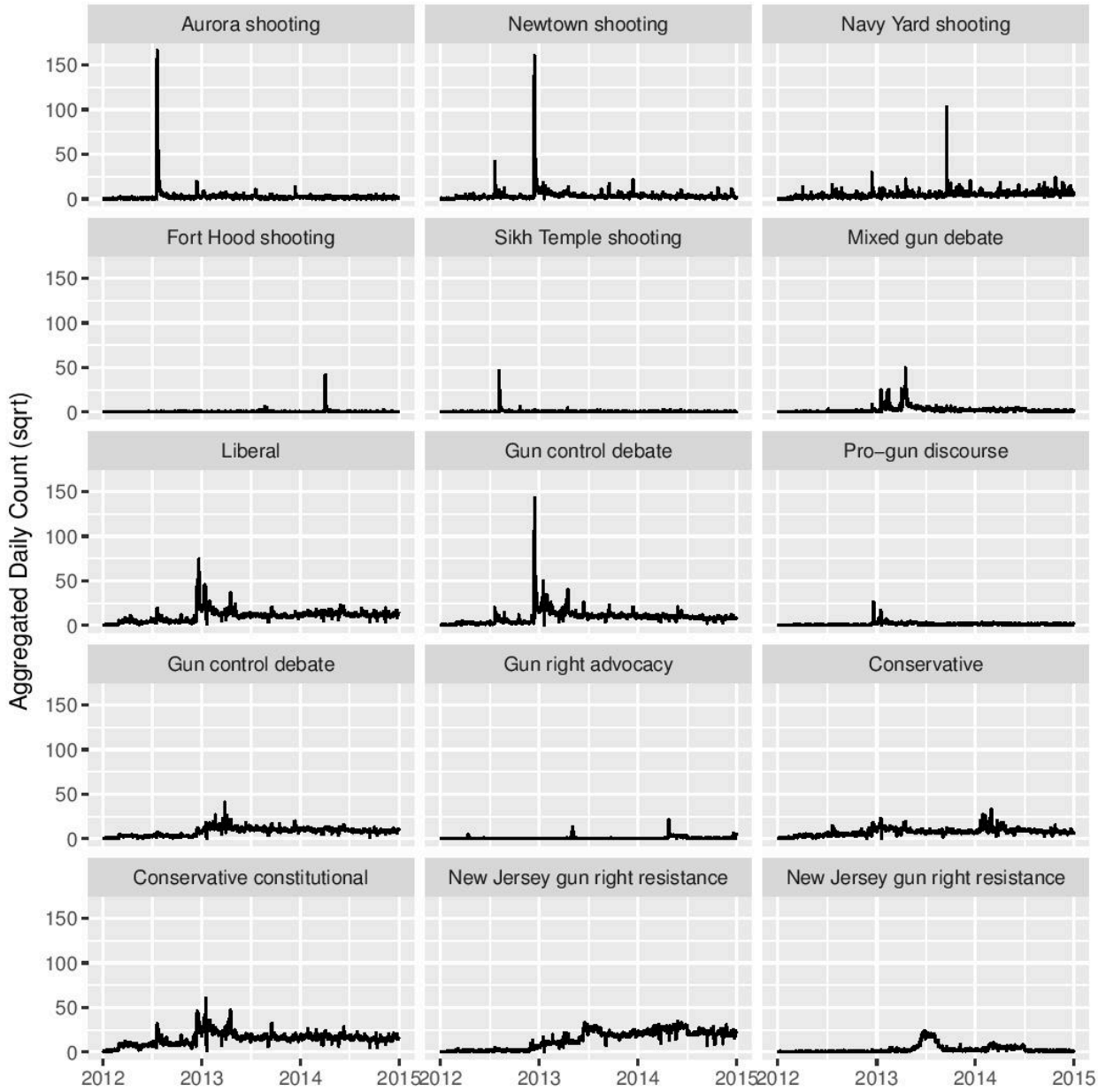

Figure 2. Aggregated daily counts of selected handle clusters from 2012 to 2014

Appendix A: Full hashtag lists and clusters

ID	Hashtag cluster label	Examples
1	Romney's comment during the Presidential debate	#debate, #debates
2	Gun control and liberal media	#gunsoverpeople, #endgunviolence, #maddow, #edshow
3	Fort Hood shooting	#forthood, #forthoodshooting
4	Aurora shooting	#theatershooting, #aurora, #colorado, #batman, #prayforaurora, #coloradoshooting, #aurorashooting, #theatreshooting, #tragic, #denver, #justicewillbeserved
5	New Jersey gun right resistance	#2a, #nj2as, #gunsense, #pjnet, #gunfail, #ccw, #stopatt, #firearm, #forex, #life
6	Oakland shooting	#oakland, #weapons, #preppertalk
7	News and emotion	#cnn, #wtf, #sosad, #smh, #crazy, #stoptheviolence, #godbless
8	Gun control debate	#guncontrol, #newtown, #prayfornewtown, #usa, #gunlaws, #shootings, #prayfornewto, #mentalhealth, #idiots
9	Arapahoe school shooting	#nomoresilence, #neverforget, #arapahoehigh
10	New Jersey gun right resistance	#newnjgunlaws, #nj, #dgu, #nj2, #nsa, #4a, #nj2a
11	Regional news and gun policy debate	#whatwillittake, #atlanta, #ga, #georgia, #wsbtv, #nagr
12	Regional news and gun policy debate	#cc, #california, #florida, #hounews, #obamacare, #houston, #gunbullies, #armedcitizen, #standyourground, #iamthenra, #orpuw, #ucsb, #scotus, #gunssavelives, #gunowners
13	News and gun policy debate	#chicago, #foxnews, #endthenra, #crime, #bbc, #dead, #detroit, #fox, #preppers, #oklahoma, #gunman, #inners, #dallas, #world, #abc, #losangeles, #worldnews, #baltimore, #gunfreezones, #stoprush, #arizona
14	Mixed gun debate	#nowisthetime, #votegunsense, #protect2a, #backgroundchecks, #merica, #senate, #nrastandandfight
15	MIT shooting	#boston, #mit, #prayforboston

16	Liberal	#nra, #demandaplan, #nowaynra, #violence, #ows, #nomorenra, #topprog, #wiunion, #standdownnra, #p2b
17	FSU shooting	#update, #opencarry, #miami, #ohio, #fl, #fsushooting
18	Pro-gun discourse	#gunsinamerica, #safety
19	Gun activists debate	#momsdemand, #notonemore, #offtarget, #vetos993, #everytown, #libcrib, #vegas, #rhshooting, #lasvegas, #uniteright
20	Navy Yard shooting	#breaking, #navyyardshooting, #breakingnews, #navyyard, #washington, #navy
21	Gun rights advocacy	#nraam, #indygunsense
22	Gun control debate	#gunrights, #uniteblue, #gunviolence, #momsdemandaction, #firearms, #demandaction, #rkba, #coleg, #rednationrising, #tyranny, #2nd, #goa, #gunsafety, #ctot, #copolitics, #wiseart, #policestate, #rights, #libertarian
23	Conservative	#teaparty, #tlot, #gop, #ccot, #lnyhbt, #ocra
24	Other mass shootings	#marysvilleshooting, #seattle, #mphs
25	Gun law debate	#tgdn, #newyork, #congress, #ny, #progun, #law, #opslam, #abortion, #control, #gunnuts, #prolife, #ncpol, #doitforgabby
26	Sikh Temple shooting	#templeshooting, #sikh, #wisconsin
27	Constitutional conservative	#tcot, #guns, #news, #p2, #gun, #2ndamendment, #obama, #secondamendment, #politics, #freedom, #constitution, #liberty, #fail, #truth, #sgp, #nwo, #msnbc, #ctl, #ndaa, #twisters, #democrats, #nobama, #infowars, #liberals, #republicans, #conservative
28	Action based emotional debate	#sotu, #wedemandavote, #groceriesnotguns, #nyc, #gunshots, #gunshot, #cdnpoli, #timetoact, #selfdefense, #gunskillpeople, #ripjessica, #txlege, #whygunsarebetterthanliberals, #enough, #gunregistry, #chsnews, #concealedcarry, #bloomberg, #gunlawsareajoke
29	Newtown shooting	#ctshooting, #guncontrolnow, #rip, #sandyhook, #prayfornewton, #connecticut, #schoolshooting, #sad,

		#prayersfornewtown, #prayers, #pray, #newton, #praying, #ct, #school, #prayerfornewtown, #prayersfornewton, #heartbreaking, #connecticutshooting
30	LA international airport shooting	#lax, #laxshooting

Appendix B: Full handle lists and clusters

ID	Cluster label	Examples
1	Mainstream media and pundit	@charlespgarcia, @tednugent, @examinercom, @politics_pr, @kurtschlichter, @thedailybeast, @theteaparty_net, @zite, @p0tus, @beforeitsnews
2	Public agents and ordinary people	@trutherbot, @po_st, @gerfingerpoken, @dbargen, @soderstromk, @baseman2001, @johnrlottjr, @peddoc63, @wakeup__america
3	Local news outlets	@abc, @fox29philly, @abc7chicago, @6abc
4	Conservative media agents	@sharethis, @breitbartnews, @theblaze, @drudge_report, @realalexjones, @foxnewspolitics, @demandaplan, @worldnetdaily, @pac43, @patdollard, @townhallcom
5	News and anger/frustration	@ap, @foxnews, @cbsnews, @marmel, @joerogan, @buzzfeedandrew, @ezraklein, @abc7newsbayarea, @paulwesley, @richarddawkins, @pattonoswalt, @abcworldnews, @miafarrow, @alexalltimelow, @bbcnewsus, @repubgrlprobs, @piersmorgan
6	Mainstream/local media	@washingtonpost, @nbcnightlynews, @abc7news, @nbcwashington, @911buff, @globalgrindnews, @wusa9, @mittromney
7	Liberal activists and conservative people	@momsdemand, @a5h0ka, @shannonrwatts, @everytown, @kroger, @bikininmaine, @kharyp, @politicallaughs, @azws, @endnra, @tlw3, @petefrt, @wallsofthecity, @paladincornelia, @tazcat2011
8	NRA and non-verified	@nraila, @hauzofsam, @fernand0monster
9	Politician and media	@emilymiller, @gabbygiffords, @gop, @mmfa, @joenbc,

		@morning_joe, @kellyayotte, @sengillibrand
10	New Jersey gun law	@2anow, @njsenatepres, @mgdauber, @lougreenwald, @erikh1776, @carydc, @hd_ride, @molonlabenj, @ccwinnj, @flamanar, @3r1tech, @janknepper
11	Celebrity and non-verified	@holykatyperry, @ryandeirey, @katyperry
12	Liberal news and pundits	@kagrox, @tpm, @thetweetofgod, @dailykos, @kennettdems, @rwwatchma, @pari_passu, @thebaxterbean, @rawstory
13	Conservative politicians	@sentedcruz, @senrandpaul, @tedcruz, @senmikelee, @sentoomey
14	Non-verified and parody account	@bowdowngomez, @causewereguys, @horanycalum
15	News and thoughts/prayers	@itsrealted, @tmz, @9news, @instagrvm, @channinngtatum, @denverpost, @ikeepittooreal, @mashable, @snooki, @jessicaredfield, @joshdevinedrums
16	Online liberal media and public agents	@nra, @slate, @bradybuzz, @johnfugelsang, @gawker, @chrislhayes, @corybooker
17	Liberal celebrity and conservative politician	@robdelaney, @sarahpalinusa
18	Non-verified	@badkidandrew, @stfudustin
19	Mainstream liberal media and public agents	@thinkprogress, @nytimes, @yahoonews, @motherjones, @mikebloomberg, @reuters, @msnbc, @teapartycat, @salon, @mmflint, @ac360, @guardian, @anthonycumia, @ericboehlert, @mailonline, @markfollman
20	New Jersey gun law	@govchristie, @eqlf1, @njmorrisvoter, @david_schulze, @njsendems, @lluizzijr, @njassemblydems, @nj2as, @ladylibertynj, @javierrojasj, @rightwingart, @njgop, @anthonydiana, @nj2asprez, @njmike319
21	Local news outlets	@wwltv, @wsvn, @ktvu, @ohwonka, @nbc6, @kiro7seattle
22	Pro-gun vs anti-gun activist groups	@demandaction, @votingfemale, @youngcons, @lifeasrednecks, @starbucks, @ofa, @newtownaction, @proseish
23	News and pundits	@thedailyedge, @louis_tomlinson, @uberfacts, @andersoncooper, @bbcworld, @earldibblesjr,

		@tobeymonster, @wesleylowery, @meekmill, @wsfa12news
24	Call for thoughts/prayers	@frank_ocaen, @daidridgetnt, @theliluminati
25	Online blog and non-verified	@youranonnews, @anonymousfm
26	Call for donations/retweets	@realkg5, @c10jones
27	Mixed media and account	@nranews, @washtimes, @dailycaller, @proadstudio, @sfgate
28	Celebrity and politician	@yokoono, @senatorreid
29	Information sharing	@mysportslegion, @ajc
30	Newtown prayer and liberal public agent	@pray_newtown, @billmaher, @pray4newtownct, @borowitzreport, @nickkristof, @unclerush, @pierstonight, @toure
31	Major breaking news	@cnnbrk, @breakingnews, @huffingtonpost, @cnn, @usatoday, @abc7, @nbcnews, @bbcbreaking, @wsj, @huffpostcrime, @kdtrey5, @todayshow
32	News and celebrities	@theonion, @jimcarrey, @kimkardashian, @chicagotribune, @khloekardashian, @suntimes, @nbcchicago
33	Local news outlets (Houston)	@khou, @abc13houston
34	Public agents	@dloesch, @csgv, @katiepavlich
35	Public agents	@vp, @speakerboehner, @anncoulter, @edshow, @maddow, @seanhannity, @ingrahamangle, @benshapiro
36	Local news outlet	@latimes, @nbcla, @lanow, @nickjonas
37	Media and public agent	@sallykohn, @nypost, @nbcphiladelphia, @ktla, @buzzfeednews, @10tv, @nydailynews
38	Non-verified	@onedirslaytion, @orgasmicgomez, @linoge_wotc
39	Mainstream politics and media	@barackobama, @huffpostpol, @whitehouse, @politico, @twitchyteam, @michellemalkin, @cspanwj, @senfeinstein, @thehill, @bloombergnews, @mediaite, @nprnews, @talkmaster, @theplumlinegs
40	Media and public agents	@newsbreaker, @juddlegum, @bostonglobe