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Climate change and YouTube: Deliberation Potential in Post-video Discussions

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ABSTRACT

YouTube videos are a ubiquitous source of information but also a venue for users to comment on discussion boards that addend videos. There are no moderators of these discussions, and thus there is a possibility for self-appointed leaders to emerge, responding incessantly and across a genre of videos. These "elites," as they are labelled here, use the discussion as a personal campaign tool, diminishing the deliberative potential of provocative topics. To determine whether this is happening and to complement existing research analyzing the content of comments, this paper focuses on the structure of the discussions that follow the most popular climate change-related videos. Network analysis confirms that discussions can be elite-driven, appearing in two different network structure types. Among the core group of elite commenters, most are either climate change activists or sceptics, and the most prolific commenters among this core group are activists.

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1. Introduction

With more than four billion video views a day, YouTube is the third most visited website worldwide, has more than 72 hours of videos uploaded to it every minute, and outperforms traditional media by being both a vast source of information as well as a creator of visual memes (Pew Research Center, 2012; Smith & Joffe, 2012; Xie, Natsev, Kender, Hill, & Smith, 2011; Xu, Park, & Park, 2015). In this paper, we look at a sample of the most popular climate change-related videos—the commentary attached to these videos specifically—in order to understand how YouTube users affect the overall post-video discussion. These fora have been shown to impact one's interpretation of the original video content (Shi, Messaris, & Cappella, 2014; Walther, DeAndrea, Kim, & Anthony, 2010) and ultimately offer some sort of parallel to public discourse on the issue of climate change.[1]

Normatively—and given the increased participatory culture of the Internet (Jenkins, 2006)—when a public is engaged in open and rational discourse, deliberative and democratic potential are increased (Habermas, 1989). This is evidenced with regard to online deliberations in general (Farrell, 2012; Freelon, 2015) as well as with regard to science- and climate change-related deliberations more specifically (Brossard & Scheufele, 2013; O'Neill & Boykoff, 2011; Stilgoe, Lock, & Wilsdon, 2014). There are, of course, disagreements in online discussions of environmental issues (Holliman, 2011; Painter, 2011; Uldam & Askanius, 2013), some argumentative and quite vicious (Lange, 2007; Uldam & Askanius, 2013). Conceptualizing deliberation as the replies YouTube users make to each other in the post-video discussion,[2] our core assertion is that online deliberations among the public must be closely examined before automatically qualifying the Habermasian

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discourse argument. Online discussions can be dominated by only a few "elite" YouTube users and thus disadvantage other, more average, and less vocal users. Given the politicized nature of climate change, these elite-oriented distortions in the deliberative process imply that politically motivated YouTube commenters are directing the overall post-video discussion.

As more deliberation moves online, we should assess the extent to which it serves the purpose it is intended to service. One way to do this is to analyze the structure of the discussion network that endogenously arises in response to YouTube videos. Three separate analyses are employed here. First, we identify the network structure of the post-video discussion to determine whether the presence of elites varies across videos. Our results confirm greater elite dominance in half of the selected post-video discussions. Second, we examine co-commenters, that is, those that contribute to the discussions of multiple videos, but aggregate their effects at the level of the video. Our analysis confirms that co-commenters help establish two groups of videos based on their network structures, one more elite-oriented than the other. Third, we look at those individuals that contribute to every single discussion, that is, those that are highly motivated by the climate change issue and are thus prolific commenters. After coding for each individual's climate change orientation, we observe that activists are more central than sceptics. In sum, post-video YouTube discussion fora are not viable outlets for balanced deliberation about a topic such as climate change. At least half of the time, the discourse is driven by small groups of individuals running campaigns for or against climate change-related action. These campaigns offer limited deliberative opportunities for new discussants and ideas.

2. Theoretical framework

We invoke theories related to information acquisition problems, in line with Lupia and McCubbins (1998), as a basis for understanding how people become competent voters. We also invoke Habermas's claims that rational discourse and deliberation among members of the public increase democratic potential (1987, 1989). The ideal is open pathways for information acquisition and equitably distributed deliberation among a wide swath of the public; more elite-oriented deliberations create distortions that diminish information accuracy. After all, single messages online can significantly impact political behaviour (Coppock, Guess, & Ternovski, 2016; Teresi & Michelson, 2015), so when discussions are not provocative and thoughtful but centred around arguments to advance a particular view regarding climate change, these distortions are likely to be further compounded. Specifically, discussion leaders capitalize on events reported in the traditional media by concentrating the narrative online (Jung, No, & Kim, 2014; Lin, Keegan, Margolin, & Lazer, 2014), a pattern that is consistent with identified differences in the climate change-related semantics employed online relative to traditional journalism (Hellsten & Vasileiadou, 2015).

Underlying this is the assumption that comments posted in post-video discussions are read by anyone other than the commenters themselves. Some have claimed, for instance, that the replacement of older comments by newer comments at the top of the discussion fora precludes a thorough reading of the discussion (Thelwall, Sud, & Vis, 2012). Yet, there is evidence that comments are impactful based not on replies—our measure—but by users assigning a thumbs-up/down to each comment (Siersdorfer, Chelaru, Nejdl, & San Pedro, 2010; Siersdorfer, Chelaru, Pedro, Altingovde, & Nejdl, 2014). As well, Lange's (2007) ethnographic study highlights the effects of existing comment content on an individual's decision to contribute to the discussion. As this remains an open question in the extant literature, we are unable to determine conclusively whether it is a few dominating commenters that establish the post-video commenting content or whether non-commenters are also actively and extensively reading the comments. At the very least, few will choose to engage in deliberation at all; at the other extreme, deliberations may be relied upon by the government as a signal of public opinion (Gunitsky, 2015).[3]

Returning to the Habermasian claim about deliberation and democratic potential, the linear relationship between participation in online discussions and competent political behaviour has been overstated. Existing research identifies a positive relationship between online discussions and

voting (Mossberger, Tolbert, & McNeal, 2008), between social media and political participation (Boulianne, 2015; Feezell, 2016; Skoric, Zhu, Goh, & Pang, 2015) and between online-based deliberation and political behaviour (Gainous, Marlowe, & Wagner, 2013; Shah, 2016; Zhang, Johnson, Seltzer, & Bichard, 2010). More recently, however, a crucial distinction has been made: online discussions lead to less voting (Feezell, Conroy, & Guerrero, 2016).[4] These differences in political outcomes from different online activities are, we believe, attributable to two related phenomena. First, online content about particularly divisive issues—YouTube videos about climate change (McCright & Dunlap, 2011; Smeltz, Daalder, Friedhoff, & Kafura, 2015), for example—is not designed to increase dialogue (Collins, 2013). Second, online political communications typically produce feedback to reinforce one's political beliefs and expressions (Cho, Ahmed, Keum, Choi, & Lee, 2016). Thus, the identified positive effects of online political discussion on offline political and citizen participation may simply be a reflection of individuals' pursuit of homophilous online networks. Elite discussants tap into this dynamic and easily dominate the post-video discussion.

To some extent, we are testing for evidence of Collins and Nerlich's (2015) "reciprocity" in online communications as a means of determining whether a small group has secured a monopoly of communication. More contributors and contributions increase deliberation about the discussed issue (Cavanagh & Dennis, 2013; Collins & Nerlich, 2015), but what about those cases when there are fewer contributors and more contributions? We must thus focus on the structure of the discussion to identify the presence and function of elites by assessing the strength and nature of ties among the various commenters. Network analysis and the relational approach it employs is applied below. Just as it has helped explain many different phenomena, including how people in communities form social ties with others, and how these ties tend to be made with similar types of people (Christakis & Fowler, 2014), it can be used to determine the extent of reciprocity in communications among post-video commenters.

We invoke Siegel's (2009) typology of different network structures as the basis for making comparisons among post-video discussion networks. The two network structures identified by Siegel (2009) that are of most relevance here are the Opinion Leader and Hierarchy networks, the former representing a structure in which several YouTube commenters have many connections, the latter representing a structure where a core group is central to an expanding, multilevel network. Elites are present in both networks but function differently: Opinion Leader-based elites are essentially connected to the entire network, while Hierarchy-based elites are connected by degree, that is, by commenters that mediate communications (Siegel, 2009). The implication is that there are many more conversations occurring in Hierarchy networks while elites in the Opinion Leader network participate in fewer but more intense conversations, often only with other elites. Deliberation and deliberative characteristics are more likely to be present when elites' impacts are comparatively diffuse, that is, in Hierarchy networks relative to Opinion Leader networks. Otherwise, we argue, the post-video discussion forum becomes a bastion for climate change activists and sceptics.

We cannot ignore the content of the video itself when analyzing the network structure of post-video discussions, as there are connections between video characteristics and the tone of post-video discussion (Edgerly, Vraga, Dalrymple, Macafee, & Fung, 2013; Miller, 2015). Given that climate change is among the most divisive issues for the public (Hart, Feldman, Leiserowitz, & Maibach, 2015; McCright & Dunlap, 2011; Smeltz et al., 2015), we expect that a politicization frame within a video will increase the intensity of the discussion between climate change activists and sceptics. Participation in a network is a function of the cultural and political diversity of the network (Quintelier, Stolle, & Harell, 2012). As climate change is now strongly correlated to both cultural and political factors (in the US) (Bolsen, Leeper, & Shapiro, 2014), commenters in discussions following videos that include a politicization frame are expected to comment frequently and thus increase the density and reciprocity of the network, excluding average and less vocal YouTube users. In other words, Opinion Leader networks are expected to be correlated with videos employing a politicization frame.

Also acknowledged here is the interconnectedness of videos with a shared theme. YouTube employs an algorithm to help direct content to users based on previous searches on the YouTube website, and individuals are likely to view more than a single video on a particular topic. Thus, we explore the possibility that climate change-related videos are not isolated from each other but are in fact connected by the individuals who comment across multiple post-video discussion fora. We know that individuals who comment across multiple fora are more likely to generate lengthier discussions (Rowe & Keynes, 2011). What are the implications if such individuals are strong activists or sceptics? Are co-commenting individuals among the "elite" of the Opinion Leader networks? The implications are significant, as cross-commenting individuals from Opinion Leader networks will likely foster an environment which limits greater public participation (Siegel, 2009).

3. Methods

To recapitulate, our goals are to identify the network structure of the post-video discussion to determine the presence of elite commenters. We shall also determine whether commenters present in multiple post-video discussions help maintain the network structures through their co-commenting efforts. A sample of the 10 most popular (most viewed) videos was drawn from the population of online YouTube videos in early December 2011 through a keyword search for "global warming" videos on the YouTube website. We opted to search using "global warming" rather than "climate change" (or both sets of terms simultaneously) as it was expected to yield more controversial responses from commenters (Schuldt, Konrath, & Schwarz, 2011; Whitmarsh, 2009). Details about these 10 videos are provided in Table 1.[5]

There are no systematic differences among these videos in terms of style and description. There is, however, variance in terms of the number of video views and, more importantly, the number of comments. While both are important for information acquisition and deliberative potential, the number of comments raises concerns about representativeness. YouTube's API download restrictions limit access to only the most recent 1000 comments from each video. Thus, our sample represents a total of 10,000 comments downloaded through YouTube's API on 5 December 2011.[6] There are, thus, different proportions of the total number of comments for each; for example, the 1000 most recent comments for "National Geographic" represent 1.3% of its total comments, while the 1000 most recent comments for "Will Farrell" represent 60.5% of its total comments. However, and in line with previous studies showing that concerns about the generalizability of this line of inquiry are overstated (Khan & Vong, 2014; Thelwall et al., 2012), we believe that this is not a fatal flaw of our methodology. Readers of these comments and new participants to the discussion are uniformly limited by YouTube's restrictions from reading and replying to more than 1000 comments earlier. If individuals are uniformly prone to reading/replying to posts that are nearest to the top of the list of comments,[7] YouTube users' accessibility to the available discussion is not a function of the artefact attributed to procedural issues like API restrictions but rather the characteristics of the existing post-video discussion.

Turning to the content of the video itself, we draw upon Nisbet's (2009) approach to climate change communication and ultimately classify these 10 videos into the following narratives: videos calling for action by presenting global warming as a moral challenge and/or a solvable challenge, videos calling for action to address deficiencies in the science and/or politics of global warming, possibly because of perceived elitism, and videos with an unsystematic narrative presence (Shapiro & Park, 2015).[8] Among the 10 videos, those that call "for action to address deficiencies in the science and/or politics of global warming" are "Suing Al Gore," "Global warming scam!" "Chart," and "Lord Monckton." These findings will be revisited when we present the results of the subsequent network analysis.

The networks that we are expecting to identify in the post-video network of commenters are either Siegel's (2009) Opinion Leader network or the Hierarchy network. As we stated earlier, Opinion Leader networks are indicated by most people having few connections while a central

Table 1. Video descriptions.

Title	Chart	Lord Monckton	Human art	National Geographic	Will Farrell	Polar bear animation	Blue Man Group	Global warming scam!	Suing Al Gore	Kiribati
Brief description	A risk analysis shows a need for action.	Copenhagen and other international laws intend to trump domestic laws.	Hundreds of nude people pose on the glacier as "human art" and to attract attention to the issue.	Provides an overview of anthropogenic global warming.	Spoofs President Bush and the issue of global warming.	Polar bears talk about possible causes of climate change.	The Blue Man Group expresses its concerns about global warming.	A monologue criticizes Al Gore and weak science.	The Weather Channel founder announces his intentions to sue Al Gore for fraud.	Provides an overview of rising sea levels and interviews with Kiribati residents
Style	Lecture	Lecture	Documentary	Documentary	Comedy	Animated PSA	Performance art	Lecture	Interview	Documentary
Year posted	2007	2009	2007	2007	2007	2007	2006	2007	2008	2009
Number of views	5 million	2.6 million	1.7 million	1.5 million	1.2 million	1.1 million	826,000	800,000	705,000	679,000
Number of comments	30,000	9700	7500	78,000	1600	4200	8800	54,000	53,000	2200

Source: Shapiro and Park (2015).

group of YouTube users has many. Hierarchy networks are distinct from Opinion Leader networks in that, while there is a central group of individuals with connections to each other, the frequency with which members of this more central group connect to others in the centre is on par with the frequency with which they connect with those outside of the central group. The distribution of connections is more balanced because those that are connected with more central individuals each connect with several individuals who each then connect with several others who, in turn, each connect with several others. This process continues to the point that growth in the network from centrally positioned commenters is exponential, like smaller and smaller branches of a tree that originally branched off of a (relatively thin) trunk. For the purposes of the present study, the nature of the connections among individuals in post-video discussion fora is directional, meaning that it is based on whether one person replies to another person's post.

The network structures of commenting YouTube users will be assessed quantitatively as well as visually. A core indicator is "centrality," a measure of how close and with what intensity individuals are connected to others in a social network. Connectedness has emerged as a popular measure of centrality in political networks because of its sensitivity to both the strength and direction of relationships (Desmarais, Kowal, Moscardelli, & Schaffner, 2012; Fowler, 2006). In the case of post-video discussions, individuals who are well connected and thus more central are assumed to have the ability to influence more people than those who are less connected. Granted, this influence could also be a function of whether a specific comment attracts more attention because of the content itself, for example, whether it is a controversial point. This requires extensive content analysis beyond the breadth of this research, and we reserve these topics for future study.

The specific reply-to network-level measures that we analyze in the following analysis are fourfold. First, we calculate both in-degree and out-degree centralization measures. Out-degree centrality represents a directed tie from one point, P_i, to any other point, while in-degree centrality represents a directed tie from any other point to P_i. In the case of post-video YouTube discussions, in-degree and out-degree centrality scores represent, respectively, the replies in the network that one receives makes. The measures that we employ, out-degree centralization and in-degree centralization, represent the ratio of out-degree connections and in-degree connections to, respectively, the maximum number of available out-degree and-in-degree connections. Second, we examine transitivity. This is present when, for three points, P_i, P_j, and P_k, a reply-to tie connects P_i to P_j, while P_j is also connected to P_k, which is finally connected back to P_i. Our calculation of transitivity represents the ratio of transitive triples to the number of triples that have the potential to be transitive (Hanneman, 2005).

Our third and fourth measures address reciprocity. "Reciprocity," the first of the two, represents ties that are present when, for a pair of points, a tie is connected from one point, P_i, to another, P_j, while there is a similar directional tie back from P_i to P_j. For our purposes, we have counted the number of dyads connected by a tie (that may or may not be reciprocated) and calculated the proportion of dyads that have reciprocated ties (Hanneman, 2005). Finally, we calculate an inverted assessment of reciprocity: the graph hierarchy measurement of Krackhardt's graph theoretic dimension of organizations. The graph hierarchy measurement represents the extent in the post-video discussion fora that,

> for each pair of points where one, P_i, can reach another, P_j, P_j cannot reach P_i. For example, in a formal organizational chart, a high-level employee can 'reach' through the chain of command her subordinate's subordinate. If the formal organization is working properly, this lower level employee cannot simultaneously 'reach' the higher level employee. (Krackhardt, 1994, p. 97)

Taken together, lower reciprocity scores and higher hierarchy scores indicate the extent to which paths in the network are not reciprocated, both attributes of Hierarchy networks.

In light of seminal research on network strength and dynamics (Granovetter, 1973; Huckfeldt, Beck, Dalton, & Levine, 1995), our comparison of these 10 videos' networks also accounts for differences in the overall density of the network of replies. When there are fewer but much more frequently commenting individuals in the post-video fora, the density of the reply-to network

increases. This is but one characteristic that we attribute to the Opinion Leader network. The opposite is the case for Hierarchy networks, where there are relatively more commenters, but the frequency with which they reply to each other is less. The implication is that Hierarchy networks are less dense than Opinion Leader networks. Together, density and centrality provide an image of strongly or weakly connected commenters and, thus, a post-video discussion that is tightly or more loosely controlled.

4. Results

Our analysis is based principally on the statistics presented in Tables 2 and 3. The network-level statistics presented in Table 2, ordered by network density, reveal considerable variance across post-video discussion networks for the 10 selected videos. We divide these 10 videos into 2 groups based on differences in network density, centrality, transitivity, and reciprocity. We conclude that the first five videos listed have attributes of Opinion Leader networks in that, relative to the second five videos listed, the network density is greater, out-degree and in-degree centralization is greater, transitivity is greater, and reciprocity and hierarchy are, respectively, greater and less. The apparent diffusion of the post-video discussion for the second five videos, indicated by relatively lower network densities, centralization, transitivity, and reciprocity more closely resembles Siegel's (2009) Hierarchy network structure.

We also present network graphs of "Global warming scam!" and "Kiribati," presented in Figures 1 and 2, respectively, to visually display the differences between Opinion Leader and Hierarchy networks.[9] We acknowledge that Figures 1 and 2 are not perfectly readable, but they serve the purpose

Table 2. Network-level statistics from network analysis.

	Density	Out-degree	In-degree	Transitivity	Reciprocity	Hierarchy
"Suing Al Gore"	0.178	0.496	0.586	0.394	0.666	0.445
"Global warming scam"	0.099	0.764	0.430	0.277	0.592	0.500
"National Geographic"	0.078	0.766	0.538	0.243	0.562	0.573
"Blue Man Group"	0.053	0.477	0.439	0.146	0.702	0.545
"Chart"	0.024	0.413	0.259	0.106	0.631	0.742
"Human art"	0.006	0.066	0.070	0.010	0.640	0.829
"Lord Monckton"	0.005	0.084	0.081	0.052	0.380	0.739
"Will Farrell"	0.005	0.129	0.135	0.062	0.385	0.764
"Kiribati"	0.005	0.087	0.106	0.032	0.287	0.769
"Polar bear animation"	0.004	0.043	0.059	0.031	0.291	0.839

Table 3. Descriptive statistics from network analysis.

	Number of commenters	Average number of replies	Number of clusters	Politicization frame[a]	Duration of commenting (months)	Percentage of total comments
"Suing Al Gore"	23	8.174	10	Yes	0.5	1.9
"Global warming scam"	37	7.297	12	Yes	2	1.8
"National Geographic"	44	6.864	12	No	18	1.3
"Blue Man Group"	51	5.451	10	No	9	11.3
"Chart"	72	3.417	8	Yes	1	3.3
"Human art"	203	2.512	9	No	38	13.2
"Lord Monckton"	230	2.400	8	Yes	10	10.3
"Will Farrell"	243	2.436	10	No	16	60.5
"Kiribati"	209	2.010	9	No	9	44.0
"Polar bear animation"	255	2.094	7	No	49	23.5

[a]Based on Shapiro and Park (2015).

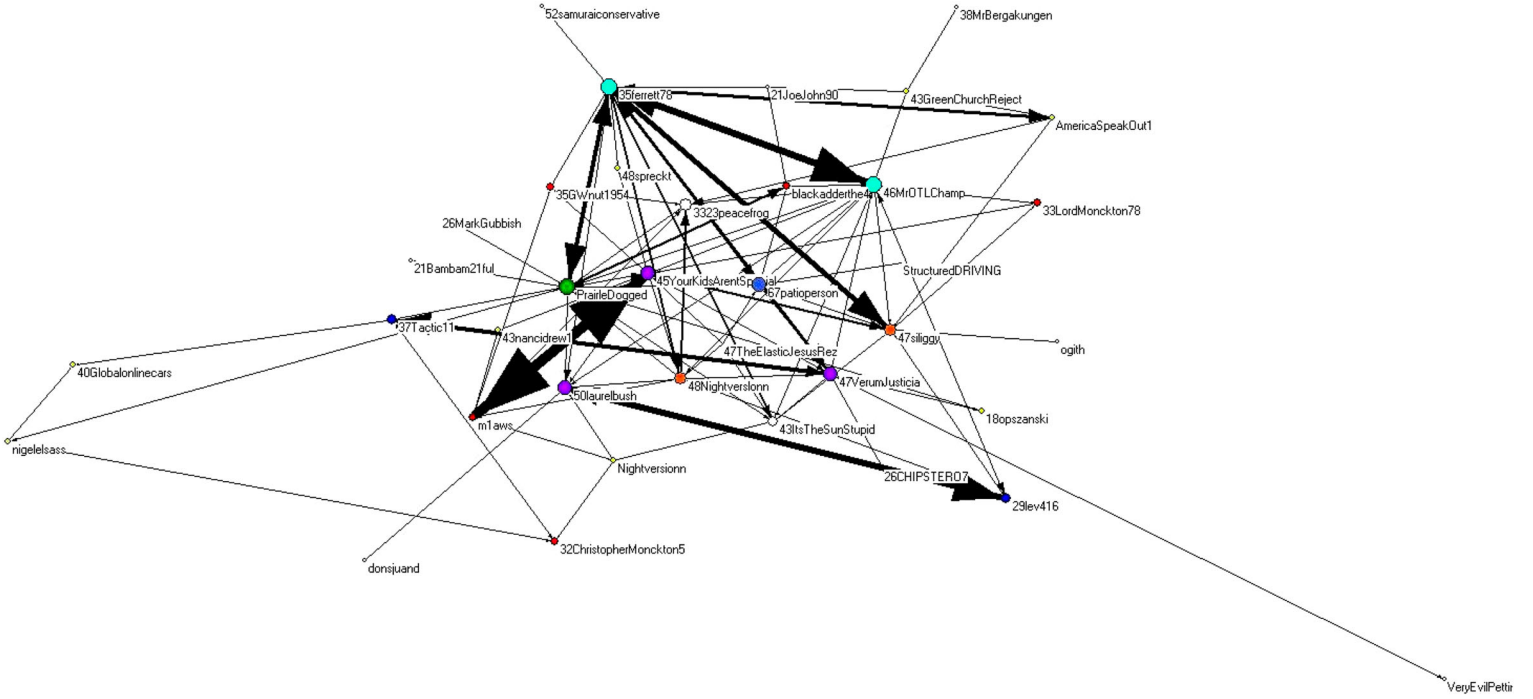

Figure 1. Opinion Leader network example: Replies-to network of commenters for "Global warming scam!"

Note: The figure was drawn using Pajek. Links between users indicate replies, where thickness of lines corresponds to frequency of YouTube users replying to each other. Arrows represent the nature of the relationship; they are pointed at those receiving the reply. Node colors represent partition assignments.

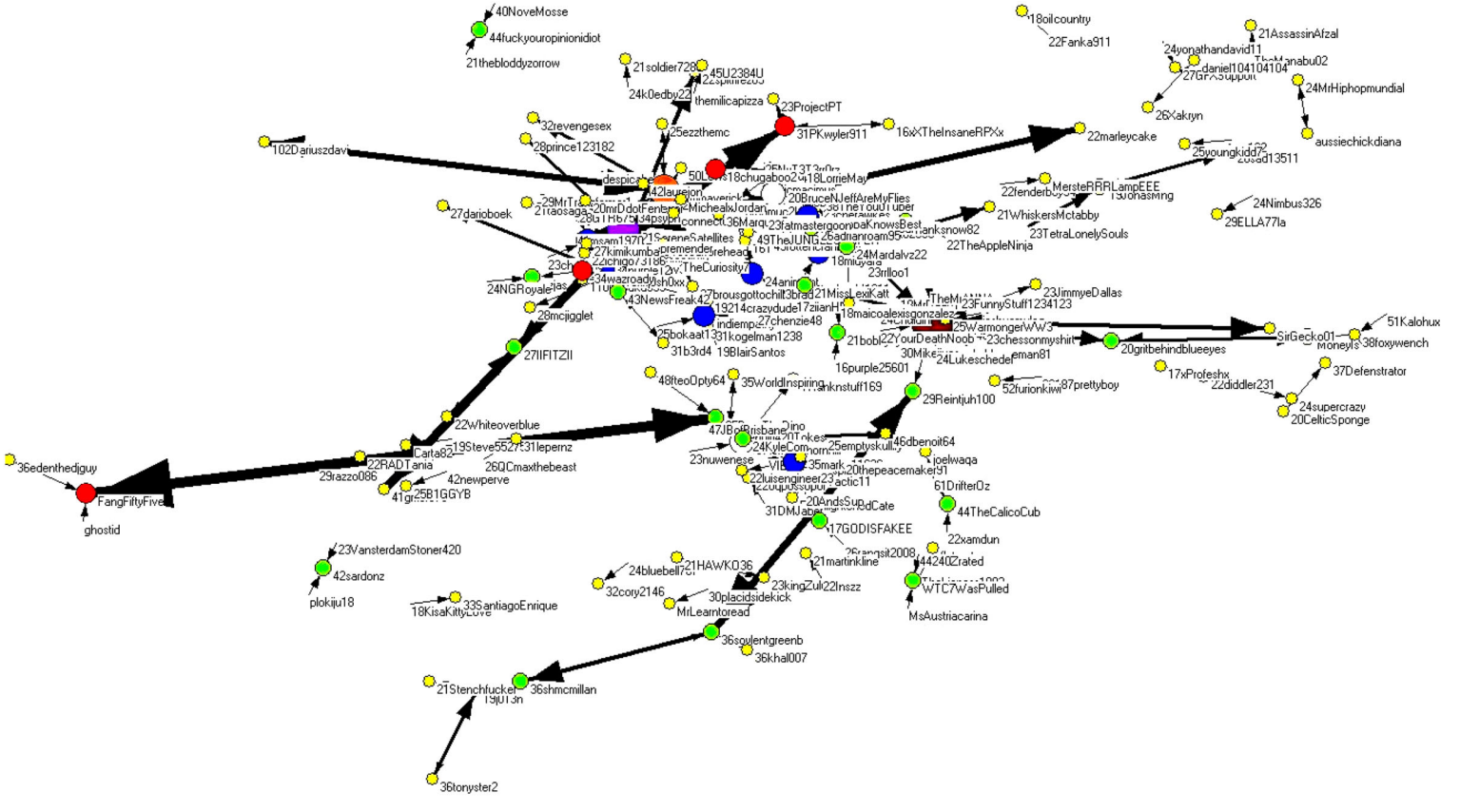

Figure 2. Hierarchical network example: Replies-to network of commenters for "Kiribati."

Note: The figure was drawn using Pajek. Links between users indicate replies, where thickness of lines corresponds to frequency of YouTube users replying to each other. Arrows represent the nature of the relationship; they are pointed at those receiving the reply. Node colors represent partition assignments.

of providing references for centrality, transitivity, reciprocity, and density for the two types of networks. The size of nodes in Figures 1 and 2 was drawn to be proportional to its vector value (the actual number of lines divided by the possible number of lines), and the colour of the node was based on its shared partitions. Partitions, or groupings, were determined based on patterns of their (in)direct linkages with others within the network. The Kamada-Kawai Spring-Energy algorithm was used. The most central nodes were fixed at the centre of the network, and others were iteratively positioned. "Global warming scam!" represents a typical Opinion Leader network with a density of 0.099, out-degree centralization of 0.764, in-degree centralization of 0.430, transitivity of 0.277, reciprocity of 0.592, and hierarchy of 0.500. This was based on only 37 commenters, with each commenter replying an average of 7.297 times. Contrast this with "Kiribati," a representative Hierarchy network, having a density of only 0.005, out-degree centralization of 0.087, in-degree centralization of 0.106, transitivity of 0.032, reciprocity of 0.287, and hierarchy of 0.769. Two hundred and nine commenters replied an average of 2.010 times.

The contents of Table 3 reveal more clearly the associations between network type and the duration of the most recent 1000 comments as well as between network type and the percentage of total comments represented by the most recent 1000 comments. There tends to be greater density, centralization, transitivity, and reciprocity—and thus a tendency for a post-video discussion to take the form of an Opinion Leader network—when the conversation itself is current rather than protracted. We believe that the recent and dense conversations present in Opinion Leader networks are a function of devoted YouTube users that regularly check and update their communications. On this basis, the Opinion Leader networks we present are less representative of all commenters than Hierarchy networks. The network of replies for "Kiribati," presented in Figure 2, represents 44% of all comments made in response to the video; however, the network of replies for "Global warming scam!" represents only 1.8% of all possible comments. Within the constraints of YouTube's API download restrictions, users that help create the Opinion Leader networks are both active and timely repliers. It is perhaps an analog of the more recent trend by parts of the social media-using public to post/repost, Tweet/re-Tweet, etc. incessantly (Perrin, 2015).

The data in Table 3 also reveal little association between the presence of a politicization frame and each video's network type. The implication is that commenters in post-video discussions respond not to the content of the video itself but rather to other commenters' statements. The network dynamic is thus not associated with the politicization frame of the video but rather the possibility that elite discussants have recently made comments. While this is not typical for post-video discussions in general (Edgerly et al., 2013; Miller, 2015), the evolution of the discussion network beyond a focus on the video's content is consistent with research analysing discussions following climate change-related YouTube videos (Shapiro & Park, 2015).

Based on a maximum of 10,000 comments (1000 from each of the 10 videos in line with YouTube's API download restrictions), we also find that there are connections across videos that have the same network structure. Indeed, the pattern of commenting by individuals contributing to the discussions of multiple videos creates a natural delineation between Opinion Leader and Hierarchy networks, in line with the network-level statistics presented in Table 2. Aggregated at the level of the video and drawn using the Fruchterman Reingold Algorithm embedded in Webometric Analyst (http://lexiurl.wlv.ac.uk/), the co-commenter network presented in Figure 3 may be divided into hemispheres. Opinion Leader networks are presented on the right-hand side and include "Chart," "National Geographic," "Blue Man Group," "Global warming scam!" and "Suing Al Gore." The Hierarchy networks are grouped on the left-hand side of the figure. With the exception of "Kiribati," the overall network of co-commenters (aggregated at the level of the video) is relatively dense and connected. Ultimately, the left-right hemispheres of Figure 3 identify qualitatively different co-commenters for Opinion Leader and Hierarchy networks. Equally important, and given that individuals commenting across multiple fora generate lengthier discussions (Rowe & Keynes, 2011), co-commenters are quite likely propagating the division of networks by opting to reply in certain fora but not others.

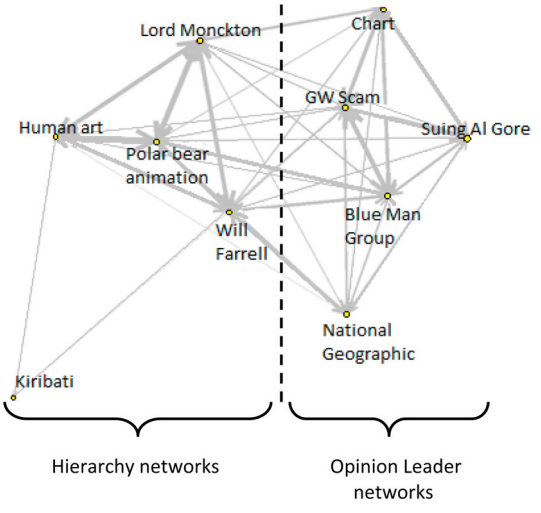

Figure 3. Co-commenter network for all ten videos.

Note: The figure was drawn using NodeXL. Links between videos indicate co-commenting, where thickness of line corresponds to frequency of YouTube users commenting on more than one video. Arrows represent the nature of the relationship.

We disaggregate from the level of the video to that of the individual in order to still better understand the nature of commenters themselves, particularly the most prolific commenters, that is, those that have connections to each of the 10 videos under analysis here. Based on this conservative criterion, a total of 46 individuals qualify. The network figure presented in Figure 4 is based on the Fruchterman Reingold Algorithm in NodeXL (Smith, 2015). Node/YouTube user ID colour is based on centrality using the Kamada-Kawai Spring-Energy algorithm, where the higher (lower) the degree centrality, the greener (redder) the node. The most central nodes are fixed at the middle of the network, and other nodes are iteratively positioned. Node shape is based on whether a commenter is an activist (triangle), a sceptic (square), or not clearly identifiable (circle).[10] Based on an analysis of the network of these 46 users, climate change activists such as *Nightversionn*, *nonsnmckfyb2*, *blackadderthe4*, and *Herecomesthefatlady* are more likely to occupy the central area of Figure 4. Commenters who are sceptical of climate change are also central to the network, such as *JonThm*, but the majority of the most central commenters are activists. That is, six of the seven most central commenters are activists, while 2 of the 10 most central commenters are sceptics. Overall, climate change activists are the most central users and thus the most likely to be engaged in a discussion across these 10 videos.

The outlined commenters in Figure 4 represent the five most central commenters for at least one of the 10 videos' reply-to network. While several of the outlined commenters in Figure 4 are key commenters in only one of the 10 videos (*stopglobalwarming08*, *JonThm*, and *mphello* for "Will Farrell"), three of the other outlined commenters are essential for videos with Opinion Leader networks. *PrairleDogged*, a climate change sceptic, is among the five most central commenters for "Blue Man Group," Global warming scam!" and "Suing Al Gore"; *Nightversionn*, a climate change activist, is among the five most central commenters for "Chart," "National Geographic," and "Blue Man Group"; and *YourKidsArentSpecial*, a climate change activist, is among the five most central commenters for "National Geographic," "Global warming scam!" and "Suing Al Gore." In other words, among those YouTube users that are connected across all 10 videos, these three individuals are responsible for driving the commentary for at least half of the most popular videos concerning climate change.

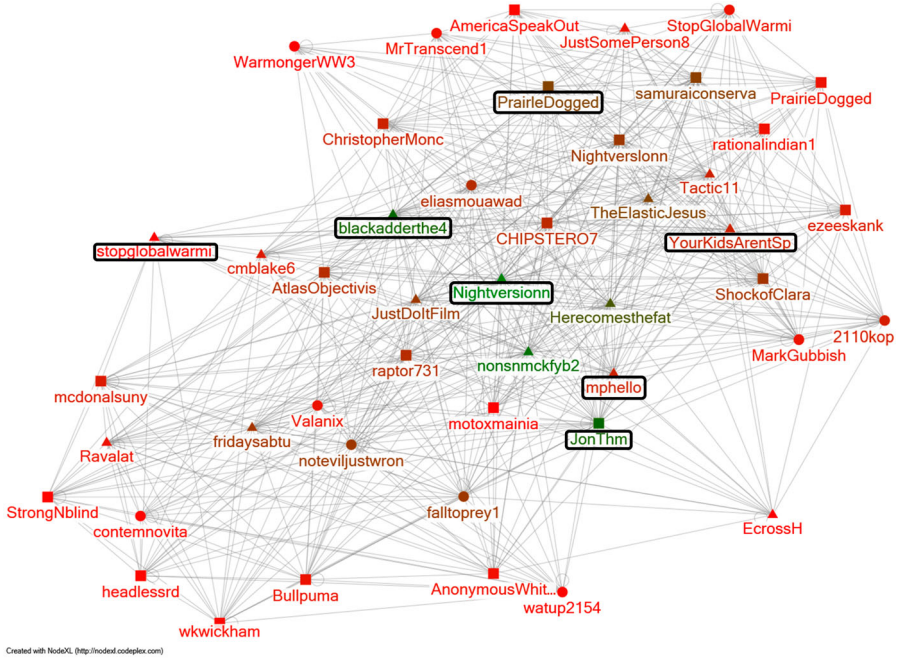

Figure 4. Network structure for commenters of all ten videos.

Note: The figure was drawn using NodeXL and identifies activists (triangles), skeptics (squares), and undetermined individuals (circles). Outlined commenter names represent top commenters for one or more videos. Node color corresponds with degree centrality, where greener (redder) nodes represent higher (lower) centrality. For clarity, arrows have been omitted.

5. Conclusion

This research addresses problems related to information acquisition and unbalanced deliberation by members of the public, framed here by the ongoing discussion surrounding climate change. Our comparison of descriptive and network-level statistics from the post-video discussion fora of the 10 most popular climate change-related YouTube videos reveals three important findings. First, elites are present in varying degrees in all post-video discussions, but variance in network centrality, transitivity, and reciprocity measurements helps promulgate two of Siegel's (2009) network structures. That is, half of the post-video discussions qualifies as Opinion Leader reply-to networks; the other half qualifies as Hierarchical networks. Second, based on the pattern of individuals that co-comment across multiple post-video discussions, there are stronger connections within each network structure than between them, further reinforcing the division of networks into two types. Finally, for half of our sample of YouTube videos, post-video discussions were driven by small groups of individuals, many of whom were running campaigns for or against climate change-related action. As the scope of viable deliberation has harrowed, YouTube users are undoubtedly impacted by post-video discussions dominated by this handful of frequent and commanding commenters. Further, there is a tendency for the most central commenters across all 10 videos to be climate change activists.

All of this invites two important points for consideration. In line with Habermas (1987, 1989), what are the implications of less-than-balanced climate change deliberations? And, how are these discussions contributing to the information acquisition problems outlined in Lupia and McCubbins (1998)? If we are to look at the effects of social media upon environmentalism, such as those modelled in Ballew, Omoto, and Winter (2015), we would be inclined to believe that environmental activism is a positive function of social media. Yet, online content about particularly divisive issues does little to increase dialogue (Collins, 2013); it may in fact only reinforce one's political beliefs (Cho

et al., 2016). Thus, the evidence provided above indicates that both climate change activists and sceptics in the post-video discussions are tapping into a reservoir of pre-existing beliefs. As more and more users are added to YouTube each year (Brubaker, Horning, & Toula, 2015; Perrin, 2015; Pew Research Center, 2012), we can expect that casual readers and participants of post-video discussions will continue to increase and, thus, more people will be exposed primarily to discussions that are intended to promulgate activist discourse but especially sceptic discourse. This is the case for those reading and replying to comments posted in Opinion Leader networks.

We acknowledge that we have not identified the precise effects of prolific commenters on readers of post-video discussions. The dissemination of information in post-video discussions by prolific commenters is generally consistent with research on the context of political news. Online comments are dichotomized between elites (as news sources and news catalysts) and nonelites (news participants and distributors) (Dylko, Beam, Landreville, & Greidner, 2012; Heo & Park, 2014; Himelboim, Gleave, & Smith, 2009; Park, Lim, & Park, 2015). Readers of post-video comments from Opinion Leader networks will be more likely to observe established discussions by commenters and will thus have a smaller pool of comments from which to draw information. We emphasize the importance of research which examines the framing effects of YouTube videos and discussions just as rigorously as they are examined in the traditional media.

Ultimately, we have established that network structures of post-video discussions are driven by co-commenters. Our analysis of YouTube users contributing to the discussion fora of all 10 videos shows that the majority of the most central co-commenters are climate change activists. We conclude that post-video discussions tend to be moderated and influenced by users who believe climate change to be a real and urgent issue. Across both types of networks, we can conclude that the activists are relatively more productive and determined than the sceptics. Yet, all of this continues to verify that post-video YouTube discussion networks—neither Opinion Leader nor Hierarchy—fora are not viable outlets for balanced deliberation even for crucial topics such as climate change. At least half of the time, the discourse is driven by small groups of individuals running campaigns for or against climate change-related action. We are loath to attract further attention to this subset of the YouTube user community, as their qualifications as leaders in public discourse are based thus far on repeated and dedicated commenting across multiple post-video discussion fora. Yet, there remain unidentified communication strategies, and thus future study must attend to the specific content of the most influential post-video commenters. Or perhaps it is less content-specific and more related to the popularity of those post-video discussions specifically. Whatever the case, these are the individuals that will continue to be the most important among Opinion Leader networks and, to a much lesser degree, among Hierarchical networks. For the foreseeable future, these individuals will define the nature of post-video online deliberation.

Notes

1. We acknowledge that the user base/audience for YouTube is younger than the general public (Burgess & Green, 2009): "82% of 18- to 29-year olds used YouTube in 2014, compared with 34% of those 65 and older" (Pew Research Center, 2015). It is, however, increasingly used by larger swaths of the public (Pew Research Center, 2012).
2. We do not consider comments that fail to generate a response.
3. These signals are, of course, not representative of the general public given differences between the Internet-connected and the non-connected public (Perrin & Duggan, 2015), but there has been a groundswell in viewership and commenting, particularly for YouTube-based political discussions among the youth (Brubaker et al., 2015).
4. Consumption of "civic information" online, however, does lead to more voting (Feezell et al., 2016).
5. Web addresses for each of these 10 videos can be found in the Appendix. It should be noted that YouTube-based information is public for public accounts and thus no formal approval is required from YouTube users (Thelwall, 2009).
6. See Sams, Lim, and Park (2011) and Thelwall (2012), respectively, for further insight into API-based social science e-research and YouTube techniques.

7. It should be noted that the convention for listing post-video comments in reverse chronological order ended in 2013, after the collection of our data.
8. Details about the coding process, as stated in Shapiro and Park (2015) are as follows:

> A total of 10 relevant narratives were identified [from Nisbet (2009)]: climate change/global warming … is economically costly, is a shared moral challenge for everyone, is a solvable challenge, has unavoidable consequences (i.e. fatalism), is a matter for scientists and experts, is still debated by scientists, has been blown out of proportion by scientists, has been blown out of proportion by politicians, reveals problems with science and expertise in policymaking, and is a game among elite. To limit bias and establish a reliable assessment of each video's narrative(s), we employed 17 undergraduate students at a university in Chicago to assign narratives to each of these videos. [W]e assigned an affirmative code if at least 70 percent or more respondents selected the respective narrative category.

9. Network figures for the remaining eight videos are available upon request to the corresponding author.
10. "Skepticism" and "activism" codes were confirmed through intercoder reliability checks of random samples of comments ($n = 50$) by each of the 46 highlighted commenters. This coding exercise involved both authors being simultaneously present. No intercoder reliability statistics are provided because there was complete agreement.

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Appendix: Web addresses of selected YouTube videos

1. "Chart": http://www.youtube.com/watch?v=zORv8wwiadQ
2. "Lord Monckton": http://www.youtube.com/watch?v=PMe5dOgbu40
3. "Human art": http://www.youtube.com/watch?v=0RVp8Q6H9e0
4. "National Geographic": http://www.youtube.com/watch?v=oJAbATJCugs

5. “Will Farrell”: http://www.youtube.com/watch?v=jOjfxEejS2Y
6. “Polar bear animation”: http://www.youtube.com/watch?v=EDIP71Lviys
7. “Blue Man Group”: http://www.youtube.com/watch?v=snPdEl0Duoo
8. “Global warming scam!”: http://www.youtube.com/watch?v=oRSOkHU2ZcQ
9. “Suing Al Gore”: http://www.youtube.com/watch?v=FfHW7KR33IQ
10. “Kiribati”: http://www.youtube.com/watch?v=cIG7vt1ZPKE