Walter, Stefanie; Brüggemann, Michael (2018): Opportunity makes opinion leaders. Analyzing the role of first-hand information in opinion leadership in social media networks. In *Information, Communication & Society*, pp. 1–21. Available online at https://doi.org/10.1080/1369118X.2018.1500622.

[Final accepted manuscript]

Opportunity makes opinion leaders: Analyzing the role of first-hand information in opinion leadership in social media networks

Stefanie Walter[1]
Institute for Journalism and Communication Science,
University of Hamburg, Germany

Michael Brüggemann
Institute for Journalism and Communication Science,
University of Hamburg, Germany

Abstract:

Theorizing information flows is at the heart of traditional communication theories such as the two-step flow of communication and the concept of opinion leadership. Social media have fundamentally altered how information reaches people. This study examines opinion leadership in social media networks and argues that opinion leaders may no longer need to rely on information provided by the media if they have access to first-hand information. To test this assumption empirically, we used data from the 2015 United Nations Climate Change Conference (COP21). Attendees of the conference had direct information about what was happening, which they were able to share live with their followers via social media. We used geo-located tweets to identify Twitter users who attended the COP21 summit. We then located these users in a data set of tweets that were collected based on the main conference hashtag (#COP21) and represent the wider social media debate on the conference. Our results, which are based on network analysis measures and Twitter user data, show that COP21 participants were more central actors compared to the average user in the network, and that they were more likely to have brokering positions. They were also more involved in the debate and received more attention from other users. We used automated content analysis to divide COP21 participants into different actor types and performed the analysis by actor group. The results show only minor differences across the actors and support the robustness of our analysis.

Introduction

[1] **Corresponding author:**
Stefanie Walter
University of Hamburg, Allende-Platz1, 20146 Hamburg, Germany
Email: Stefanie.Walter@uni-hamburg.de

Walter, Stefanie; Brüggemann, Michael (2018): Opportunity makes opinion leaders. Analyzing the role of first-hand information in opinion leadership in social media networks. In *Information, Communication & Society*, pp. 1–21. Available online at https://doi.org/10.1080/1369118X.2018.1500622.

Social media have not only influenced the way we communicate; they have also challenged – or at least required rethinking – traditional communication theories. This article makes a theoretical and empirical contribution to our understanding of the concept of opinion leadership and the two-step flow of communication in the social media age. In short, the two-step flow of communication assumes that the mass media indirectly influence individuals by first reaching opinion leaders, who then spread the information through their social networks (Lazarsfeld, Berelson, & Gaudet, 1948). Some previous studies have suggested that the emergence of social media has only had a limited effect on the two-step flow of communication, as those performing the role opinion leaders in the social media environment continue to be a rather small group that is better informed through (and redistributes information by) traditional news outlets (Wu, Hofman, Mason, & Watts, 2011). Yet others claim that social media have reduced the influence of opinion leaders, as media outlets are now able to target their audience more directly rather than having to rely on opinion leaders (Bennett & Manheim, 2006). This study argues that there is a third option: Under certain circumstances, people might be able to become opinion leaders on social media without having previously been exposed to news media content. They must have access to first-hand information that they can share within their networks and which gives them a structural advantage to become opinion leaders in the debate. This study therefore asks: *Is there a relationship between access to first-hand information and opinion leadership in social media networks?*

The concept of opinion leadership has evolved over time, has been treated in diverse ways both theoretically and methodologically (see Weimann, 2016), and is a concept that is difficult to operationalize (Noelle-Neumann, 1999). Few studies have been able to measure opinion leaders' actual influence in shaping the opinions of others. Instead, studies have often relied on survey measures that assess self-perceived levels of personal influence and certain personality traits (e.g., Lazarsfeld, Berelson, & Gaudet, 1948; Schäfer & Taddicken, 2015;

Song, Cho, & Kim, 2017; Weimann, Tustin, van Vuuren, & Joubert, 2007). Lazarsfeld et al.'s (1948) traditional theory of opinion leadership, however, focused on "how information and ideas are disseminated through both mass media and networks of interpersonal communication" (Weimann et al., 2007, p. 175). The dissemination of information remains an important criterion in more recent definitions (e.g., Burt, 1999). Following these approaches, this study focuses on the flow of information as an indicator of opinion leadership. By providing information to their "followers", opinion leaders exercise influence (Weimann et al., 2007, p. 174).

Opinion leadership is related to a specific area of expertise (Shoham & Ruvio, 2008), which can range from political affairs to finance, to everyday matters such as fashion, to scientific issues (Schäfer & Taddicken, 2015). We focus on climate change, particularly the 2015 United Nations Climate Change Conference (COP21). The Paris Agreement – the outcome of the summit – was signed by 174 states and aims to reduce climate change by holding the increase in the global average temperature below 2°C. Conference attendees had direct information about what was happening at the summit, and conference venue in particular, which they were able to share live with their followers via social media. We used geo-located tweets to identify Twitter users who attended the summit and located them in a data set consisting of tweets collected based on the main conference hashtag (#COP21), which represents the wider social media debate on the conference. Our results suggest that access to the conference venue and to direct information played a crucial role in becoming an opinion leader on social media.

1. Opinion leadership in the social media age

This study argues that social media, under certain circumstances, give users the opportunity to become opinion leaders in the wider online debate. The idea of the "two-step flow of communication" (Katz, 1957; Lazarsfeld, Berelson, & Gaudet, 1948) provides a good starting point for such a consideration. As discussed above, according to this notion the mass media

first reach "opinion leaders," who then spread information to their followers (Lazarsfeld et al., 1948) by circulating and reinforcing the media's messages (Katz & Lazarsfeld, 1966, p. 82), thus fulfilling a central role in social networks. Follow-up studies have found that this is a multistep process (Katz & Lazarsfeld, 1955) in which followers spread information from opinion leaders though their own networks.

Previous research suggests that opinion leaders do not necessarily hold positions of power and/or prestige, but their area of expertise (Katz, 1957, p. 73) allows them to provide their followers with information and advice (Weimann, 2016, p. 909). Others argue that an opinion leader's position in a social network is more important than their personal characteristics (Burt, 1999; Roch, 2005). They are bridging structural holes and thereby occupy distinct positions, which provide them with a structural advantage over others in controlling the spread of information. From this perspective, opinion leaders are not the frontrunners or centers of particular social groups; instead, they are "opinion brokers" (Burt, 1999) who operate at the edge of networks to convey information *across* different groups. Recent definitions of opinion leadership particularly stress the importance of the *diffusion* of information (Kavanaugh et al., 2007; Weimann, 1994).

The internet, and new media in particular, have significantly altered communication processes and impacted traditional communication theories, such as the two-step flow of communication. As the number of news outlets and other information sources has grown, some have argued that opinion leadership has become even more important by helping people orientate themselves (van der Merwe & van Heerden, 2009). But the internet has also affected how opinion leaders reach out to their followers: "Since the new media combine mass and personal channels, direct and indirect formats, and formal and intimate communication, the new opinion leaders no longer rely on personal acquaintance, direct communication, and intimate contact" (Weimann, 2016, p. 915). Instead, they can use a number of different means to make

their voices heard. Social media, and Twitter in particular, play an important role in disseminating information and interacting with others. Another important change has affected the way that information reaches opinion leaders in the first place. Opinion leaders no longer have to rely exclusively on the mass media, but can use other sources to obtain information (Weimann, 2016). Studies show that opinion leaders on Twitter do not depend more on traditional or online media content than other users (Park, 2013).

Yet, extant research suggests that new media have only a limited impact on the two-step flow of communication. Wu et al. (2011), for example, showed that information provided via the mass media also plays an important role on Twitter; they concluded that their results were broadly consistent with the original idea of the two-step flow, as about half of the information that comes from the media is diffused via opinion leaders and hence reaches people indirectly (for a similar argument see also Cha, Benevenuto, Haddadi, & Gummadi, 2012). Others argue that communication practices have changed so significantly that we are now observing a one-step flow of communication as media outlets are able to use modern communication technologies to target their audience directly, rather than having to rely on opinion leaders to spread information (Bennett & Manheim, 2006). Hence, the importance of opinion leaders seems to be decreasing.

Previous studies have largely overlooked a potential third option, in which opinion leaders no longer need to rely on information provided by the media, but directly distribute information themselves. This would require opinion leaders to possess first-hand information, and here opportunity structures play an important role. For many people, social media are an important source of information (e.g., Westerman, Spence, & Van Der Heide, 2014). In the online environment, disseminating information also comes at a low cost and can foster diffusion dynamics (Bakshy et al., 2012). Studies on digital media and political participation, for example, have shown that users who were present during protest events have central roles in

online networks (Barberá et al., 2015). It is those users present at the protests who initiate the spread information from the center of the network to the periphery, keeping those absent from the ground informed about the latest developments (Barberá et al., 2015, p. 6). Protest participants are especially important at the initial phase of a protest (González-Bailón, Borge-Holthoefer, & Moreno, 2013), but peripheral users and accounts of celebrities (i.e., users with high number of followers) also play an important role in expanding the reach of their messages (Barberá et al., 2015; González-Bailón et al. 2013). Other cases where updates on recent events and breaking news are shared by users who do not belong to the category of journalists or traditional media outlets include for example people witnessing natural disasters or wars, or scientists present at a scientific breakthrough. During these types of events, laypeople are often faster at initiating information flows, perhaps "because they share information more liberally than organizations, spreading information before it has been vetted or verified" (Lotan et al., 2011, p. 1398).

Existing research points to the important role of geographic proximity for opinion leadership on social media, but has seen it as an indicator of a user's involvement in certain political issues rather than as a measure of access to information (Xu, Sang, Blasiola, & Park, 2014). On social media, other users might also see the proximity to an event as a heuristic for the credibility of a source (Lotan et al., 2011, p. 1399), which is likely to affect a user's influence in the debate, but we still lack empirical evidence regarding whether access to direct information affects opinion leadership.

2. Stakeholders in climate change communication and their social media use

As opinion leadership is related to a specific area of expertise (Shoham & Ruvio, 2008), we narrow our analysis to a specific policy area. We chose climate change for various reasons: It is one of the most important and polarized issues of our time, it gets high levels of media

attention, and opinion leaders play an important role (Nisbet & Kotcher, 2009) – this also applies to climate change debates on social media (Williams, McMurray, Kurz, & Hugo Lambert, 2015). Specifically, we focus on an international climate change summit. Participants who are physically present at the venue have first-hand information on what is happening and being decided at the conference. They can share information directly via social media and also provide their opinions to their followers. But more importantly, actors from various fields are participating. In this way, we can at the same time account for different societal statuses of opinion leaders that might impact the extent to which they can become opinion leaders in the debate.

One of the most recent and decisive summits was the COP21, which took place in 2015 in Paris. According to official statistics, more than 30,000 people participated in the event (United Nations, 2015). With a share above 60%, representatives on behalf of a country ("party") made up the largest segment of participants. Representatives of the parties are mainly head of states, ministers, members of parliament, and scientific experts, but can also include journalists or representatives of non-governmental organizations (NGOs) or companies. Observer organizations play likewise an important role in the negotiations. Despite not having formal decision-making powers, they can indirectly shape the position of the parties, e.g., through lobbying efforts. Observer organizations divide into delegates from the United Nations, specialized agencies, intergovernmental organizations, and NGOs. They jointly make up nearly 30% of the participants, most of them being sent by NGOs. Finally, journalists covering the summit make up a little less than 10% of the participants.

Thus, we can differentiate between five broader types of actors that have a stake in the climate change negotiations: political, scientific, civil society, economic and journalists. In the following, we discuss their roles in the climate change debate as well as their incentives to use social media in more detail.

Political actors from the national and international levels play a crucial role in climate change negotiations and in the wider public debate on climate change. Tackling climate change and limiting global warming requires implementing measures at the national and international levels, and climate governance has been shaped by an unprecedented number of negotiations (Harris, 2011, p. 639). Social media platforms are widely used and are becoming increasingly important among political actors for three reasons (Grant, Moon, & Grant, 2010; Gulati & Williams, 2010). First, social media allow politicians to bypass traditional gatekeepers, such as journalists; US politicians have been shown to use Twitter primarily for broadcasting and sharing information (Golbeck, Grimes, & Rogers, 2010; Graham, Broersma, Hazelhoff, & van 't Haar, 2013), often before it is officially reported by traditional media. Second, social media serve as a means of self-promotion (Graham, Broersma, Hazelhoff, & van 't Haar, 2013; Jackson & Lilleker, 2011), allowing politicians to broadcast personal information and activities. Third, social media enable direct communication between politicians and citizens. Past research has largely focused on social media use during elections and political campaigns (e.g., Nulty, Theocharis, Popa, Parnet, & Benoit, 2016; for an overview see: Jungherr, 2014); little is known about how politicians use Twitter during other periods (for an exception see Larsson, 2014).

Scientific evidence has been at the heart of the climate change debate and international climate change negotiations (Storch, Bunde, & Steher, 2011; Weart, 2011). Compared to other research areas, climate change is a field "where facts are uncertain, values in dispute, stakes high and decisions urgent" (Funtowicz & Ravetz, 1993, p. 744). In such a situation, ***scientists*** are expected to engage more actively in public discussions by managing the uncertainties that come with their findings, being transparent about the value questions involved, and formulating policy advice. Hence, more so than in other scientific fields, climate scientists have incentives to get involved and influence public debates (see also Walter, De Silva-Schmidt, Brüggemann, 2017).

Walter, Stefanie; Brüggemann, Michael (2018): Opportunity makes opinion leaders. Analyzing the role of first-hand information in opinion leadership in social media networks. In *Information, Communication & Society*, pp. 1–21. Available online at https://doi.org/10.1080/1369118X.2018.1500622.

Social media use, and Twitter in particular, has become part of many scientists' professional lives (van Noorden, 2014). One of the main reasons for scientists to engage in online communication on climate change is to provide information to the public. Social media platforms allow them to communicate their research quickly, easily, and efficiently to a large audience (van Eperen & Marincola, 2011). They also facilitate discussions with their peers, as scientists can comment on their own and others' research (van Noorden, 2014); many scientists tweet live from conferences (Darling, Shiffman, Côté, & Drew, 2013; Shiffman, 2012). Moreover, the visibility of scholarly work on social media is seen as a measure of the social impact of (and the amount of public attention paid to) scientific work (Eysenbach, 2011).

Social movements and ***civil society*** organizations play an important role in shaping public debates and raising awareness, including during climate change negotiations (Jamison, 2010). Civil society actors regularly organize protests to coincide with international conferences on climate change (Lipschutz & McKendry, 2011; Segerberg & Bennett, 2011). In addition, as representatives of NGOs have specialized knowledge, politicians turn to them for advice and thereby give civil society organizations the opportunity to influence the decision-making process (Betsill & Corell, 2008). During climate change summits, some NGO representatives have access to parts of the proceedings that are not open to the media; they therefore serve as important sources of information (Wozniak, Wessler, & Lück, 2017, p. 1436) both during summits and beyond (Powers, 2015). Civil society organizations can be considered "the champions of online climate communication" (Schäfer, 2012, p. 130). Many NGOs have scarce resources, and new media channels can inexpensively reach a broad audience. Civil society actors frequently use social media for public relations (Curtis et al., 2010) and fundraising purposes, to facilitate interactions with journalists and the public (Seo, Kim, & Yang, 2009, p. 124), and to mobilize and organize collective action (Bennett & Segerberg, 2012; Bimber, Flanagin, & Stohl, 2012; Sajuria, vanHeerde-Hudson, Hudson, Dasandi, & Theocharis, 2015).

Climate change and related policies are also important issues for ***economic actors***, who have an incentive to influence the public debate, as government regulations could impact their businesses. The automobile industry, for example, had to respond to government regulations on reducing emissions (Levy & Rothenberg, 2002). Some industries, such as fossil fuels, have an interest in maintaining the status quo of high levels of carbon dioxide emissions. Their strategy has involved participating in the public debate on climate change science.

Research on companies' social media use has primarily focused on public relations (e.g., Macnamara & Zerfass, 2012). Rybalko and Seltzer (2010) examined the Twitter use of a random sample of the largest US corporations, and found that companies engage in discussions and dialogue by tweeting questions or responding directly to other users. Twitter is also used to disseminate information, such as links to news releases, speeches, policies, and industry news. Yet very little is known about the role of economic actors in climate change communication on social media.

Finally, **journalists** and media organizations fulfill a crucial task in climate change communication. They influence public opinion on climate change (Corbett & Durfee, 2004; Hart, 2011) by making information available and by reporting different points of view raised in the debate. For example, by reporting on the scientific evidence of climate change, journalists can help raise public awareness of the issue. They serve as "key mediators between the sphere of science and the public sphere" (Brüggemann & Engesser, 2014, p. 400).

Social media platforms are becoming more important for journalistic work, and the vast majority of individual journalists and news organizations use social media (Cision, 2011) to disseminate information (Armstrong & Gao, 2010, p. 219). Particularly during times of crisis, social media (and Twitter in particular) have been important tools for reporting breaking news (Vis, 2013). Journalists also frequently use social media to promote their news stories by sharing links to news published by their organization (Lasorsa, Lewis, & Holton, 2012). Social

media also help journalists research their stories (Ausserhofer & Maireder, 2013; Cision, 2015). A comparative survey revealed that approximately half of the journalists in the sample believed they would no longer be able to carry out their work without social media (Cision, 2015). Finally, social media platforms connect journalists with their audience (Broersma & Graham, 2013).

In short, a number of diverse actors are involved in the field of climate communication; each has different stakes and incentives to communicate their point of view to the wider public. While all five groups widely use social media, we do not know whether participation in climate summits and access to first-hand information gives them an equal opportunity to become opinion leaders in the climate change debate on social media.

3. Hypotheses

According to Huffaker (2010) and Bakshy, Hofman, Mason, and Watts (2011), opinion leaders in social media networks are able to trigger feedback, spark conversations, and have a disproportionate impact on the spread of information. Huffaker (2010, p. 594) furthermore specifies that "online leaders are those who can set agendas by causing or facilitating dialog focused on a particular topic." We derived various hypotheses in order to test whether access to first-hand information gives conference participants an advantageous position in social media networks.

Research is divided over whether opinion leaders are those who (1) have a central position in a network (e.g., Weimann, 1994) or (2) occupy brokering positions and thereby connect different groups within a network (Burt, 1999). Therefore there are two ways in which COP21 conference participants could become opinion leaders:

H1: Participants of the COP21 summit have more central positions than the average user in the network.

H2: Participants of the COP21 summit are more likely to be brokers than the average user in the network.

Another way to identify opinion leaders is related to their communication behavior. Opinion leaders are more involved in a particular issue (cf. Roch, 2005, Xu et. al, 2014), and engage to a greater extent in formal and informal personal communication with others about the topic of interest (Weimann et al., 2007, p. 176). In the social media sphere, the number of messages a user sends can be seen as an indication of their involvement. Hence, our assumption is:

H3: Participants of the COP21 summit send more messages than the average user.

A characteristic of opinion leaders included in the definition above is that they ought to have a disproportional impact on the spread of information (Huffaker, 2010). In the social media sphere, the number of shares that a post by a certain user receives can signal the user's influence in the debate (Ausserhofer & Maireder, 2013; Ghosh & Lerman, 2010). Our expectation is:

H4: The posts of participants of the COP21 summit are shared more often than posts of the average user.

To address potential endogeneity concerns, we must determine that the participants of the COP21 conference were not previously opinion leaders, and that it was their access to first-hand information that elevated them to this status. Here, past research suggests that influential social media users have a high number of followers (Bakshy et al., 2011). If the participants were not opinion leaders prior to the summit, then we would expect that:

H5: The number of followers of COP21 participants is not higher than that of the average user.

4. Data and samples

Observation can be considered "the most accurate" way (Weimann, 2016, p. 911) to identify opinion leaders. Analysis of social media data has the advantage that network structures are easily observable, and researchers do not need to rely on surveys and self-reported measures.

Twitter in particular has been identified as a promising source for observing how information spreads via (online) networks (Bakshy et al., 2011), since users share information with their followers. Debates on Twitter are about current events, and it is relatively widely used by the stakeholders in climate change communication. Twitter allows the collection of tweets through its public API, and provides metadata such as user information (e.g. the number of followers), which is crucial for the purpose of this study. The following section describes the data-generating process and the sample in more detail.

Twitter users can make their geo-location visible in their privacy settings. While few users do so (Graham, Hale, & Gaffney, 2014; Kirilenko & Stepchenkova, 2014), the existence of this feature is crucial for this study. Previous research has shown that it is difficult to infer based on tweets whether or not a user attended an event (Ross et al., 2011, p. 223). Geo-location is a convenient indicator for attendance, so we assume that people who were present at the conference venue also participated in the summit. For a period of two weeks during the COP21 (30 November 2015 to 12 December 2015), we gathered geo-located tweets covering the area of the conference venue using the streamR package for R (Barberá, 2014), hence capturing tweets of people who were present at the summit. We created a subset of tweets including the conference-related Twitter handle #COP21, a further verification that we captured tweets of conference participants (as opposed to people who happened to be at the spot incidentally). We ended up with 1,765 tweets and were able to identify 418 unique users in what we will henceforth refer to as the "geo-location data set."

To classify the users according to the five stakeholder types described above, we relied on information provided in the users' description in their Twitter profiles. We extracted their self-declared professions and classified them using automated content analysis[2], specifically a

[2] We used automated coding for this rather small number of cases because this study is part of a larger project looking at actors involved in the climate change debate on Twitter.

dictionary method using the "quanteda" R package (Benoit et al. 2016). We compared the automated coding with a manual coding of a random subsample and gained highly reliable results (Krippendorff's alpha = 0.90). Users whose description could not automatically be classified as belonging to any of the five categories were coded manually. Often, the information that was provided turned out to be "not useful" for classifying a user's professional affiliation (e.g., "I am a free spirit"), which was included as an additional category, and a small number of users provided no information and were thus coded as "missing values". Where users provided information about their profession that did not fit any of the categories above (e.g., artist), we classified them as "other specific actors".

Since we are interested in examining whether users who were physically present played a leading role in the wider debate, the analysis draws on a second data set of tweets collected based on the conference-related Twitter handle (#COP21). We refer to this data set as the "#COP21 data set". This data set includes 711,044 tweets[3] sent by 256,710 unique users. We employed the usernames found in the geo-location data set, to identify these same users in the #COP21 data set. We were able to match all but 30 of those users. In the #COP21 data set, conference participants (i.e. those who were present in both data sets) were then compared to the average user in the same data set.

5. Measures

The empirical analysis draws on user data included in Twitter profiles and network analysis measures. For the network analysis, we used the igraph package for R (Csardi & Nepusz, 2006). To determine whether participants of the COP21 summit have more central positions in the network than the average user (H1), we use network centrality measures. *Degree centrality* measures the extent to which a node (here a Twitter user) is connected to all other nodes by

[3] After the removal of duplicates.

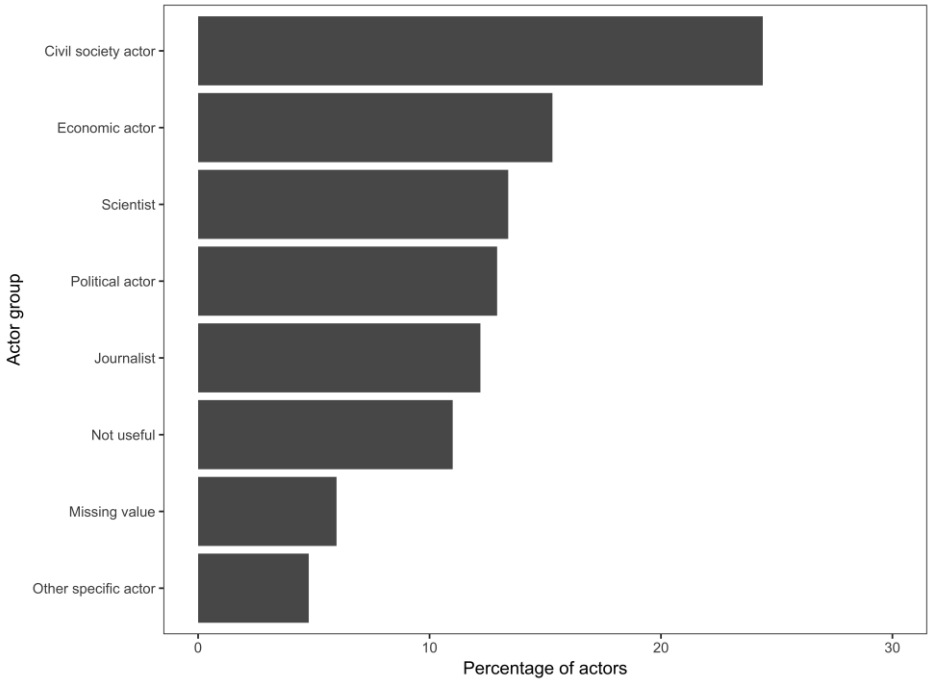
calculating the number of ties it has in the network (Borgatti, Everett, & Johnson, 2013; Knoke & Yang, 2008). Network centrality is further divided into in-degree and out-degree centrality. *In-degree centrality* measures the number of incoming ties, i.e., the number of users that mentions a certain user. *Out-degree centrality*, however, measures the number of outgoing ties, i.e., the number of other users that a certain user mentions in their tweets. Another indicator of a user's centrality within a network is closeness centrality, which estimates how close a user is to all other users in the network. It is a measure for how efficient a node can spread information to the other nodes of the network. The closeness centrality of a node is calculated as the inverse of the average length of the shortest paths to/from all the other nodes.

To study H2 (whether opinion leaders are brokers), we measure *betweenness centrality* (Huffaker, 2010) – how often a given user falls along the shortest path between two other users (Borgatti et al., 2013, p. 174). For example, in the Twitter context, a user with high betweenness centrality has the ability to broker information between two users who do not follow each other. To analyze whether conference participants sent more messages than average users (H3), we calculated the number of tweets sent by each user. Similarly, to determine whether the tweets of summit participants were shared more often (H4), we took the number of retweets into account. The number of retweets was measured by calculating how many times the tweet of a given user was shared by others in the data set by extracting the user name that followed after "RT" or "via" from the text of a tweet using regular expressions. To verify that the participants were not previously considered opinion leaders but that it was the first-hand information they gathered as summit participants that raised their profile (H5), we take their average number of followers (at the time of the tweet posting) into account.

6. Results

This study uses the 2015 UN climate change conference to analyze whether there is a relationship between access to first-hand information and opinion leadership in social media networks. Figure 1 shows the share of users who were present at (and tweeted from) the conference venue by actor type. The largest group consists of civil society actors (24%), followed by economic actors (15%), scientists (13%), political actors (13%), and journalists (12%). A further 5% of users were classified "other specific actors." About 11% of users did not provide any information that could be used to infer their profession ("not useful"), while 6% provided no details in their user description ("missing value").

Figure 1: Users in geo-location data set by actor type[4]



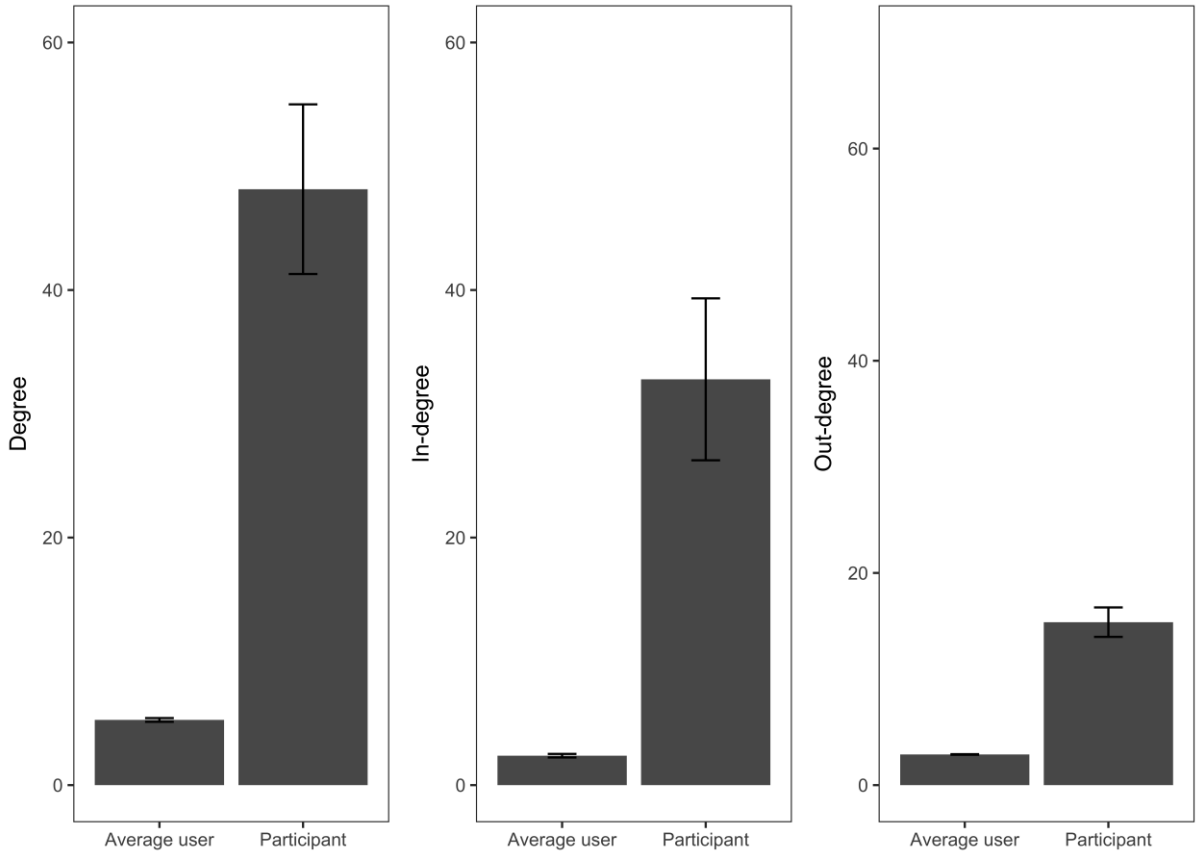
Note: N = 418

In order to examine the level of influence of summit participants in the wider debate, we located the users from the geo-located sample in the #COP21 data set. To test whether participants of the COP21 summit occupied more central positions in the network than the average user (H1),

[4] The results presented in Figures 1-4 are also significant at the $p<0.000$ level, if bivariate linear regressions are used instead of t-tests, while the results shown in Figure 5 remain insignificant in the regression model.

we use conventional centrality measures from network analysis. Figure 2 shows the centrality measures comparatively for the "average user" in the network and for COP21 conference "participants." The average user has a degree centrality of 5, meaning that users are typically connected with five other users in the network. The degree centrality of users who participated in the summit varies significantly and is nearly ten times higher than the average (48). We also observe strong differences in the in-degree and out-degree centrality, which is approximately 2 and 3 for the average user and 33 and 15 for conference participants. This indicates that Twitter users who attended the COP21 conference engaged in more discussions with other users, and received more attention from others in the network. Closeness is another centrality measure that takes into account how close a user is to all other users in the network, which likewise differs significantly between two groups and is higher for conference participants (Figure 3). The results therefore support our first hypothesis that conference participants have a more central position in the network.

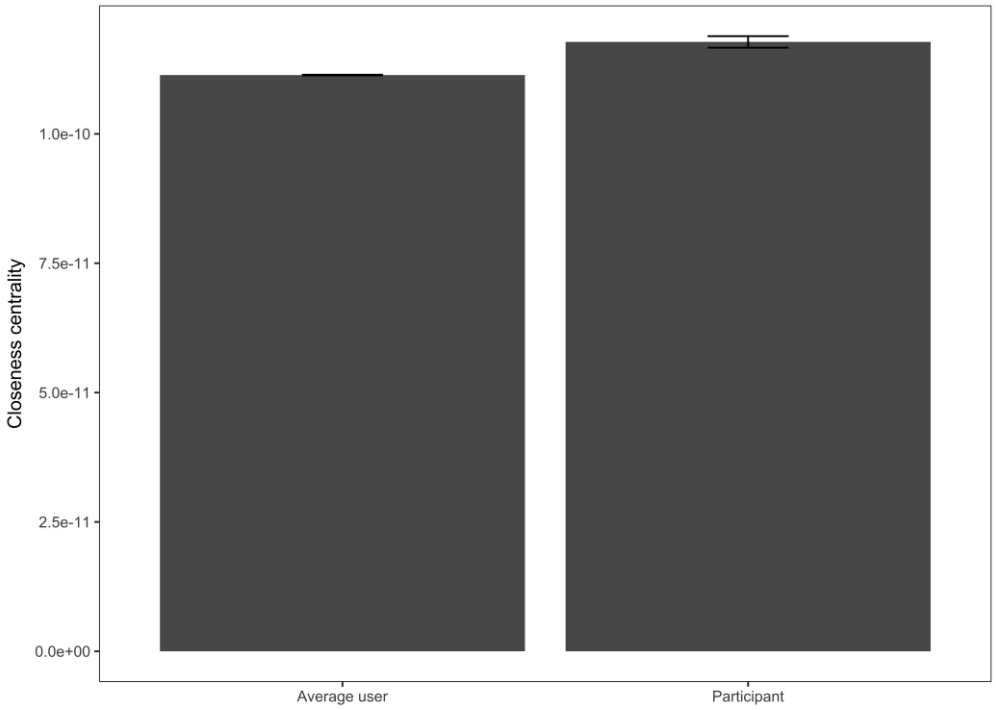
Figure 2: Degree centrality measures for average user and COP21 participants



Note: N = 257710, degree t= -6.35, p<0.000; in-degree t= --4.65, p<0.000; out-degree t= -8.98, p<0.000.

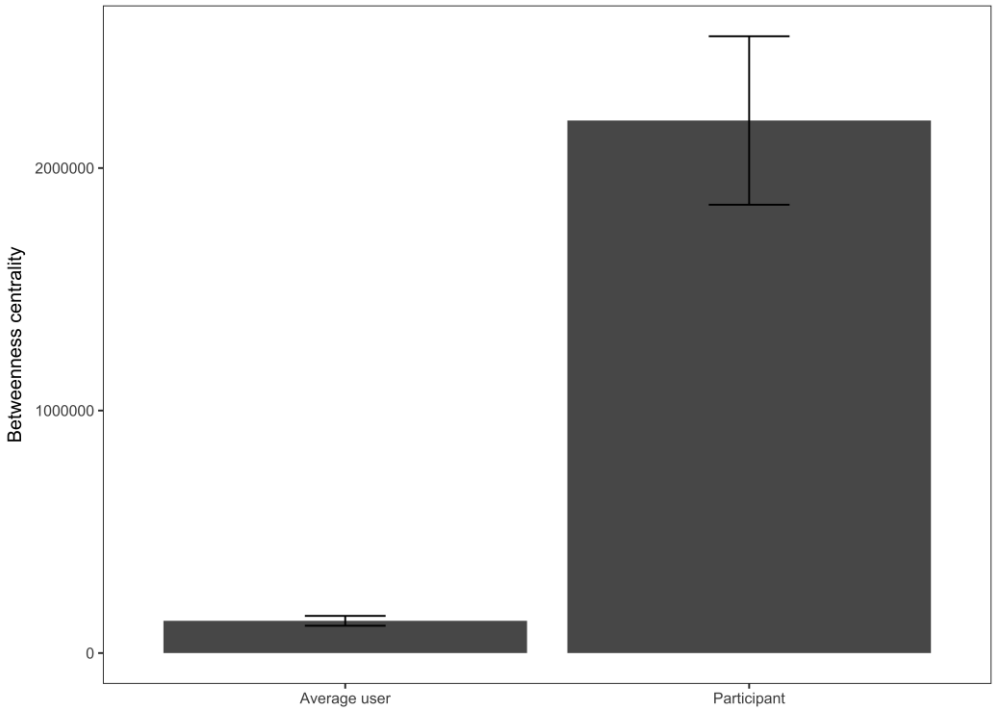
Others have argued that opinion leaders are bridging structural holes and thereby occupy distinctive positions in a network, which give them a structural advantage over others (Burt, 1999). Rather than being more central actors, opinion leaders might be brokers, connecting different groups (H2). We use betweenness centrality to measure brokerage and the extent to which a user can influence the diffusion of information in a network (Huffaker, 2010). Figure 4 illustrates that betweenness centrality is significantly higher for COP21 conference participants compared to the average user in the network. We can therefore conclude that Twitter users who were present at the conference venue played a more important role as information brokers in the network, which is in line with H2.

Figure 3: Closeness centrality for average user and COP21 participants



Note: N = 257710, t= -5.76, p<0.000.

Figure 4: Betweenness centrality for average user and COP21 participants

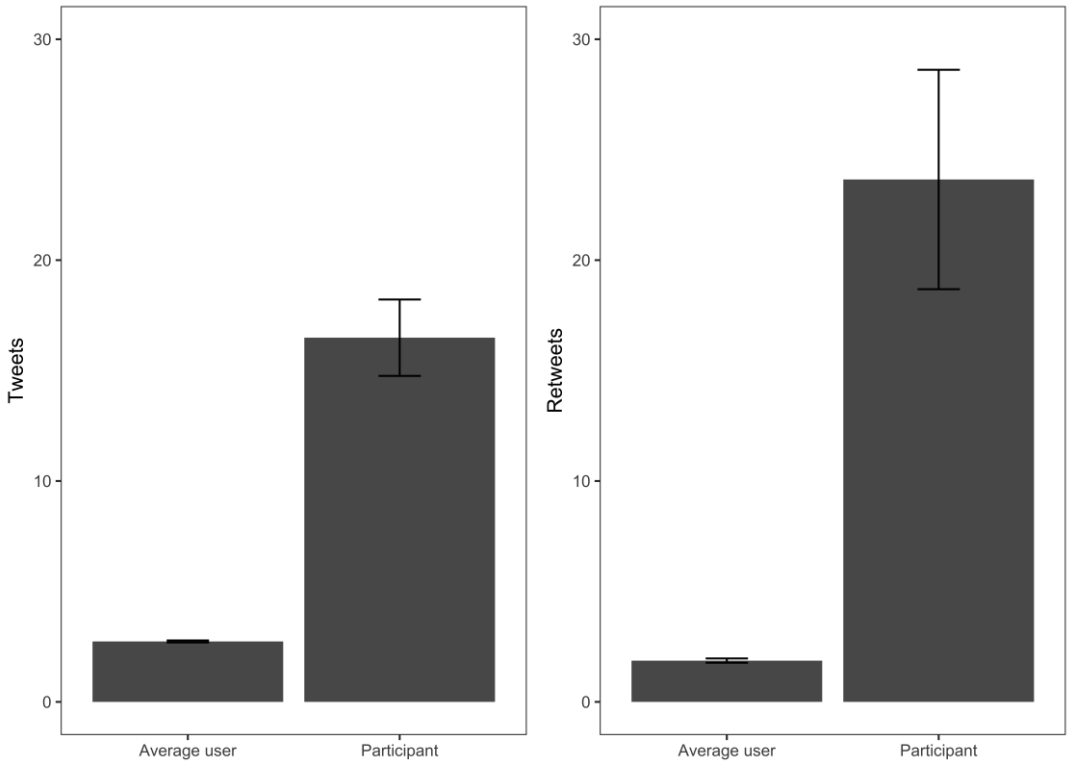


Note: N = 257710, t= -5.93, p<0.000.

Our analysis of out-degree centrality has already established that participants are mentioning more users in their tweets, but this does not automatically mean they are also

sending more tweets (as tweets might not include @-mentions). Opinion leaders ought to be more involved in the issue than others (cf. Roch, 2005), and we took the number of tweets sent by a user as an indication of involvement in the debate.

Figure 5: Tweets and retweets for average user and COP21 participants

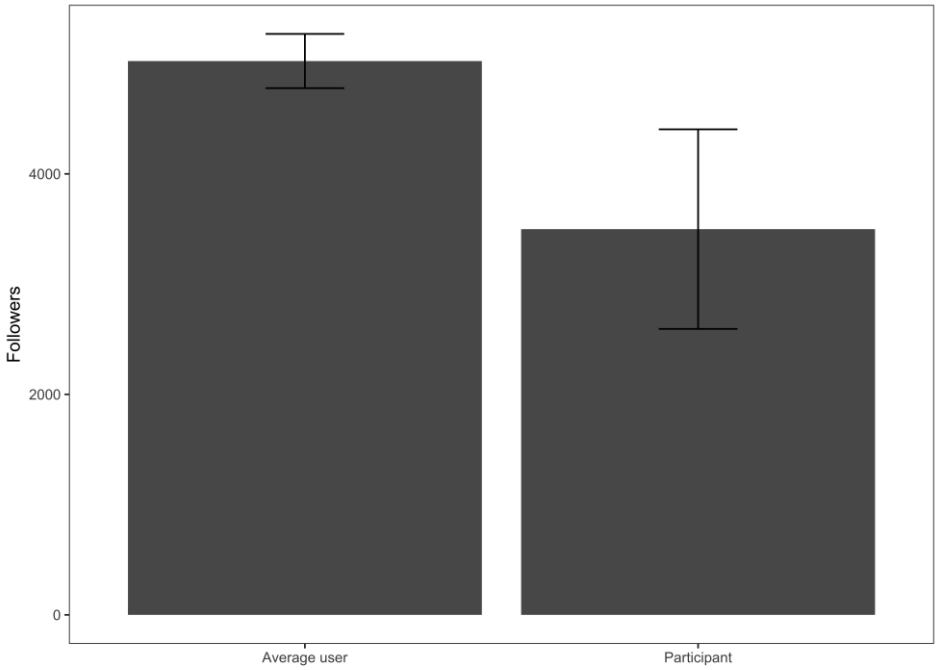


Note: N = 257710, tweets t= -7.95, p<0.000; retweets t= -4.38, p<0.000.

Our hypothesis that participants sent more tweets compared to the average user in the network (H3) is likewise confirmed. While the average user only sent 3 messages, conference participants sent, on average, 16 tweets (Figure 5, left column). Yet, are their tweets more influential than those of the average user (H4)? This question can be addressed by looking at the average number of retweets. In line with our expectation, the results show that tweets by COP21 attendees were shared significantly more often than those of the average user (Figure 5, right column).

Finally, H5 addresses the issue of endogeneity: Are COP21 participants more influential users in the network because they have direct information about the events happening at the summit, or because they are generally more popular than the average Twitter user? We used the number of followers to indicate the general popularity of a Twitter user.

Figure 6: Average number of followers for average user and COP21 participants



Note: N = 257710, t= -1.63, p= 0.105.

COP21 participants have 3,499 followers, which is below the average of 5,023 (Figure 6), but the difference is non-significant. Hence, it can be concluded that the participants did not have more followers than the average user, which confirms H5 and supports the assumption that it is the access to first-hand information that contributes to their accentuated role in the debate on the COP21 conference on Twitter.

The question is whether these results differ across actors. Here, we only focus on the five dominant actor types in the climate change debate and exclude users with other professions as well as those that did not provide any (useful) information about their profession in their Twitter profiles. Table 1 shows that the degree centrality of civil society, economic actors,

journalists, and scientists is relatively similar and varies between 37 and 43. Only political actors are an outlier, with a degree of 118. This can be explained by a much higher in-degree centrality of political actors: Compared to other actor types, they receive much more attention from other users in the network, which may indicate that they are considered more influential. In line with this finding, other studies have shown that Twitter users with high centrality measures tend to be politicians who can arguably provide authoritative information on political issues (Dubois & Gaffney, 2014). Another interesting finding is that journalists have the lowest out-degree. This suggests that they are more focused on broadcasting news, rather than engaging in discussion with other users. Nevertheless, the values for the in-, out-, and overall degree differ significantly for all actor types from the average user. With the exception of economic actors and journalists, also closeness centrality differs significantly for the different actor types. This overall supports the robustness of our results regarding the first hypothesis. The analysis also support our second hypothesis: Betweenness centrality – a measure for brokerage – is significantly higher for all actor groups compared to the average user.

Table 1: Degree centrality measures, betweenness centrality, number of tweets, retweets, and followers by actor type

	Civil society actor	Economic actor	Scientist	Political actor	Journalist
Degree	40.10***	36.73***	39.93***	117.63*	42.65***
In-degree	21.00***	22.27*	20.98**	99.10*	32.54**
Out-degree	19.10***	14.47***	18.94***	18.53***	10.10***
Closeness	1.18e-10***	1.15e-10	1.18e-10*	1.20e-10***	1.15e-10
Betweenness	1752758.60**	1377851.90**	2598719.50*	3828251.5**	1866227.00**
Number of tweets	20.52**	13.44***	20.00***	20.96***	15.49***
Number of retweets	13.41***	14.59**	17.70**	73.63*	25.63***
Number of followers	2608.09*	1866.30***	1170.45***	10122.43	3506.94

Note: Stars indicate that the value differs significantly from the average based on a t-test (*p<0.05; **p<0.01; ***p<0.000). The t-test results can be found in the Appendix. The values for the remaining actor types were respectively set as missing values when the t-test was carried out.

Concerning the number of tweets sent we find minor differences: Economic actors and journalists tweet somewhat less often than other COP21 participants. Yet, the number of tweets for all groups differs significantly from the average user in the network (H3). Likewise, all actor types are significantly above average in terms of the number of retweets (H4). It is again political actors who receive the highest number of retweets, arguably indicating that people attribute more importance to their messages. We find the most pronounced difference between political actors and other groups in the number of followers. Political actors have more than 10,000 followers, which is higher than the average, but the difference is non-significant. In contrast, civil society, economic actors, and scientists have significantly *less* followers than the average, while no significant difference is found for journalists. This confirms that also when looking at the actor groups separately, the number of followers of COP21 participants is not higher than that of the average user (H5).

In sum, the analysis by actor type has shown the robustness of the results, suggesting that access to first-hand information enables all types of participants – politicians, scientists, journalist, economic and civil society actors – to become opinion leaders, in the sense that they are more influential in the Twitter debate than the average user.

7 Conclusion

This paper examined whether access to first-hand information constitutes a structural advantage that enables people to become opinion leaders in the wider social media debate. We focused on the 2015 COP21 climate summit, as opinion leadership is related to a specific area of expertise (Shoham & Ruvio, 2008). Climate change is an important political issue that requires transnational decision-making and hence fosters a global debate. It furthermore involves stakeholders from different societal fields that are also participating in the climate conferences: Political, scientific, civil society, media, and economic actors. This paper argued that as

participants of an international summit, these actors have first-hand information about what is happening at the conference that they can share online, which gives them the opportunity to become opinion leaders in the social media debate.

To test this assumption empirically, we collected geo-located tweets sent from the conference venue to identify participants of the COP21 conference and used automated content analysis of their user descriptions to allocate them to one of five actor groups. We then identified those users in the Twitter network based on the main conference Twitter hashtag (#COP21) and compared their impact to that of the average user. Using network analysis measures, our results showed that participants of the COP21 summit are more central than the average user in the network. Participants engaged more in discussions with other users (out-degree), and were addressed more often by others (in-degree) and were closer to all other users in the network (closeness centrality). At the same time, an analysis of betweenness centrality showed that participants were more likely to be brokers in the network than the average user, meaning that they were connecting different groups. This provides them with a structural advantage and the opportunity to influence the diffusion of information in a network (Huffaker, 2010).

We used the number of tweets sent by a user to measure another indicator of opinion leadership – greater involvement in the debate (Roch, 2005; Weimann, Tustin, van Vuuren, & Joubert, 2007). Since opinion leaders ought to have a disproportionate impact on the spread of information (Huffaker, 2010), we took the average number of retweets into account. COP21 attendees tweeted more and got more retweets than the average user in the network. One could argue that summit participants might have already been influential users in the debate before the conference, and more popular than the average user. However, we did not find any significant differences in the number of followers of the COP21 participants and the average Twitter user.

Linking back to the theory of the two-step flow of communication and information flows on social media, our analysis showed that participation in the COP21 summit enabled attendees to become highly influential in shaping the public debate on Twitter. We argue that this is because they had first-hand information about what was happening at the COP21 summit, which they shared with their networks. They were able to overcome the traditional paradigm of the two-step flow of communication, in which information first spreads via the media to opinion leaders, who then influence the wider public. Social media platforms such as Twitter give opinion leaders the opportunity to directly share information with their networks. Their followers can then spread the information further, i.e., by retweeting it. However, a two-step or even multi-step flow in this manner requires first-hand information: Physical presence at the climate summit provided this access and offered the opportunity to become an issue-specific opinion leader.

Yet our results also showed that there are differences between the different types of actors that participated in the conference. Political actors better match the definition of opinion leaders: They spark conversations and trigger feedback by sending a large number of tweets and being frequently mentioned by other users. They had a significant impact on the debate, as their messages received the most retweets among the different actor groups. Civil society actors and scientists likewise aimed to spark conversation by sending a large number of tweets, but their impact in the debate was lower as they received fewer retweets and mentions by other users. It is likely that political actors after all benefit from their high numbers of followers, suggesting that there might be limits to the extent to which first-hand information *alone* can facilitate opinion leadership. Another explanation is that political actors are ultimately responsible for the outcome of the summit (while scientists and civil society actors provide their input and journalists report on the events) and other users therefore view them as the most important source of information. Future research should investigate this process in the context

of different events in order to further develop the theory of opinion leadership and multi-step flow of information, taking into account the situation in which certain actors have exclusive access to information.

A limitation of our study is that we are unable to measure the direct effect that opinion leaders have on the opinions of others by disseminating information online. The study furthermore relies on Twitter users' geo-location, which requires that they activate the function; based on previous research, we know that only a limited number of users do so (e.g., Graham, Hale, & Gaffney, 2014). Yet, user data based on geo-location was a necessary requirement for this study as it was used to indicate conference attendance. Since the study is based on cross-sectional data, we are unable to draw any conclusions about the sustainability of participants' opinion leadership. Even though past research noted that opinion leaders are influential at certain times but not others (Katz, 1957), it would be of interest to examine whether people who became opinion leaders due to access to first-hand information are able to maintain an important role in the debate.

References

Armstrong, C. L., & Gao, F. (2010). Now tweet this: how news organizations use Twitter. *Electronic News*, *4*(4), 218–235. https://doi.org/10.1177/1931243110389457

Ausserhofer, J., & Maireder, A. (2013). National politics on Twitter: structures and topics of a networked public sphere. *Information, Communication & Society*, *16*(3), 291–314. https://doi.org/10.1080/1369118X.2012.756050

Barberá, P. (2014). *streamR: Access to Twitter Streaming API via R*. R package version 0.2.1. https://CRAN.R-project.org/package=streamR

Barberá, P., Wang, N., Bonneau, R., Jost, J. T., Nagler, J., Tucker, J., & González-Bailón, S. (2015). The critical periphery in the growth of social protests. *PloS one*, 10(11), e0143611.

Bakshy, E., Hofman, J. M., Mason, W. A., & Watts, D. J. (2011). Everyone's an influencer. In I. King, W. Nejdl, & H. Li (Eds.), *Proceedings of the fourth ACM international conference on Web search and data mining - WSDM '11* (p. 65). New York, NY: ACM Press. https://doi.org/10.1145/1935826.1935845

Bakshy, E., Rosenn, I., Marlow, C., & Adamic, L. (2012, April). The role of social networks in information diffusion. In *Proceedings of the 21st international conference on World Wide Web* (pp. 519-528). ACM.

Bennett, W. L., & Manheim, J. B. (2006). The one-step flow of communication. *The ANNALS of the American Academy of Political and Social Science*, *608*(1), 213–232. https://doi.org/10.1177/0002716206292266

Bennett, W. L., & Segerberg, A. (2012). The logic of connective action. *Information, Communication & Society*, *15*(5), 739–768. https://doi.org/10.1080/1369118X.2012.670661

Benoit, K., Watanabe, K., Nulty, P., Obeng, A., Wang, H., Lauderdale, B., & Lowe, W. (2017). *quanteda: Quantitative Analysis of Textual Data*. R package version: 0.99. http://quanteda.io.

Betsill, M. M., & Corell, E. (2008). *NGO diplomacy: The influence of nongovernmental organizations in international environmental negotiations*. Cambridge, MA: MIT Press.

Bimber, B. A., Flanagin, A. J., & Stohl, C. (2012). *Collective action in organizations: Interaction and engagement in an era of technological change*. *Communication, Society and Politics*. New York, NY: Cambridge University Press.

Borgatti, S. P., Everett, M. G., & Johnson, J. C. (2013). *Analyzing social networks*. Thousand Oaks, CA and London: Sage Publications.

Broersma, M., & Graham, T. (2013). Twitter as a news source: how Dutch and British newspapers used tweets in their news coverage, 2007–2011. *Journalism Practice*, *7*(4), 446–464. https://doi.org/10.1080/17512786.2013.802481

Brüggemann, M., & Engesser, S. (2014). Between consensus and denial: climate journalists as interpretive community. *Science Communication*, *36*(4), 399–427. https://doi.org/10.1177/1075547014533662

Burt, R. S. (1999). The social capital of opinion leaders. *The ANNALS of the American Academy of Political and Social Science*, *566*(1), 37–54. https://doi.org/10.1017/S0022381608090130

Cha, M., Benevenuto, F., Haddadi, H., & Gummadi, K. (2012). The world of connections and information flow in Twitter. *IEEE Transactions on Systems, Man, and Cybernetics - Part A: Systems and Humans*, *42*(4), 991–998. https://doi.org/10.1109/TSMCA.2012.2183359

Cision. (2011). *Social journalism 2011*. Frankfurt am Main. Retrieved from uk.cision.com/en-gb/Resources/Public-relations-white-papers/2011-social-journalism-study-EU/

Cision. (2015). *White Paper: 2015 global social journalism study*. Retrieved from http://www.cision.com/us/resources/white-papers/2015-global-social-journalism-study/?clid=whitepaper-ty

Corbett, J. B., & Durfee, J. L. (2004). Testing public (un)certainty of science: media representations of global warming. *Science Communication*, *26*(2), 129–151. https://doi.org/10.1177/1075547004270234

Csardi, G., Nepusz, T. (2006) The igraph software package for complex network research. *InterJournal*, Complex Systems. http://igraph.org

Curtis, L., Edwards, C., Fraser, K. L., Gudelsky, S., Holmquist, J., Thornton, K., & Sweetser, K. D. (2010). Adoption of social media for public relations by nonprofit organizations. *Public Relations Review*, *36*(1), 90–92. https://doi.org/10.1016/j.pubrev.2009.10.003

Darling, E., Shiffman, D., Côté, I., & Drew, J. (2013). The role of Twitter in the life cycle of a scientific publication. *Ideas in Ecology and Evolution*, *6*, 32–43. https://doi.org/10.4033/iee.2013.6.6.f

Dubois, E., & Gaffney, D. (2014). The multiple facets of influence. *American Behavioral Scientist*, *58*(10), 1260–1277. https://doi.org/10.1177/0002764214527088

Eysenbach, G. (2011). Can tweets predict citations? Metrics of social impact based on Twitter and correlation with traditional metrics of scientific impact. *Journal of Medical Internet Research*, *13*(4), e123. https://doi.org/10.2196/jmir.2012

Funtowicz, S. O., & Ravetz, J. R. (1993). Science for the post-normal age futures. *Futures*, *25*(7), 739–755.

Ghosh, R., & Lerman, K. (2010). Predicting influential users in online social networks. *arXiv preprint arXiv:1005.4882*.

González-Bailón, S., Borge-Holthoefer, J., & Moreno, Y. (2013). Broadcasters and hidden influentials in online protest diffusion. *American Behavioral Scientist*, 57(7), 943-965.

Golbeck, J., Grimes, J. M., & Rogers, A. (2010). Twitter use by the U.S. Congress. *Journal of the American Society for Information Science and Technology*, n/a-n/a. https://doi.org/10.1002/asi.21344

Graham, M., Hale, S. A., & Gaffney, D. (2014). Where in the world are you? Geolocation and language identification in Twitter. *The Professional Geographer*, *66*(4), 568–578. https://doi.org/10.1080/00330124.2014.907699

Graham, T., Broersma, M., Hazelhoff, K., & van 't Haar, G. (2013). Between broadcasting political messages and interacting with voters: the use of Twitter during the 2010 UK general election campaign. *Information, Communication & Society*, *16*(5), 692–716. https://doi.org/10.1080/1369118X.2013.785581

Grant, W. J., Moon, B., & Grant, J. B. (2010). Digital dialogue? Australian politicians' use of the social network tool Twitter. *Australian Journal of Political Science*, *45*(4), 579–604. https://doi.org/10.1080/10361146.2010.517176

Gulati, J., & Williams, C. B. (2010). Communicating with constituents in 140 characters or Less: Twitter and the diffusion of technology innovation in the United States Congress. *SSRN Electronic Journal*. Advance online publication. https://doi.org/10.2139/ssrn.1628247

Harris, P. G. (2011). Reconceptualizing global governance. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford handbook of climate change and society* (pp. 639–652). Oxford, New York: Oxford University Press.

Hart, P. S. (2011). One or many? The influence of episodic and thematic climate change frames on policy preferences and individual behavior change. *Science Communication*, *33*(1), 28–51. https://doi.org/10.1177/1075547010366400

Huffaker, D. (2010). Dimensions of leadership and social influence in online communities. *Human Communication Research*, *36*(4), 593–617. https://doi.org/10.1111/j.1468-2958.2010.01390.x

Jackson, N., & Lilleker, D. (2011). Microblogging, constituency service and impression management: UK MPs and the use of Twitter. *The Journal of Legislative Studies*, *17*(1), 86–105. https://doi.org/10.1080/13572334.2011.545181

Jamison, A. (2010). Climate change knowledge and social movement theory. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(6), 811–823. https://doi.org/10.1002/wcc.88

Jungherr, A. (2014). Twitter in politics: a comprehensive literature review. *SSRN Electronic Journal*. Advance online publication. https://doi.org/10.2139/ssrn.2402443

Katz, E. (1957). The two-step flow of communication: an up-to-date report on an hypothesis. *Annenberg School for Communication Departmental Papers (ASC)*. Retrieved from http://repository.upenn.edu/cgi/viewcontent.cgi?article=1279&context=asc_papers

Katz, E., & Lazarsfeld, P. F. (1955). *Personal influence: the part played by people in the flow of mass communication*. Glencoe, IL: Free Press.

Katz, E., & Lazarsfeld, P. F. (1966). *Personal influence: The part played by people in the flow of mass communications* (2nd ed.). New Brunswick, NJ: Transaction Publishers.

Kavanaugh, A. L., Zin, T. T., Rosson, M. B., Carroll, J. M., Schmitz, J., & Kim, B. J. (2007). Local groups online: political learning and participation. *Computer Supported Cooperative Work, 16*(4-5), 375–395. https://doi.org/10.1007/s10606-006-9029-9

Kirilenko, A. P., & Stepchenkova, S. O. (2014). Public microblogging on climate change. *Global Environmental Change, 26*, 171–182.

Knoke, D., & Yang, S. (2008). *Social network analysis* (2nd ed.). *Quantitative applications in the social sciences: Vol. 154*. Los Angeles, CA: Sage Publications.

Larsson, A. O. (2014). The EU Parliament on Twitter—assessing the permanent online practices of parliamentarians. *Journal of Information Technology & Politics*, *12*(2), 149–166. https://doi.org/10.1080/19331681.2014.994158

Lasorsa, D. L., Lewis, S. C., & Holton, A. E. (2012). Normalizing Twitter: journalism practice in an emerging space. *Journalism Studies*, *13*(1), 19–36. https://doi.org/10.1080/1461670X.2011.571825

Lazarsfeld, P. F., Berelson, B., & Gaudet, H. (1948). *The people's choice: How the voter makes up his mind in a presidential campaign*. New York: Columbia University Press.

Levy, D. L., & Rothenberg, S. (2002). Heterogeneity and change in environmental strategy: technological and political responses to climate change in the global automobile industry. In A. J. Hoffman & M. J. Ventresca (Eds.), *Stanford business books. Organizations, policy, and the natural environment: Institutional and strategic perspectives* (pp. 173–193). Stanford, CA: Stanford University Press.

Lipschutz, R. D., & McKendry, C. (2011). Social movements and global civil society. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford handbook of climate change and society* (pp. 369–383). Oxford, New York: Oxford University Press.

Lotan, G., Graeff, E., Ananny, M., Gaffney, D., & Pearce, I. (2011). The revolutions were tweeted: Information flows during the 2011 Tunisian and Egyptian revolutions. *International Journal of Communication, 5(31)*, 1375–1405.

Macnamara, J., & Zerfass, A. (2012). Social media communication in organizations: the challenges of balancing openness, strategy, and management. *International Journal of Strategic Communication*, *6*(4), 287–308. https://doi.org/10.1080/1553118X.2012.711402

Nisbet, M. C., & Kotcher, J. E. (2009). A two-step flow of influence? Opinion-leader campaigns on climate change. *Science Communication*, *30*(3), 328–354. https://doi.org/10.1177/1075547008328797

Noelle-Neumann, E. (1999). Die Wiederentdeckung der Meinungsführer und die Wirkung der persönlichen Kommunikation im Wahlkampf [The rediscovery of opinion leaders and the impact of personal communication during the election campaigns]. In E. Noelle-Neumann, H. M. Kepplinger, & W. Donsbach (Eds.), *Kampa: Meinungsklima und Medienwirkung im Bundestagswahlkampf 1998* [*Climate of opinion and media effects during the federal election campaign 1998*] (pp. 181–214). Freiburg im Breisgau: Alber.

Nulty, P., Theocharis, Y., Popa, S. A., Parnet, O., & Benoit, K. (2016). Social media and political communication in the 2014 elections to the European Parliament. *Electoral Studies.* Advance online publication. https://doi.org/10.1016/j.electstud.2016.04.014

Park, C. S. (2013). Does Twitter motivate involvement in politics? Tweeting, opinion leadership, and political engagement. *Computers in Human Behavior*, *29*(4), 1641–1648. https://doi.org/10.1016/j.chb.2013.01.044

Powers, M. (2015). Contemporary NGO-journalist relations: reviewing and evaluating an emergent area of research. *Sociology Compass*, *9*(6), 427–437. https://doi.org/10.1111/soc4.12267

Roch, C. H. (2005). The dual roots of opinion leadership. *The Journal of Politics*, *67*(1), 110–131. https://doi.org/10.1111/j.1468-2508.2005.00310.x

Ross, C., Terras, M., Warwick, C., & Welsh, A. (2011). Enabled Backchannel: Conference Twitter Use by Digital Humanists. *Journal of Documentation*. *67*(2), 214–237.

Rybalko, S., & Seltzer, T. (2010). Dialogic communication in 140 characters or less: How Fortune 500 companies engage stakeholders using Twitter. *Public Relations Review*, *36*(4), 336–341. https://doi.org/10.1016/j.pubrev.2010.08.004

Sajuria, J., vanHeerde-Hudson, J., Hudson, D., Dasandi, N., & Theocharis, Y. (2015). Tweeting Alone? An analysis of bridging and bonding social capital in online networks. *American Politics Research*, *43*(4), 708–738. https://doi.org/10.1177/1532673X14557942

Schäfer, M. S. (2012). Online communication on climate change and climate politics: a literature review. *Wiley Interdisciplinary Reviews: Climate Change*, *3*(6), 527–543. https://doi.org/10.1002/wcc.191

Schäfer, M. S., & Taddicken, M. (2015). Mediatized opinion leaders: new patterns of opinion leadership in new media environments? *International Journal of Communication, 9, 960–981.*

Segerberg, A., & Bennett, W. L. (2011). Social media and the organization of collective action: using twitter to explore the ecologies of two climate change protests. *The Communication Review*, *14*(3), 197–215. https://doi.org/10.1080/10714421.2011.597250

Seo, H., Kim, J. Y., & Yang, S.-U. (2009). Global activism and new media: A study of transnational NGOs' online public relations. *Public Relations Review*, *35*(2), 123–126. https://doi.org/10.1016/j.pubrev.2009.02.002

Shiffman, D. S. (2012). Twitter as a tool for conservation education and outreach: What scientific conferences can do to promote live-tweeting. *Journal of Environmental Studies and Sciences*, *2*(3), 257–262. https://doi.org/10.1007/s13412-012-0080-1

Shoham, A., & Ruvio, A. (2008). Opinion leaders and followers: A replication and extension. *Psychology and Marketing*, *25*(3), 280–297. https://doi.org/10.1002/mar.20209

Song, S. Y., Cho, E., & Kim, Y.-K. (2017). Personality factors and flow affecting opinion leadership in social media. *Personality and Individual Differences*, *114*, 16–23. https://doi.org/10.1016/j.paid.2017.03.058

Storch, H. von, Bunde, A., & Steher, N. (2011). The physical sciences and climate politics. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford handbook of climate change and society* (pp. 113–128). Oxford, New York: Oxford University Press.

United Nations. (2015). *List of participants*, FCCC/CP/2015/INF.3 (11 December 2015).

van der Merwe, R., & van Heerden, G. (2009). Finding and utilizing opinion leaders: social networks and the power of relationships. *South African Journal of Business Management*, *40*(3), 65–76.

van Eperen, L., & Marincola, F. M. (2011). How scientists use social media to communicate their research. *Journal of Translational Medicine*, *9*(199), 1–3. https://doi.org/10.1186/1479-5876-9-199

van Noorden, R. (2014). Scientists and the social network. *Nature*, *512*(7513), 126–129.

Vis, F. (2013). Twitter as a reporting tool for breaking news. *Digital Journalism*, *1*(1), 27–47. https://doi.org/10.1080/21670811.2012.741316

Walter, S., De Silva-Schmidt, F., & Brueggemann, M. (2017). From "Knowledge Brokers" to Opinion Makers: How Physical Presence Affected Scientists' Twitter Use During the COP21 Climate Change Conference. *International Journal of Communication*, 11, 570-591.

Weart, S. (2011). The development of the concept of dangerous anthropogenic climate change. In J. S. Dryzek, R. B. Norgaard, & D. Schlosberg (Eds.), *Oxford handbook of climate change and society* (pp. 67–81). Oxford, New York: Oxford University Press.

Weimann, G. (1994). *The influentials: People who influence people*. Albany, NY: State University of New York Press.

Weimann, G. (2016). Opinion leadership. In G. Mazzoleni, K. G. Barnhurst, K. Ikeda, R. Maia, & H. Wessler (Eds.), *The International encyclopedia of political communication* (pp. 908–917). Oxford: Wiley-Blackwell.

Weimann, G., Tustin, D. H., van Vuuren, D., & Joubert, J. P. R. (2007). Looking for opinion leaders: traditional vs. modern measures in traditional societies. *International Journal of Public Opinion Research*, *19*(2), 173–190. https://doi.org/10.1093/ijpor/edm005

Westerman, D., Spence, P. R., & Van Der Heide, B. (2014). Social media as information source: Recency of updates and credibility of information. *Journal of Computer-Mediated Communication, 19(2)*, 171-183.

Williams, H. T. P., McMurray, J. R., Kurz, T., & Hugo Lambert, F. (2015). Network analysis reveals open forums and echo chambers in social media discussions of climate change. *Global Environmental Change*, *32*, 126–138. https://doi.org/10.1016/j.gloenvcha.2015.03.006

Wozniak, A., Wessler, H., & Lück, J. (2017). Who prevails in the visual framing contest about the united nations climate change conferences? *Journalism Studies*, *18*(11), 1433–1452. https://doi.org/10.1080/1461670X.2015.1131129

Wu, S., Hofman, J. M., Mason, W. A., & Watts, D. J. (2011). Who says what to whom on Twitter. In S. Sadagopan, K. Ramamritham, A. Kumar, M. P. Ravindra, E. Bertino, & R. Kumar (Eds.), *The 20th international conference* (pp. 705–714). https://doi.org/10.1145/1963405.1963504

Xu, W. W., Sang, Y., Blasiola, S., & Park, H. W. (2014). Predicting opinion leaders in Twitter activism networks. *American Behavioral Scientist*, *58*(10), 1278–1293. https://doi.org/10.1177/0002764214527091

Appendix: T-test results

	Civil society actor	Economic actor	Scientist	Political actor	Journalist
Degree	t=-5.64 p=0.000	t=-3.53 p=0.000	t=-4.32 p=0.000	t=-2.53 p=0.014	t=-4.05 p=0.000
In-degree	t=-5.89 p=0.000	t=-2.35 p=0.021	t=-3.26 p=0.001	t=-2.20 p=0.032	t=-3.49 p=0.001

Out-degree	t=-3.44 p=0.000	t=-6.29 p=0.000	t=-5.02 p=0.000	t=-6.78 p=0.000	t=-5.17 p=0.000
Closeness	t=-5.50 p=0.000	t=-1.01 p=0.317	t=-2.41 p=0.019	t=-4.07 p=0.000	t=-1.05 p=0.300
Betweenness	t=-2.83 p=0.005	t=-3.01 p=0.003	t=-2.37 p=0.021	t=-3.06 p=0.003	t=-2.93 p=0.005
Number of tweets	t=-2.86 p=0.005	t=-5.70 p=0.000	t=-4.72 p=0.000	t=-6.63 p=0.000	t=-5.17 p=0.000
Number of retweets	t=-5.11 p=0.000	t=-2.92 p=0.004	t=-2.84 p=0.006	t=-2.10 p=0.040	t=-3.80 p=0.000
Number of followers	t=2.07 p=0.041	t=4.10 p=0.000	t=9.71 p=0.000	t=-0.85 p=0.399	t=1.69 p=0.096