Social Networks

Networked discontent: The anatomy of protest campaigns in social media

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ABSTRACT

We analyze the communication network that emerged in social media around an international protest campaign launched in May 2012. Applying insights from network science and the theory of brokerage, we examine the cohesion of the network with community detection methods, and identify the users that spanned structural holes, creating bridges for potential information diffusion. We also analyze actual message exchange to assess how the network was used to facilitate the transmission of information. Our findings provide evidence of fragmentation in online communication dynamics, and of a distribution of brokerage opportunities that was both uneven and underexploited. We use these findings to assess recent theoretical claims about political protests in the digital age.

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1. Introduction

The terms 'networked politics' and 'networked social movements' have become very salient in the study of political protests and collective action in the digital age (Bennett and Segerberg, 2013; Castells, 2012; Earl and Kimport, 2011; Faris, 2013; Juris, 2008). Recent political events – from the Arab Spring or the Occupy movement in 2011, to the more recent protests emerging in Turkey, Brazil and Hong Kong (2013–2014) – have spurred much interest in how online technologies are helping coordinate large numbers of people in the absence of central organizations. Theoretical accounts of those events often rely on implicit assumptions about how online networks operate – assumptions that are rarely put to an empirical test and that are often not consistent with well-established findings in network science (Easley and Kleinberg, 2010; Newman, 2010; Newman et al., 2006; Watts, 2003) and the analysis of social networks (Carrington et al., 2005; Diani and McAdam, 2003; Kadushin, 2012; Monge and Contractor, 2003; Wasserman and Faust, 1994). This article applies the analytical tools of network theory to evaluate how online networks mediate collective action efforts.

Networks reflect organic forms of organization and they create a structure through which information flows (Monge and Contractor, 2003; Wasserman and Faust, 1994). A growing body of research suggests that online networks fall far from the decentralized structures to which new social movements are often metaphorically compared. In addition, online technologies offer no guarantee for a fast and broad diffusion of information: only when the structure of connections is conducive to chain reactions and cascading effects can online networks encourage diffusion (Easley and Kleinberg, 2010; Newman, 2010). Most online networks are sparse, which means that they are organized around structural holes that hamper diffusion and information spreading. The existence of bridges spanning those holes and the willingness of information brokers to facilitate diffusion are necessary conditions for information to travel. This requirement is not specific to online networks: social research has long identified the relevance of those features for diffusion in a number of contexts, including political mobilization (Burt, 1992; Gould, 1989; Gould and Fernandez, 1989; Granovetter, 1974; Kim and Bearman, 1997; Rogers, 2003; Valente, 1995; Watts, 2003). In spite of that evidence, network mechanisms are barely considered in recent theoretical accounts that describe how social media is used to organize collective action (Bennett and Segerberg, 2013; Castells, 2012; Faris, 2013; Gerbaudo, 2012). As a consequence, an important level of analysis is disregarded.

This article starts from the premise that, when seen through an empirical lens, networks are very diverse objects. As such, they need to be characterized before they can be linked to functions like

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the spread of information or the emergence of collective action. This exercise requires analyzing networks as structures of opportunity that might (or not) be realized. The analyses that follow show that the global connectivity often taken for granted in online networks depends on the existence of bridges (i.e. ties spanning structural holes) and the existence of brokers activating those connections. We provide evidence that online networks are highly centralized and fragmented, far from the horizontal and fluid structures they are often assumed to be (Castells, 2009, 2012). We show that only a minority of users bring online networks together and facilitate global dissemination in protest communication.

These empirical patterns, and what they reveal about digital mobilization and collective action, are obscured when theoretical accounts use networks as synonyms of 'social movements' and 'horizontal organizations'. Using network terms as shorthand for different slices of reality (i.e. social movements, decentralized action, communication structures) may be useful on a descriptive level, but it conceals how networks operate in practice. This paper focuses on the structure of one specific online network (Twitter), and on how it was activated to disseminate information about one specific global campaign ("United for Global Change", sponsored in 2012 by Indignados and Occupy members). The mechanisms and network features identified in this paper point, however, to generic principles behind the structure and function of many networks – and can therefore be generalized beyond our particular case study. The ability to generalize findings is core to any research endeavor; and it is, we argue, more difficult to attain under recent (but not necessarily compatible) theoretical accounts of how social media facilitates collective action. The following section elaborates on this point, fleshing out the conceptual elements behind the theory of networks as derived from network science and from studies on power.

We derive our working hypotheses from this theoretical discussion. Section 2 introduces the methods and data employed to test those hypotheses, and Section 3 presents the empirical findings. The results consider both the structural properties of the protest communication network (i.e. the opportunities for information flow) and the dynamic use of that structure (i.e. the extent to which those opportunities were realized to engage in actual communication). The final section concludes with a broader theoretical discussion of the findings and with the message that we need a more nuanced exploration of the network mechanisms underlying digital protests if we are to build theories that are both cumulative and generalizable.

2. The theory of networks

2.1. Networks as communication structures

Network theory offers a language and a method to understand patterns of organization and interdependence. Decades of analytical and empirical research have contributed to the development of the theory, which now stands as a solid common ground spanning many disciplines (Carrington et al., 2005; Monge and Contractor, 2003; Newman et al., 2006; Wasserman and Faust, 1994; Watts, 2003). Communication offers one of the main avenues for interdependence, creating ties that bring individuals together and channels through which information flows. Digital technologies have accelerated the speed of communication and amplified its reach; they have also made it easier to analyze connections and improve our understanding of how networks mediate the emergence of collective action. From a theoretical point of view, networks can be instrumental for two reasons: they open the paths for information to travel; and they place individuals at the crossroads of those paths, granting different abilities to control or promote information flows.

Actors with the ability to control the flow of information are, in network theory parlance, the brokers that create bridges and help maintain global connectivity. A common definition of brokerage in social networks relies on measures of structural constraint and betweenness centrality: brokers build networks with non-redundant connections, and they tend to lie in many of the paths that connect the other nodes in the network (Burt, 1992, 2005; Freeman, 1977, 1979; Girvan and Newman, 2002; Gould, 1989; Gould and Fernandez, 1989). Online technologies allegedly allow anyone with an internet connection to become an information broker and be in a position to trigger diffusion reactions. Network theory allows testing that assumption while answering two interrelated questions: How does this potential materialize? And what are the implications for how information flows online? In our context, the diffusion of information is relevant because it helps organize protests.

The idea that bridges in a network have important consequences for information flow is at least as old as the strength of weak ties argument (Granovetter, 1973). Weak ties bring socially distant groups together: they link parts of the network that would be unconnected (or less well connected) in their absence. The measure of structural constraint builds on this idea in the context of organizations: actors that span structural holes have lower constraint and are in a better position to manage information flow (Aral and Van Alstyne, 2011; Burt, 1992, 2005). When networks can be partitioned according to discrete categories (e.g. supporters of different causes or members of different organizations), the notion of brokerage adopts an additional dimension: it helps identify the actors that build bridges across groups, creating opportunities for information to travel beyond clusters of redundant communication (Gould, 1989; Gould and Fernandez, 1989). As Gould put it, "it may be misleading to analyze social structures under the assumption that all social ties have the same analytical status. Communication across sub-groups (. . .) may have profound effects on the relative power of individuals in social networks, while communication within such groups may be so frequent or unproblematic that its structure affords no insight into social processes" (Gould, 1989). The idea, in other words, is that the notion of brokerage can incorporate a criterion to group nodes in clusters where information is likely to be redundant.

Community detection methods offer a data-driven approach to such classification (Girvan and Newman, 2002; Newman, 2012). These methods also rely on the idea of betweenness but applied to the edges, not the nodes, which helps identify structural holes on a larger scale, i.e. beyond personal networks. Prior research suggests that communities identified on the basis of network structure often respond to exogenous attributes like ideological alignment or affiliations (Adamic and Glance, 2005; Conover et al., 2011; Grabowicz et al., 2012; Traud et al., 2011). Identifying communities in a network is important because they might make global information flows more difficult to attain: the relative absence of ties across communities means that information will, more often than not, be trapped in the areas of higher internal density.

Summing up, previous work suggests that networks facilitate the diffusion of information if some actors – the brokers – integrate with their ties communities and clusters. In the context of social movements, the absence of brokers means that networks would break into isolated components, separated by political or social barriers. Bridges, on the other hand, create paths for information diffusion – if and when they are activated. These bridges can be local, as captured by measures like structural constraint; or global, as captured by community detection methods. In addition, actors occupying brokerage positions need to engage in actual exchange to become information brokers. Networks afford but do not determine dynamics of information diffusion.

2.2. Networks as power structures

Controlling information flow grants power. This is the idea at the core of recent theoretical accounts of how digital technologies are transforming social movements and collective action – most prominently, the theories proposed by Castells (2009, 2012) and Bennett and Segerberg (2013). Online networks of communication, their argument goes, have flattened and decentralized the flow of information; as a consequence, they have helped undermine the old asymmetries that gave prominence to an elite of gatekeepers. This basic argument is elaborated under the rubric of two different theories: the theory of communication power (Castells, 2009) and the logic of connective action (Bennett and Segerberg, 2013), which offer alternative stories of why online networks are transforming social movements.

In Castells' approach, power relies on the ability to shape the minds of the public (Castells, 2009). This implies that "power is based on the control of communication and information, be it the macro-power of the state and media corporations or the micro-power of organizations of all sorts" (Castells, 2009, p. 3). According to this account, there are four types of power in contemporary societies. The first, "networking power", refers to how actors and organizations that are included in global networks have power over those who are not included; the second, "network power", refers to asymmetries that result from coordinating standards: power is exercised not by exclusion from networks but by an imposition of inclusion rules; the third, "networked power", refers to the power that some social actors have over other actors in the same communication network; and finally, there is the "network-making power", which results from the ability to build and program networks according to the interests and values of the "programmers" (Castells, 2009, pp. 42–47). This last form of power, the theory sustains, is the most crucial in contemporary societies and core to what Castells calls "networked social movements".

Other than changing the inflection of the word 'network', however, there is nothing in this conceptualization that allow us to characterize the role that networks play in communication dynamics. In a description of his network theory, Castells claims: "Of course, networks are formed by actors in their networking arrangements. But who these actors are and what their networks are is a matter of the specific configuration of networks in each particular context and in each particular process (. . .) Who does what, how, where, and why through this multipronged networking strategy is a matter for investigation, not for formal theorization" (Castells, 2011, p. 786). His more recent account of the Arab Spring, the 'Indignados' movement, and the Occupy campaign, however, does not offer that kind of investigation (Castells, 2012). The organizational ability of online networks is taken for granted, and no evidence is provided on how they enhance (or hamper) connectivity and information flow. Instead, the theory is distilled into claims such us "Movements are viral, following the logic of the Internet networks" (Castells, 2012, p. 224) or "the horizontality of networks supports cooperation and solidarity while undermining the need for formal leadership" (Castells, 2012, p. 225). These claims stand in opposition to much empirical evidence produced by network research and the analysis of online communication.

In Bennett and Segerberg's approach, on the other hand, communication becomes a new form of organization (Bennett and Segerberg, 2012). Digital technologies, they claim, demand changing the traditional paradigms used to explain collective action. These paradigms highlight the importance of resource mobilization, rational decision making, and the constant pondering of the costs and benefits of collective action; digital technologies, they argue, demand a theory that moves away from these notions and highlights, instead, the new logic of "connective action". This new logic results from large-scale personalized and digitally

mediated political engagement: "ideas and mechanisms for organizing action become more personalized than in cases where action is organized on the basis of social group identity, membership, or ideology" (Bennett and Segerberg, 2012, p. 744). Communication networks, the theory goes, articulate this type of personalized politics; but again, the theory does not provide guidance to characterize networks as they facilitate (or not) organized action. A theory that sees in networks the backbone of social and political life would benefit greatly from a more accurate inspection of how those networks form and function.

Other recent accounts of protests and contentious action depart from these theoretical constructs to add more empirical nuance to the claim that online networks and social media empower individuals. Gerbaudo's account of the Arab Spring, the 'Indignados' in Spain, and the Occupy campaign, for instance, challenges the assumption that these were leaderless movements (Gerbaudo, 2012). As he claims, "far from inaugurating a situation of absolute 'leaderlessness', social media have in fact facilitated the rise of complex and 'liquid' or 'soft' forms of leadership which exploit the interactive and participatory character of the new communication technologies" (Gerbaudo, 2012, Chapter 1). An alternative study of the 2011 Egyptian protests argues that social media networks "can trigger informational cascades through the effects of their interaction with independent media outlets and on-the ground organizers" (Faris, 2013, p. 22). And yet another study on the Egyptian mobilizations showed that social media use had a positive impact on the decision to protest (Tufekci and Wilson, 2012); the argument relies once more on the assumption that online networks facilitated information flow.

Overall, a review of the literature suggests that the language of networks has become common currency in different attempts to understand social movements in the digital age; however, abstractions and metaphors need to be translated into concrete operationalizations if they are to serve an explanatory purpose. Networks vary drastically in their properties and functionalities; claiming that we live in the age of networks offers little information if we do not also provide a richer picture of what those networks look like and how they allow individual actors to communicate and organize. The theoretical accounts just described are too ambiguous in their terminology to give a precise answer to those questions.

2.3. Research questions

The analysis of protest communication through online networks requires examining three levels of analysis: the global structure of the network; the local positions of individual actors; and the actual flow of information through those connections. Our first question focuses on the global level. Prior research suggests that many networks can be characterized by gaps separating areas of densely connected clusters (Easley and Kleinberg, 2010; Newman, 2010). The first step in our analyses determines whether the presence of structural holes is a significant feature in the protest campaign network. This question is theoretically important because structural holes create bottlenecks that can limit information diffusion, especially if the holes respond to constraints imposed by offline factors like affiliation to local groups (Breiger, 1974; Feld, 1981). If those factors crystalize in the form of sub-networks with higher internal density of connections, information flow risks being locally bounded.

The second question focuses on the individual level, that is, on the positions that specific actors have in the overall network. We are interested in the distribution of those positions and, in particular, in the degree of heterogeneity in brokerage potential. We contend that actors that have brokerage positions are more important for the global exchange of information. Following the theoretical discussion above, we differentiate two types of

brokerage: one based on the local definition of constraint (Burt, 1992); the other based on the global definition derived from community detection (Girvan and Newman, 2002). The theories of network power discussed above presume that online networks are flattening access to brokerage; however, alternative accounts of recent mobilizations suggest that self-organized movements also produce leadership structures (Gerbaudo, 2012). Our second question aims to test whether there were any visible heads in the campaign we analyze, as assessed by the brokerage potential of participants and the prominence conferred to them by other contributors to the network.

Finally, the third question focuses on the more dynamic level of actual information flow. It aims to operationalize the claim made above that networks offer opportunity structures that need to be realized. Our first two questions consider the network structure and the opportunities it affords; this third question is about how those opportunities are materialized in the actual exchange of protest information. We hypothesize that communication networks offer brokerage opportunities that are not exploited, which creates additional constraints on the ability of online networks to diffuse information. While previous research suggests that the structural properties of networks are important to understand the dynamics of information flow, it also offers evidence that the structure alone cannot always explain diffusion (Carrington et al., 2005; Newman et al., 2006; Wasserman and Faust, 1994; Watts, 1999). This is because networks respond to exogenous factors that depend on the political context, but also because networks ultimately respond to individual decisions: being in a position to broker information does not necessarily lead to brokerage behavior.

These research questions derive from network theory and prior research on brokerage in social networks. The analyses below offer an empirical lens to understand how social media operates, given the constraints and opportunities it affords to users. The goal is to shed light on dynamics that are obscured when theories are developed on a level of abstraction that precludes the empirical analysis of networks. Overall, our questions aim to reconstruct the anatomy of protest campaigns as they materialize in social media. Our main assumption is that social media creates channels for information exchange that can be instrumental in the coordination of social movements. The argument does not imply that decentralized forms of organization (or social movements, in general) can be reduced to a single layer of communication; rather, it suggests that analyzing the structure and dynamics of online networks can illuminate the mechanisms of self-organization that characterize new forms of collective action. In this sense, the mechanisms we identify transcend the use of any particular social media platform.

3. Data and methods

3.1. Case study: the 'Indignados' and Occupy

We focus on the communication network linking the 'Indignados' and Occupy movements as manifested in the use of social media (Twitter in particular). Both movements made instrumental use of social media to recruit sympathizers and participants, and to coordinate their calls for action (Andersen, 2011; Castells, 2012; Gerbaudo, 2012). These movements also converged several times since their emergence in 2011 to ally in the organization of global campaigns and to exchange information about strategies and tactics.

The 'Indignados' brewed up online in the early months of 2011. The movement rose as a response to the politics of austerity imposed by the Spanish government in the aftermath of the financial crisis. It was partly fueled by the uprisings in the Middle East, especially Egypt, which became a source of inspiration for many protesters. There were, however, many local precedents and campaigns that also gave muscle to the movement. The online platform Democracia Real Ya (Real Democracy Now) emerged as a network of blogs and online platforms that gravitated around a discussion group in Facebook. The platform and their manifesto gained a lot of attention through networks like Facebook and Twitter, which played a significant role in attracting interest and promoting conversations among protesters, journalists, and sympathizers.

A demonstration day was planned for May 15, a week prior to regional and municipal elections. This call was supported online by thousands of individuals and by hundreds of civil society organizations. On demonstration day, it also received the offline support of hundreds of thousands of protesters who turned up in the streets of many cities around the country. After the demonstration, some protesters decided to camp in public squares until the date for municipal elections, which were to take place throughout the country on May 22. During that week, the visibility of the movement in mainstream media grew exponentially, and so did online activity (Borge-Holthoefer et al., 2011; Vanilla-Rodirguez et al., 2012). Election Day arrived, and after that, the movement started to wind down. The camps were dismantled, and online networks entered a dormant phase.

These protests left behind a trail that was to lead to the emergence of the Occupy movement. When the Canadian activist magazine Adbusters launched a call in July of 2011 to occupy Wall Street, the idea was to exploit the tactics introduced by the Egyptian uprising and the Spanish 'Indignados' and encourage "a fusion of Tahrir with the acampadas of Spain" (Adbusters, 2011). The call established September 17 as the date for action and during the intervening months online networks were targeted with messages (and #OccupyWallStreet hashtags) and symbolic imagery, including the famous picture of the ballerina posing on the back of the Charging Bull in the financial district of Manhattan.

The beginnings of the Occupy movement are different from the 'Indignados' because it was originally orchestrated by established (albeit alternative) news media. Only when organizers on the ground got involved, which included groups from the anarchist scene of New York but also other grassroots and community-based organizations, did the movement start to consolidate and grow. Other online groups, like the hacktivist Anonymous, helped spread the message through online networks, and the Spanish 'Indignados' contributed to the spread of the Occupy call as early as July. This created the first explicit alliance between the two movements.

The estimated number of people gathering in Manhattan on September 17 ranges from 1000 to 5000 – which fell far from the original target of mobilizing 20,000 people. The movement spread to other cities in the U.S. only after some violent police reactions and the massive arrests that followed the Brooklyn Bridge march on October 1. The dynamics of that spatial diffusion reveal high levels of locality in the patterns of communication and a very unequal distribution in the allocation of attention, which was absorbed by a small number of locations, namely New York, California, and Washington, D.C. (Conover et al., 2013). After these events, the movement and their slogan ("we are the 99%") became a global phenomenon.

Again, Facebook and Twitter were essential tools for communication and mobilization – to the point that some protesters felt uneasy for depending so much on proprietary tools, in conflict with the openness of the movement (Castells, 2012, p. 175). A second explicit connection linking the Occupy and the 'Indignados' protests came with the international call for action planned for October 15, 2011 under the slogan "United for Global Change". Mobilizations were organized in more than 900 cities in 85 different countries around the world. Many of these protests resulted in new camps.

Since then, and with the camp sites ultimately dismantled, the movements were dormant for a few months and not very visible offline. They were still active in online networks, although
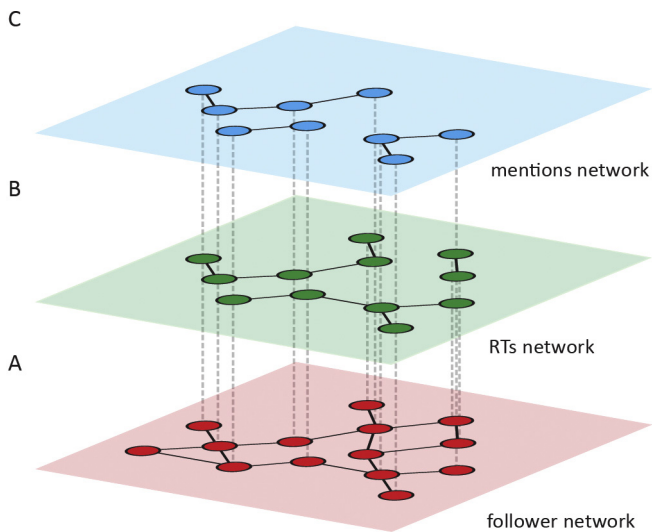
Fig. 1. Schematic representation of networks analyzed.

Table 1
Descriptive statistics of communication networks.

	Following/ follower	RTs	@Mentions
N (number of vertices)	125,222	85,307	60,485
E (number of directed edges)	8,510,654	178,781	132,431
$\langle d \rangle$ (mean degree)	136	4	4
Max (k_{in}) (maximum indegree)	27,518	3,930	1584
Max (k_{out}) (maximum outdegree)	9047	912	600
q (reciprocity)	0.489	0.026	0.036
C (mean transitivity or clustering)	0.181	0.113	0.226
r (degree correlation coefficient)	−0.139	−0.065	−0.094
# Components	41	3485	3574
N giant component	125,135	76,538	51,505
N 2nd largest component	4	53	76

with lower frequency of communication. The noise started to build up again as the date of the first anniversary of the 'Indignados' approached, and a new international call for action was planned for May 12, 2012, again under the slogan "United for Global Change". This is the protest we analyze here. We chose this case because it offers a good example of international mobilization through online networks when there is no clear offline organizational structure. In addition, a lot of attention has been paid in the literature to these movements and to how they used social media; our case selection was also informed by the empirical focus of that prior work.

3.2. Networks and metrics

We collected data during the period 30 April to 30 May using the Twitter search API, querying for messages that contained the top five hashtags related to the 'Indignados' movement, identified in previous work (González-Bailón et al., 2011), and variations of the word 'occupy*'. A total of 445,153 messages were collected. Because hashtags are often co-used, these messages contained many other hashtags we did not include in the original search list (close to 30 thousand). Using hashtags as a proxy to content, in line with the convention devised by Twitter users themselves, we classified messages as being related to the 'Indignados' or to the Occupy campaigns. Many messages contained hashtags relevant for the two movements.

Every message in our sample is linked to a unique user ID, which we used to snowball the following/follower structure. The one-step snowball crawl returned a network of more than 38 million users; of these, we only retained users that had sent at least one protest message during the period we observe, as well as their connections to other users that were also involved in protest communication. In addition, we parsed the messages to identify re-tweets (RTs) and mentions (@), which allowed us to reconstruct direct interactions and explicit channels of protest information flow. These three networks are nested layers of the same communication structure, as illustrated in Fig. 1.

To answer our first question, we only use the following-follower network (layer A): structural holes are defined at this level of interaction, which offers the basic opportunity structure for communication in this platform. Our second question, on the other hand, requires the three levels of analysis: our measures of brokerage are calculated using the following-follower network (layer A); but our definition of centrality in the flow of information relies

on activity in layers B and C. Finally, our third question considers activity on the networks that unfold in layers B and C.

The network statistics for these three networks are summarized in Table 1. They reveal that, as is usual in most online networks, centrality is distributed very unevenly: a minority of users concentrates most of the connections, and again a minority attracts and sends most of the messages (the maximum values compared to mean degree is indicative of the underlying long tailed distribution). The networks, however, are highly connected, with most users being part of a single giant component. In the analyses that follow, we use the follower network to identify bridges and structural brokers; we use the RTs and mentions networks to assess the extent to which those brokerage opportunities were realized.

For each user we have the number of messages sent, and a count of how many were intended for the Occupy audience (i.e. used variations of the Occupy* hashtag), and how many were intended for the 'Indignados' (i.e. used hashtags related to the Spanish protests). We used this count to classify users as affiliated to one of the two protest groups. Because our observation window includes the demonstrations to celebrate the first anniversary of the 'Indignados', there is more activity on that side of the network and as a consequence more users are classified in this group ($N = 74,007$); the rest are classified as users communicating mostly about the Occupy movement ($N = 51,212$). Our data does not allow us to determine whether these patterns of communication signal real affiliation to the offline movements (for instance, in the form of users actually protesting in the streets). However, our questions are not about how online activity translates into offline action, but instead about how online networks facilitate information flow.

Following the theoretical discussion above, we identify the brokers in the network using two structural definitions: one focusing on the local characteristics of personal networks; the second focusing on the modularity of the overall structure. The local definition employs the measure of structural constraint (Burt, 1992, Chapter 2; Burt, 2004, p. 362, n. 6). Constraint helps identify the nodes that are in a position to span structural holes in personal networks: it is a measure of local density and redundancy in connections. In the context of Twitter, the constraint of a user is higher if the user has less contacts, or the contacts are mutually connected (so connections in their personal networks are redundant); it is lower if a user is connected to other users that are not following each other (which means that the user has the possibility to span structural holes). A lower constraint indicates that an actor has higher brokerage opportunities.

The second definition of brokerage zooms out and takes into account the overall structure of the network making use of community detection algorithms. These methods partition the network in groups according to patterns in the density of connections. The approach assumes that users that are part of the same group will

have more internal links, which offers a bottom-up strategy to identify communities (and the holes that separate them) using the network structure itself. Classic methods for community detection use the betweenness of edges (Newman, 2012). The method first removes the edges that have higher betweenness scores and counts the number of communities that emerge as a result (that is, the number of unconnected sub-networks that result from the removal); it then iterates the process until there are as many communities as nodes in the network (i.e. all edges are removed). Going back through all the iterations, this method finds the best partition to classify nodes in dense groups.

The best partition is the classification that maximizes the modularity score, a coefficient that quantifies the strength of community structure by measuring how separated the groups are from each other. This score measures the fraction of all edges in the network that connect nodes in the same group minus the expected value in a network with the same classification but random connections. The expected value provides the benchmark or null model against which to test the significance of the community structure observed in networks. If the number of connections within groups is no better than random, the modularity score is $Q = 0$; as the score approaches $Q = 1$, the evidence that the network has a community structure becomes stronger. In practice, most values fall in the range from 0.3 to 0.7, which higher values being rarely observed (Newman and Girvan, 2004). According to this, a value above 0.5 can be interpreted as a significant departure from randomness and thus as evidence of community structure and the existence of structural holes.

Betweenness methods have high computational costs and are not efficient for networks that have more than a few thousand nodes. Because of the size of our data, we apply three alternative methods that are designed for large networks: fast greedy community detection (Clauset et al., 2004), label propagation (Raghavan et al., 2007), and network mapping based on the probability of information diffusion (Rosvall and Bergstrom, 2008; see also Csárdi and Nepusz, 2006 for details on implementation of these methods). The first two methods are still based on the assumption that connections should be denser inside groups than outside groups. The information mapping approach, by contrast, introduces a conceptual change by identifying communities not on the basis of patterns of connections but on how those connections would allow information to flow. Unlike the other two methods, this approach takes into account the directionality of links. Our analyses compare the consistency of these three classifications, and uses the modularity scores to assess the significance of the fragmentation.

Finally, we assess the extent to which these structural opportunities for brokerage are realized by looking at cross-posting behavior and at the flow of RTs and mentions. Although we classify users as 'mostly Indignados' or 'mostly Occupy' by counting the number of messages they send showing the corresponding hashtags, a minority of them (about 6.45% of all users, $N = 8082$) posted at least one message relevant for the two audiences. We label these users 'information brokers' to explicitly compare them with the 'structural brokers' (that is, users that have low constraint, or that bridge holes across communities). We also look at RTs and mentions to determine if both structural and information brokers are more visible and central in the actual flow of information – a precondition if global diffusion is to be channeled by the network.

4. Results

The results that follow consider both the structural properties of the communication network (i.e. the opportunities for information flow) and the dynamic use of that structure (i.e. the extent to which those opportunities are realized). Each section considers one of the three research questions introduced above.

4.1. Bridges and structural holes

The first question aims to evaluate whether the network used for protest communication is built around structural holes. Evidence supporting the presence of structural holes is theoretically important because those holes restrict the number of channels that can be activated for information flow. Fig. 2 shows the outputs of the three community detection algorithms described in the methods section; in particular, the figure displays the five largest communities, how they connect to each other, and the associated modularity score Q. Each community is represented by a pie chart that summarizes its composition in terms of movement affiliation (Fig. 2, panels 1a–3a) and in terms of presence of 'information brokers', that is, users sending messages relevant for both audiences (Fig. 2, panels 1b–3b). The goal of these analyses is to shed light on whether structural holes reflect offline affiliations and whether information brokers are concentrated on one part of the network.

According to the label propagation method, the network can be split in 61 communities (M), although 99.8% of users are classified in the top five (N_{top5}). The fast greedy approach results in 123 communities, although again a high percentage of users (99.6%) are assigned to the main five communities. The information mapping approach departs more significantly from the other two: it results in a higher number of communities, with the top five containing just above half of all users (53.2%). This departure is not surprising given that the method, as explained in the previous section, takes into account the directionality of links: it assigns users to communities depending on how easy information can flow among them. The information flow approach offers, for this reason, an interesting insight into how the network can operate as a conduit for diffusion. More communities means that there are more structural holes in the network – and therefore more bottlenecks affecting information flow.

In spite of these differences, the three methods offer a similar picture of the divide that exists across the 'Indignados' and Occupy side of the network. Information brokers (the minority of users posting messages relevant for both sides) are represented in most of these groups, which means that brokerage opportunities as afforded by the structure are potentially realized from all sides of the divide. The modularity scores Q for the three methods, however, suggest that the community structure (and the presence of structural holes) is very characteristic of this network – that is, the observed levels of fragmentation depart significantly from the expectation under the assumption of a null, random model of network formation. These communities reveal an organizational logic that cannot be reduced to chance, and (as the composition of the pie charts show) is not independent of exogenous factors like language or geographical distance.

4.2. Structural brokers

The second question tests whether users spanning structural holes are more central, influential, and visible than other users, forming an elite in the network of communication. The community detection approach discussed in the previous section allows us to identify the global brokers, that is, users spanning the structural holes separating communities on the meso-level. In addition, we can also identify the local brokers, that is, users who have low structural constraint in their personal networks and can potentially act as mediators amongst their neighbors. Fig. 3 summarizes the association between these two measures of brokerage and centrality, influence, and visibility as measured by the number of followers, the number of re-tweets, and the number of mentions received.
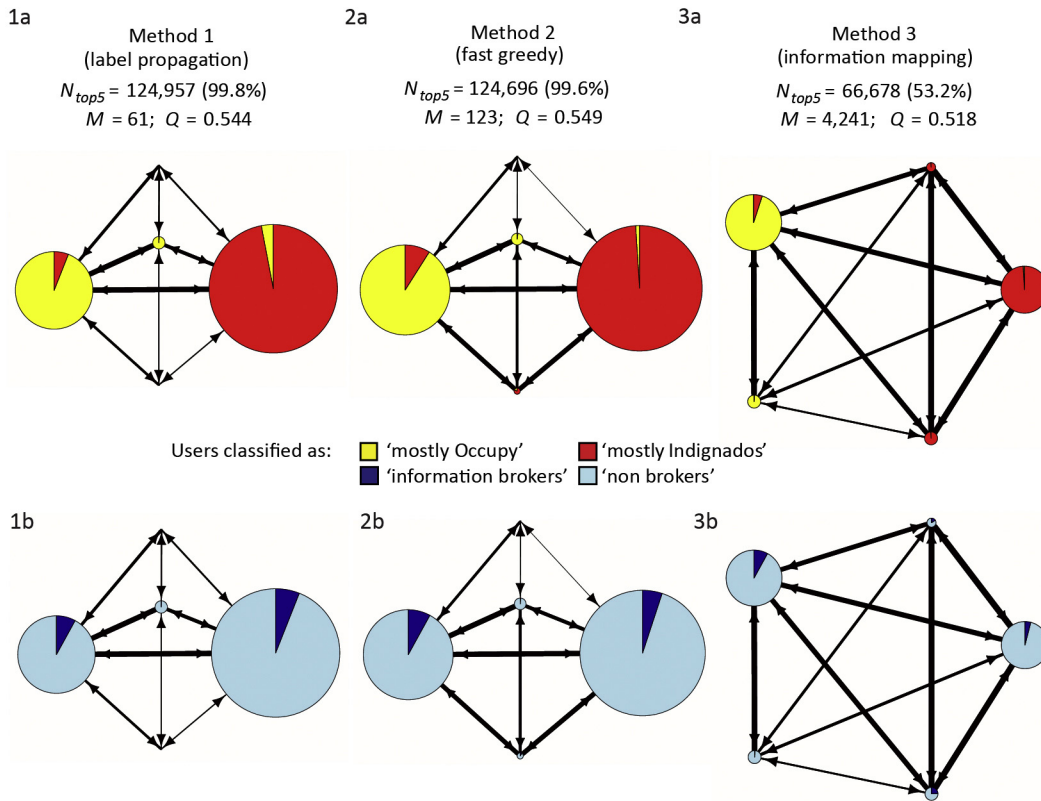
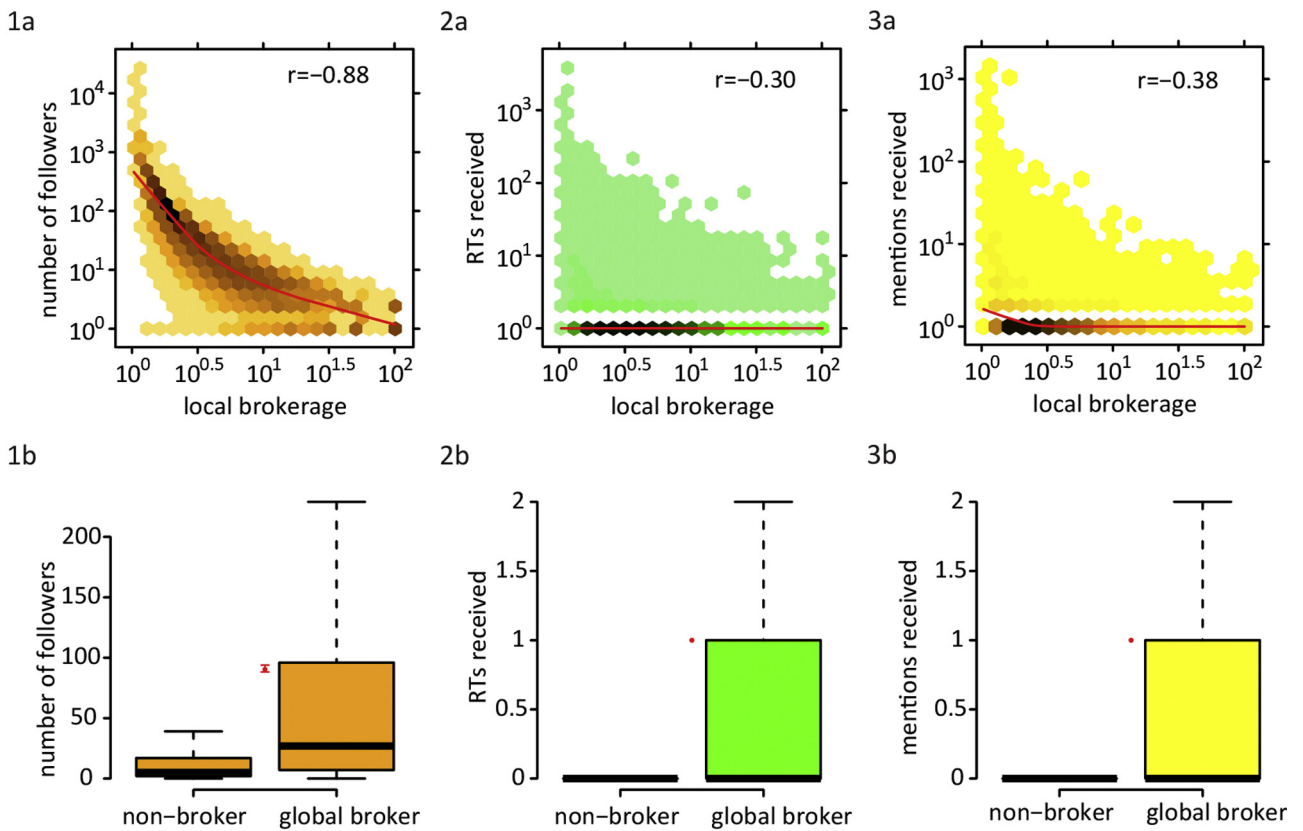**Fig. 2.** Structural holes and community composition.

Fig. 3. Association of brokerage (local and global) and centrality.

The scatterplots in Fig. 3, panels 1a–3a focus on the local measure of brokerage (data points are binned to avoid cluttering; darker colors signal higher frequencies). The first plot reveals a substantive and significant association between brokerage and indegree centrality (Spearman's rank correlation $r = -0.88$, 99% bootstrapped confidence intervals, $CI = -0.886, -0.881$). This means that users with larger audiences tend to span more local holes in their personal networks – not surprisingly, given that the size of networks affects how constraint is calculated. However, the association of local brokerage with influence is very weak ($r = -0.30$, $CI = -0.313, -0.295$); it is also weak for visibility ($r = -0.38$, $CI = -0.395, -0.373$). This means that being a local broker is associated only slightly to prominence in the exchange of information.

Structural brokers as defined by the global measure, on the other hand, are significantly more central, influential and visible than users who do not bridge structural holes (Fig. 3, panels 1b–3b; the boxplots omit outliers to ease visualization). The red dots show the observed difference in the upper quartiles; for the case of indegree centrality, the 99% CI of the difference is so small that it is barely visible ($CI = 77, 82$); for the case of influence and visibility, all boostrapped samples produced the same difference. The magnitude of the difference is not very substantive, but of course, most divergence takes place in the right tail of the distribution, which is longer for structural brokers. What this means is that users spanning structural holes at the global level are disproportionately better connected both in the network of followers in the more dynamic exchange of information via mentions and RTs. This minority of users in the tail of the distribution forms the elite that keeps the network together.

4.3. Information flow

The third question investigates what extent the brokerage opportunities offered by online networks are realized. The answer to this question is relevant because a poor activation of ties would exacerbate the limits imposed by structural holes to the ability to diffuse information. The findings discussed in the previous section showed that structural brokers, defined globally, are more visible than other users; but to what extent are they instrumental in diffusing information relevant for both audiences? Only about 10% of all the users creating bridges are information brokers, that is, they employ hashtags relevant for both the 'Indignados' and Occupy sides of the network. This suggests that there is a large number of users spanning holes across communities that do not engage in communication relevant for both audiences. Put differently, the use of the network reveals missed opportunities to promote global information flows.

Information brokers are a small minority of all users, and also a minority of the subset of users who span structural holes. The definition of information brokers, however, assumes that hashtags are a good proxy for content that is relevant for both movements. Another way to look at cross-group information flow is by analyzing the exchange of RTs and mentions, regardless of the hashtags used. RTs and mentions are the conventions used by Twitter users to broadcast information previously published by other users, or to engage in direct communication with them. Fig. 4 summarizes how many of the RTs and mentions that are generated stay inside each of the two groups, and how many travel to the other side of the network.

Panels 1a and 2a in Fig. 4 show that most information flows stay within the groups: only a tiny fraction of all RTs create communication channels from Occupy to 'Indignados' and vice versa. In the case of mentions (panel 2a), users on the Indignados side engage more frequently with users on the Occupy side – probably to gain their attention; however, their reaching out is not reciprocated by the Occupy audience. The difference between observed

and expected frequencies is statistically significant according to the Chi-squared test of independence (99% level). Panels 1b and 2b plot the standardized residuals for the cells in the contingency table; they confirm that there is substantially more exchange of information within each group than expected by chance, especially so in the case of RTs, which offer the main channel for information diffusion in this online network.

5. Discussion

The findings above provide evidence that protest communication networks are fragmented in ways that hamper the diffusion of information; that only a minority of users have the ability to bridge the structural holes in the network; and that only a few of those bridges are activated to allow information to flow from cluster to cluster. Our findings suggest that global brokerage is more important than local brokerage to identify pivotal actors in the exchange of information; the findings also reveal that online networks are not that different compared to other offline networks when it comes to creating the conditions for information flow: structural holes still need to be bridged, and the ties bridging those holes still need to be activated. In this sense, online networks are representative of wider communication structures, including more traditional forms of social networks – which have always created channels for recruitment and information flow (Gould, 1991; Lohmann, 1994; McAdam and Paulsen, 1993). Communication networks reproduce social distance in the form of fragmentation or lack of connections; and, as the findings reported here show, online networks are not an exception to that rule. The relevant theoretical question then is not how digital technologies are changing the logic of collective action, but whether and how they are changing the structure of communication networks. Determining the nature of that change is a logically prior step before an argument can be made on how social movements operate in the digital age.

Many of the accounts on how social media have changed collective action and political protest rely on arguments that border technological determinism. Distributed technologies afford many things, but users employ those technologies to build specific types of networks, and they use those networks in a way that does not necessarily exploit their diffusion potential. This paper has shown that online networks are not as fluid as the literature often implies; that only a few users span structural holes of low density; and that only a few of these users engage in actual information exchange. Most communication, our findings show, remains enclosed within clusters of redundant connections. Acknowledging this fact waters down some of the early enthusiastic claims celebrating digital technologies as revolutionary tools; it offers a more sober point of departure to decode how individuals form their political identities and decide to take part in collective action. In the end, groups and collective identities still shape much exposure to information, and these are not determined by communication alone but by the larger political context and institutional arrangements (Anduiza et al., 2012). One way in which the network approach helps advance our theoretical understanding of collective action is by analyzing dynamics of information diffusion as one important element within a larger, more complex picture. Theories that conflate different levels of analysis with a metaphorical use of network terms only make it more difficult to advance in that understanding – and go beyond the now abused claim that communication networks help people self-organize in the absence of formal organizations.

One could argue that the network analyzed here considers only one of the multiple layers of communication in which protesters and sympathizers engage; and that, were we to take into consideration all the other layers of information exchange that exist, the picture would look different – more aligned with recent theoretical
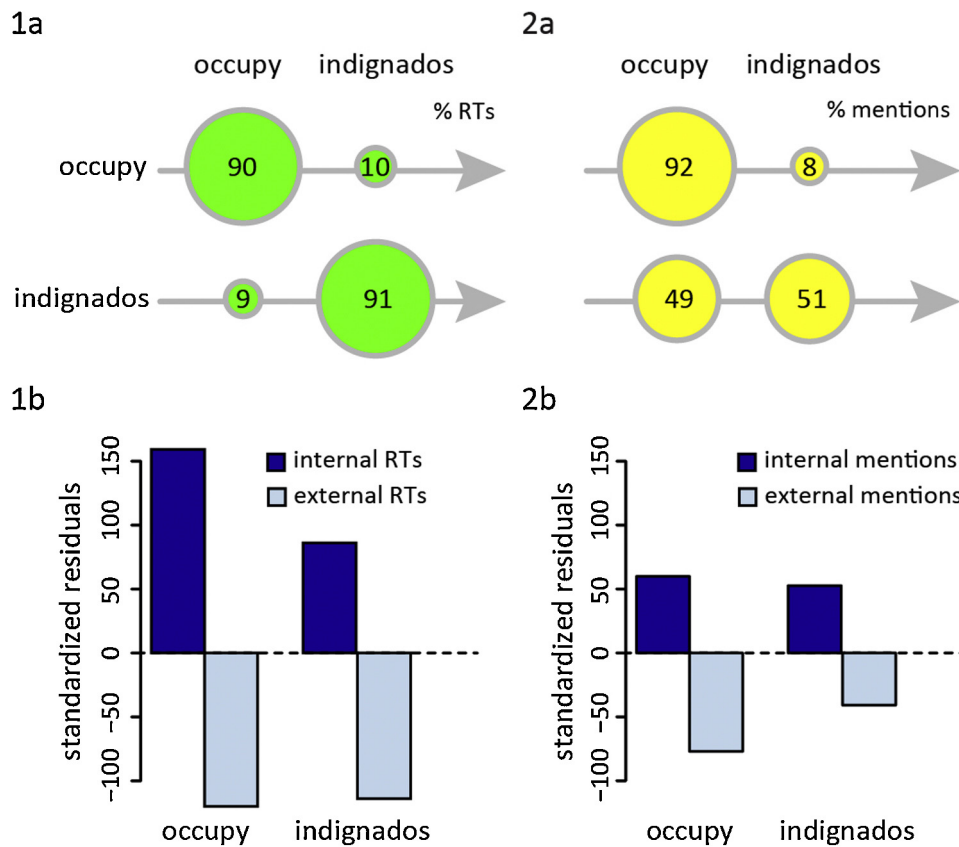
Fig. 4. Information exchange between Occupy and Indignados.

accounts of social movements and political protests (Bennett and Segerberg, 2013; Castells, 2012). Perhaps, but that is in any case an empirical question that requires an even more sophisticated analysis of how different networks of communication interact with each other. Developing our theories of networked collective action at a level of abstraction that does not differentiate networks for their features does not offer a very useful starting point to start tackling that question.

In addition, the mechanisms we identify here are generic to any network, which helps build continuity with prior research and theories exploring the role that networks play in the growth of social movements (Diani and McAdam, 2003). Digital technologies have not changed the basic social processes that underlie communication and the flow of information; they have not changed the mechanisms that encourage people to join a collective action effort. What technologies have changed is the speed and the reach of communication; but, as our findings show, we can assume very little about the nature of that change without conducting specific analyses. In the absence of those analyses, theories can only speculate about why digital networks are so important for the organization of collective action.

Our findings also point to open questions that require further attention: How do changes in the structure of protest networks affect diffusion dynamics and the growth of movements? Are there better network metrics to identify pivotal actors? How does the structural positions of actors relate to their roles within social movements? How stable are those positions and roles over time? Are protest networks able to recover from attrition or fatigue? Solving these and other related questions requires more empirical work – no single research project can tackle them all at the same time. But adopting the analytical language of networks, and assessing networks as empirical objects, gives us the tools to confront those

questions in a way that more abstract theoretical approaches do not allow, encouraging a cumulative growth of knowledge that transcends attention to specific case studies.

Future research should consider other cases where online networks have also mediated the organization of political protests, for instance the protests that emerged in Turkey in May 2013 or the more recent protests emerging in Hong Kong in December 2014. The political context surrounding these events is very different, but the network approach helps identify a common ground for comparative research: it can shed light on how similar the networks underlying those events were, and whether their activation patterns differed in any significant way. These features can then be associated with the specific details of the political context and the support provided by the respective civil societies.

The question of how online dynamics relate to offline action remains on the table (Golder and Macy, 2014). We could argue that the protest analyzed here did not attain the same repercussion as the previous call for action ("United for Global Change", October 2011) because of the fractured communication dynamics we identify. Of course, the success or failure of social protests does not depend exclusively on communication dynamics – the larger social context matters greatly, among other things because social media use responds strongly to that context. But if massive coordination depends on an effective diffusion of information, then the theoretical approach we follow in this paper gives us the criteria to differentiate episodes of collective action – instead of lumping them all together under the labels 'networked social movements' (Castells, 2012) or 'the logic of connective action' (Bennett and Segerberg, 2013). Networks are always present, both in cases of success and in cases of failure; the interesting question is under what conditions networks are more conducive to success.

6. Conclusions

The study of contentious politics in the digital age abounds in network talk, as recently expressed in influential theoretical accounts of political protests under the rubric of "the logic of connective action" (Bennett and Segerberg, 2012) and "networked social movements" (Castells, 2012). This paper has argued that, to advance in that theoretical discussion, the language of networks has to be made analytical, building on a long tradition of network research and empirical findings. A nuanced and analytical methodology is required to disentangle the ways in which communication networks allow information to flow – or trap it, instead, within the boundaries of local communities. The findings reported in this paper suggest that the global connectivity of social media networks is undermined by structural holes that only a minority of users bridge. We have assessed the theoretical implications of these findings, and defended a more cumulative approach to the analysis of how communication networks mediate collective action.

Acknowledgments

References

Adamic, L., Glance, N.S., 2005. The political blogosphere and the 2004 U.S. election: divided they blog. In: Paper Presented at the 2nd Annual Workshop on the Weblogging Ecosystem: Aggregation, Analysis and Dynamics, WWW 2005, Japan.

Adbusters, 2011, 13 July. #OccupyWallStreet: A Shift in Revolutionary Tactics, Available from: http://www.adbusters.org/blogs/adbusters-blog/occupywallstreet.html

Andersen, K., 2011, December 14. The Protester. Time, Retrieved from: http://www.time.com/time/specials/packages/article/0,28804,2101745_2102132,00.html

Anduiza, E., Jensen, M., Jorba, L. (Eds.), 2012. Digital Media and Political Engagement Worldwide. A Comparative Study. Cambridge University Press, Cambridge.

Aral, S., Van Alstyne, M., 2011. The diversity-bandwidth trade-off. Am. J. Sociol. 117 (1), 90–171, http://dx.doi.org/10.1086/661238.

Bennett, W.L., Segerberg, A., 2012. The logic of connective action. Information. Commun. Soc. 15 (5), 739–768, http://dx.doi.org/10.1080/1369118x.2012.670661.

Bennett, W.L., Segerberg, A., 2013. The Logic of Connective Action. Digital Media and the Personalization of Contentious Politics. Cambridge University Press, Cambridge, UK.

Borge-Holthoefer, J., Rivero, A., García, I., Cauhé, E., Ferrer, A., Ferrer, D., Moreno, Y., 2011. Structural and dynamical patterns on online social networks: the Spanish May 15th movement as a case study. PLoS ONE 6 (8), e23883, http://dx.doi.org/10.1371/journal.pone.0023883.

Breiger, R.L., 1974. The duality of persons and groups. Soc. Forces 53 (2), 181–190.

Burt, R.S., 1992. Structural Holes. The Social Structure of Competition. Harvard University Press, Cambridge, MA.

Burt, R.S., 2004. Structural Holes and Good Ideas. Am. J. Sociol. 110 (2), 349–399, http://dx.doi.org/10.2307/3568221, citeulike-article-id:3483879.

Burt, R.S., 2005. Brokerage and Closure. An Introduction to Social Capital. Oxford University Press, Oxford.

Carrington, P.J., Scott, J., Wasserman, S., 2005. Models and Methods in Social Network Analysis. Cambridge University Press, Cambridge.

Castells, M., 2009. Communication Power. Oxford University Press, Oxford.

Castells, M., 2011. A network theory of power. Int. J. Commun. 5, 773–787.

Castells, M., 2012. Networks of Outrage and Hope. Social Movements in the Internet Age. Polity, Cambridge.

Clauset, A., Newman, M.E.J., Moore, C., 2004. Finding community structure in very large networks. Phys. Rev. E 70 (6), 066111, http://dx.doi.org/10.1103/physreve.70.066111.

Conover, M.D., Ratkiewicz, J., Francisco, M., Goncalves, B., Flammini, A., Menczer, F., 2011. Political polarization on Twitter. In: Paper Presented at the AAAI International Conference on Weblogs and Social Media (ICWSM), Barcelona, Spain, July 17–21.

Conover, M.D., Ferrara, E., Menczer, F., Flammini, A., 2013. The Digital Evolution of Occupy Wall Street. PloS ONE 8 (5), e64679, http://dx.doi.org/10.1371/journal.pone.0064679.

Csárdi, G., Nepusz, T., 2006. The igraph software package for complex network research. InterJ. Complex Syst., 1965.

Diani, M., McAdam, D., 2003. Social Movements and Networks. Relational Approaches to Collective Action. Oxford University Press, Oxford.

Earl, J., Kimport, K., 2011. Digitally Enabled Social Change: Activism in the Internet Age. MIT, Cambridge, MA.

Easley, D., Kleinberg, J., 2010. Networks, Crowds, and Markets: Reasoning About a Highly Connected World. Cambridge University Press, New York.

Faris, D., 2013. Dissent and Revolution in a Digital Age: Social Media, Blogging, and Activism in Egypt. I.B. Tauris, London.

Feld, S.L., 1981. The focal organization of social ties. Am. J. Sociol. 86 (5).

Freeman, L.C., 1977. A set of measures of centrality based upon betweenness. Sociometry 40, 35–41.

Freeman, L.C., 1979. Centrality in social networks: conceptual clarification. Soc. Netw. 2 (3), 215–239.

Gerbaudo, P., 2012. Tweets and the Streets. Social Media and Contemporary Activism. Pluto Books, London.

Girvan, M., Newman, M.E.J., 2002. Community structure in social and biological networks. Proc. Natl. Acad. Sci. U. S. A. 99 (12), 7821–7826, http://dx.doi.org/10.1073/pnas.122653799.

Golder, S.A., Macy, M.W., 2014. Digital footprints: opportunities and challenges for online social research. Annu. Rev. Sociol. 40 (1), 129–152, http://dx.doi.org/10.1146/annurev-soc-071913-043145.

González-Bailón, S., Borge-Holthoefer, J., Rivero, A., Moreno, Y., 2011. The Dynamics of Protest Recruitment through an Online Network, vol. 1. Scientific Reports, pp. 197.

Gould, R., 1989. Power and social structure in community elites. Soc. Forces 68 (2), 531–552, http://dx.doi.org/10.2307/2579259.

Gould, R., 1991. Multiple networks and mobilization in the Paris Commune, 1871. Am. Sociol. Rev. 56 (6), 716–729.

Gould, R., Fernandez, R.M., 1989. Structures of mediation: a formal approach to brokerage in transaction networks. Sociol. Methodol. 19, 89–126, http://dx.doi.org/10.2307/270949.

Grabowicz, P.A., Ramasco, J.J., Moro, E., Pujol, J.M., Eguiluz, V.M., 2012. Social features of online networks: the strength of intermediary ties in online social media. PLoS ONE 7 (1), e29358, http://dx.doi.org/10.1371/journal.pone.0029358.

Granovetter, M., 1973. The strength of weak ties. Am. J. Sociol. 78, 1360–1380.

Granovetter, M., 1974. Getting a Job: A Study of Contacts and Careers. University of Chicago Press, Chicago, IL.

Juris, J.S., 2008. Networking Futures. The Movements Against Corporate Globalization. Duke University Press, Durham, NC.

Kadushin, C., 2012. Understanding Social Networks. Theories, Concepts and Findings. Oxford University Press, Oxford.

Kim, H., Bearman, P.S., 1997. The Structure and Dynamics of Movement Participation. Am. Sociol. Rev. 62 (1), 70–93, http://dx.doi.org/10.2307/2657453.

Lohmann, S., 1994. Dynamics of informational cascades: the Monday demonstrations in Leipzig, East Germany, 1989–1991. World Polit. 47 (1), 42–101.

McAdam, D., Paulsen, R., 1993. Specifying the relationship between social ties and activism. Am. J. Sociol. 99 (3), 640–667.

Monge, P.R., Contractor, N.S., 2003. Theories of Communication Networks. Oxford University Press, Oxford.

Newman, M.E.J., 2010. Networks. An Introduction. Oxford University Press, Oxford.

Newman, M.E.J., 2012. Communities, modules and large-scale structure in networks. Nat. Phys. 8, http://dx.doi.org/10.1038/nphys2162.

Newman, M.E.J., Barabási, A.L., Watts, D.J. (Eds.), 2006. The Structure and Dynamics of Networks. Princeton University Press, Princeton, NJ.

Newman, M.E.J., Girvan, M., 2004. Finding and evaluating community structure in networks. Phys. Rev. E 69 (2), 026113, http://dx.doi.org/10.1007/978-3-540-88192-6.64.

Raghavan, U.N., Albert, R., Kumara, S., 2007. Near linear time algorithm to detect community structures in large-scale networks. Phys. Rev. E 76 (3), 036106, http://dx.doi.org/10.1103/PhysRevE.76.036106.

Rogers, E.M., 2003. Diffusion of Innovations, 5th ed. Free Press, New York.

Rosvall, M., Bergstrom, C.T., 2008. Maps of random walks on complex networks reveal community structure. Proc. Natl. Acad. Sci. U. S. A. 105 (4), 1118–1123, http://dx.doi.org/10.1073/pnas.0706851105.

Traud, A., Kelsic, E., Mucha, P., Porter, M., 2011. Comparing community structure to characteristics in online collegiate social networks. SIAM Rev. 53 (3), 526–543, http://dx.doi.org/10.1137/080734315.

Tufekci, Z., Wilson, C., 2012. Social media and the decision to participate in political protest: observations from Tahrir Square. J. Commun. 62 (2), 363–379, http://dx.doi.org/10.1111/j.1460-2466.2012.01629.x.

Valente, T.W., 1995. Network Models of the Diffusion of Innovations. Hampton Press, Cresskill, NJ.

Vanilla-Rodriguez, N., Scellato, S., Haddadi, H., Forsell, C., Crowcroft, J., Mascolo, C., 2012. Los Twindignados: the rise of the indignants movement. In: Paper Presented at the Proceedings of ASE/IEEE International Conference on Social Computing (SocialCom), Amsterdam, The Netherlands.

Wasserman, S., Faust, K., 1994. Social Network Analysis: Methods and Applications. Cambridge University Press, Cambridge.

Watts, D.J., 1999. Small Worlds. The Dynamics of Networks between Order and Randomness. Princeton University Press, Princeton, NJ.

Watts, D.J., 2003. Six Degrees. The Science of a Connected Age. William Heinemann, London.