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Online collective identity: The case of the environmental movement☆

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ABSTRACT

Social movements are making extensive communicative and organizational use of the Internet in order to identify social problems and bring about change. We present a model of an online social movement, where actors exchange practical and symbolic resources through hyperlink and online frame networks. Our positioning of these exchanges within a continuum of conscious and unconscious expressive behavior informs our framework for the empirical analysis of online collectives. An application using data collected from the websites of over 160 environmental activist organizations reveals significant fragmentation in this field of contentious activity, which we suggest reflects offline social divisions.

1. Introduction

In recent years, social movements have made extensive use of the Internet for communicative and organizational purposes; see, for example, Garrido and Halavais (2003) and van de Donk et al. (2004) on the Global Justice movement and Pickerill (2001) on the environmental movement. Indeed, Castells (2004) argues that by enabling values such as diversity, decentralization, informality and grassroots democracy rather than centralization and hierarchy, information and communication technologies fit perfectly the ideological and organizational needs of social movements.[1]

It is clear that the web has emerged as a prime vector for the formation and operation of social movements, but what exactly does this new environment entail for the process whereby organizational actors come together to form a collectivity? Empirical research into this question has involved both obtrusive research methods, such as interviewing owners or organizers of social movement websites (e.g. Pickerill, 2001), and unobtrusive research methods involving the analysis of website content (text and hyperlink data) with no interaction with the principals in charge of the website (e.g. Garrido and Halavais, 2003; Shumate and Dewitt, 2008).

Our contribution falls within the latter group. In our view, empirical analysis of online social movements must take into account the fact that websites are dynamic (content can change frequently, and with some organizations even the URL of the site is not fixed), and that it is often very difficult to identify the people involved in running a given website. Further, such people are frequently hard to interview because they are deliberately elusive, or have little interest in interacting with researchers (there is anecdotal evidence about the rising prevalence of survey fatigue). "Large N" studies using obtrusive methods are thus difficult to achieve. In this context, unobtrusive methods involving digital trace data extracted from the websites run by social movement organizations represent an attractive option for online researchers.

However, the study of online social movements using digital trace data suffers from the absence of an appropriate theoretical framework. In fact, this problem concerns much social science research using digital trace data; as noted by Janetsko (2009, p. 170) ". . .work centering around nonreactive [online] techniques more or less exclusively addresses visualization of phenomena that are perhaps not properly understood". Empirical studies of online activist networks (Garrido and Halavais, 2003; van Aelst and Walgrave, 2004) have identified central clusters as playing important connecting roles, but have not precisely analyzed how online activists communicate their vision, or whether their hyperlinking strategies reflect significant organizational characteristics. Therein lies our paper's intended contribution.

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[1] Some authors have questioned the importance and impact of online social movements. van de Donk et al. (2004, p. 18) suggest that online social movements may lack the attractions of a group experience and the "fun and adventure" factor that accompanies some forms of "offline" protest, thus lessening their appeal to potential participants. Since online social movements are easier to join and leave, and sometimes lack ideological coherence, it may be more difficult to organize and halt campaigns, a prime bargaining tool against campaign targets (Bennett, 2004). Another contentious point is that since online social movements are easily accessible for research purposes, researchers may be tempted to overstate their importance (Rucht, 2004). While these objections have merit, we believe that the Internet plays a vital role for contemporary protest groups, in conjunction with offline activity.

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We present a network-theoretic conceptualization of an online social movement. Social networks have long been recognized as playing a central role in the formation of social movements in general and environmental activist networks in particular, whether in terms of recruitment of participants (Diani and Lodi, 1988), internal organization (Ansell, 2003) or transnational coalition-building (Rohrschneider and Dalton, 2002). However it is Diani (1992, 2001, 2003) who has done the most to advance network concepts and methods in the study of social movements, and the present paper aims to extend Diani's approach to the online world.

In line with New Social Movement (NSM) theory, with which Diani is identified, our model emphasizes the importance of a shared sense of identity between social actors for the emergence of collective behavior (Melucci, 1995). Specifically, we present a model where social movement actors exchange practical and symbolic resources in the guise of website text content and hyperlinks, as part of a process of online collective identity formation.

With regards to website text content, we build on existing research into the use of text by social movement actors when creating "frames", which enable social problems to be legitimately identified and addressed, perhaps as the basis for future collective action. Research into offline social movements (e.g. Hunt et al., 1994) has emphasized the importance of frames for the development of collective identity; Evans (1997, p. 454) argues that "collective identities result from framing processes". We present a new approach for quantitatively identifying network representations of online frames. Our approach draws on the concept of "semantic network" in organizational science (Monge and Eisenberg, 1987; Stohl, 1993) and involves the use of machine learning techniques, representing a significant departure from previous approaches to social movement frame analysis.

The other component of our online collective identity model, the formation of hyperlinks between social movement organizations, is also addressed using network concepts and techniques. However, while we model online frame development as a purely symbolic action, we regard hyperlinks as facilitating the exchange of both symbolic and practical resources. We call the latter "index authority" (since sites with more in-links tend to be ranked higher in search engine indexes such as Google).

Our network-theoretic approach to modeling online collective identity allows us to analyze the use of website text content and hyperlinks by social movement actors using techniques from statistical social network analysis (SNA). In particular, we use exponential random graph models (ERGM – e.g. Robins et al., 2007) to identify the "structural signatures" (or unique patterns of ties that can be statistically identified in a given network) of organizational online frame and hyperlink networks. By representing online collective identity as networked behavior we are able to advance three hypotheses about the use of the web by organizational actors seeking social change, providing new insights into collective behavior in the Internet age.

Our first hypothesis regards the existence of homophily – the tendency for actors to prefer to form ties with those who are similar in socially significant ways (see, e.g. McPherson et al., 2001) – in the networks that represent the hyperlink and online frame behavior of social movement organizations: we argue that this homophily is a necessary structural signature of online collective identity. Second, we contend that the informal networking behavior that is a hallmark of social movements should be empirically evident in the hyperlink networks formed by such actors, and our operationalization of the concept of informal hyperlinking allows us to test this contention. Our final hypothesis relates to the distinction between conscious expressive behavior (hyperlinking) and potentially unconscious expressive behavior (participation in development of online frames). Conceptualizing hyperlinking and online frame development as being "two sides of the same coin" in the process of online collective identity formation, and treating both of these phenomena as networked behavior at the organizational level, allows us to posit the existence of empirically-discernible differences in the structural signatures of the relevant networks. We then use unobtrusively-collected web data for over 160 environmental activist organizations and find substantial empirical support for our theoretical model.

The paper is structured as follows. Section 2 presents Diani's definition of a social movement. Section 3 outlines our approach for modeling online collective identity, and details our three hypotheses regarding the structural signatures of hyperlink and online frame networks formed by actors seeking social change. Section 4 introduces our dataset on environmental activists and discusses our data collection methods and our approach to constructing hyperlink and online frame networks. Section 5 presents analysis of the online collective identity network data. In Section 6, we discuss the analytical results in the context of the three hypotheses. Conclusions are provided in Section 7.

2. Social movements

Social movements can be understood as a plurality of individuals, groups and/or organizations, engaged in a political or cultural conflict, on the basis of a shared identity (Diani, 1992). More specifically, we follow Diani (2003), in defining a social movement as a grouping of actors who: (1) share a collective identity; (2) exchange practical and symbolic resources through informal networks; and (3) engage in conflict or competition (e.g. for resources, members and attention) to enact or resist social change.

While this definition allows for social movement actors to include individuals as well as organizations, we focus on *social movement organizations* (SMOs) as actors in a social movement. We now discuss in detail two of the three aspects of the abovementioned definition of a social movement (collective identity and exchange through networks); a companion paper (O'Neil and Ackland, 2011) examines competition in online social movements.

2.1. Social movements, collective identity and frames

Collective identity is a mutually agreed upon definition of membership, boundaries, activities and norms of behavior used to characterize a grouping of actors. Collective identity helps to understand why collective actors come together when they do, how non-material interests may motivate action, and how movements can affect not just institutional reform but also cultural representations and social norms (Polletta and Jasper, 2001). Melucci (1995) has argued that collective identity is the interactive and shared process by which social actors come together to form a collectivity: this process involves shared cognitive definitions such as language and rituals; networks of active relationships between actors; and a degree of emotional investment which enables people to feel part of a common unity. Social networks play a defining role in generating a sense of belonging and shared definitions of "us/them". A similar point is made by Snow (2001, p. 2213) who writes that "...discussions of [collective identity] invariably suggest that its essence resides in a shared sense of 'one-ness' or 'we-ness' anchored in real or imagined shared attributes and experiences among those who comprise the collectivity and in relation or contrast to one or more actual or imagined sets of 'others'".

Collective identity exists within a social movement at three levels. First, there is the collective identity of the social movement itself – all actors within the environmental movement share a common goal of protecting the environment. Second, there may be distinct and identifiable collective identities within the social movement, i.e. there may exist groupings of SMOs who constitute sub-movements. For example, within the US environmental movement Machlis (1990) identified a structural and permanent tension between local groups who are energized by confrontation and struggle, and national organizations who focus on the institutional management of issues. Another distinguishing principle is the cause around which sub-movements coalesce. The development of the Environmental Justice movement in the 1980s (Szasz, 1994; Lichterman, 1996) was followed in the 1990s by the emergence of SMOs whose collective identity was primarily focused around the issue of biotechnology (Schurman, 2004; Herring, 2008). Finally, collective identity also exists at the level of the individual SMO: the identity of an SMO will reflect that of the individual members of the organization. While not discounting the importance of collective identity at the organizational-level, this paper focuses on collective identity at the movement and sub-movement levels.

The concept of frame is central to collective identity. By rendering events meaningful, frames function to organize experience and guide collective or individual action (Benford et al., 1986). They allow for a social problem to be legitimately identified and addressed, perhaps as the basis for future collective action. Without "shared meanings and definitions" brought by people to their situation, it is unlikely that actors will form a collective identity and permanently join forces (McAdam et al., 1996).

In the context of social movements, Rucht (2004) suggests that the proliferation of issues such as environmentalism, which are apparently not related to a particular social class (which previously provided a natural base for activists), means that SMOs address broader and more diverse audiences, and consequently need to invest more in discursive struggles. In particular, environmental activists need to bridge public political discourse and their target audience's experiential knowledge of the everyday, integrating them in a coherent frame (Gamson, 1994).

2.2. Exchange of resources through networks

A network is a set of nodes (or vertices) and a set of ties (or edges) indicating connections between the nodes. The relational ties in a network may be "directed" (e.g. person x recommends person y, but person y may not recommend person x) or "non-directed" (e.g. if person x has a familial relationship with person y, the converse must also be true).

Diani's (2003) definition of a social movement mentions the exchange of practical and symbolic resources through informal networks (we return to the definition of an informal network in Section 2.3). We define practical resources as resources that can be valued or measured objectively, while symbolic resources are inherently subjective and non-quantifiable. An example of the former is money, members, information and in-kind support while the latter refers to feelings of inclusion and exclusion (a shared sense of one-ness or we-ness).

We therefore define an *organizational practical exchange network* as a directed network where ties between organizations represent the exchange of practical resources. An exchange network is also referred to by Diani (2003, p. 307) as a "concrete" network. In their analysis of the networks of voluntary organizations in two British cities, Diani and Bison (2004) asked the organizations to list their most important partner organizations in alliances. The resulting "alliance network" is used as a proxy of the underlying practical exchange network, but the authors stress (p. 290) that the network "is best interpreted as an indicator of perceptions of closeness rather than objective intensity of exchange." In their study of environmental NGOs, Hoffman and Bertels (2007) build a network of board interlocks between the NGOs as a proxy for "institutional channels of influence". The board interlock network is similarly a proxy for an underlying practical exchange network, and the authors specifically mention the importance of board interlocks for obtaining access to information and funding.

We define an *organizational symbolic exchange network* as an undirected network where ties between organizations reflect mutual recognition of shared characteristics and goals. Diani and Bison (2004, p. 298) assessed whether the voluntary organizations in their study "...feel links to their partners ...[which] imply some kind of broader and long-term mutual commitment? Do they, in other words, share a collective identity?" The authors constructed an "identity network" (or symbolic exchange network) using information on joint membership between organizations and joint participation in important recent public events.

2.3. Informal networks

An aspect of Diani's definition of a social movement that requires further elucidation is the fact that practical and symbolic resources are exchanged through informal networks. The territory in which social movement actors operate has been characterized as "free spaces" (Evans and Boyte, 1986), "sequestered social sites" (Scott, 1990) and "submerged networks" (Mueller, 1994). These concepts describe sites where social actors can develop counterhegemonic ideas and oppositional identities independently from the physical and ideological control of those in power (Polletta and Jasper, 2001). When it comes to the Global Justice movement, for example, it has become common to think not of a single movement, but of a decentralized "movement of movements", in which a fluid constellation of groups is difficult to control, monitor and police (Mertes, 2004). This organizational structure is intended to guard against the formation of hierarchies and the centralization of power: no central committee distributes the correct "line" of resistance. The absence of fixed points or centres means that themes are created and disseminated through multiple networks and connections, formed and maintained by forums and gatherings (Shukaitis, 2005).

We operationalize these ideas by proposing three measures of network informality. First, network ties need to be easily re-configured (and indeed, there should be empirical evidence that such re-configuration is occurring). Second, the network needs to be "horizontal" in that actors typically have fairly equal roles or positions within the network (thus, the network is not too highly centralized). Third, there needs to be significant evidence of purely structural network tie formation, as identified using Exponential Random Graph Modeling (ERGM).

This third measure of network informality requires further discussion. ERGM (e.g. Robins et al., 2007) is an approach for statistically "unpacking" social networks – it allows the identification of the social forces that have led to the emergence of a particular social network by decomposing the ties into two broad types of network "effects" or structural signatures.[2] Purely structural network effects refer to informal network ties (also called endogenous or self-organizing network ties) that arise as a result of social norms, rather than being related to the attributes of the actors sending and receiving ties (which are referred to as actor-relation network effects). While there are many different purely structural network effects that can be identified, two main ones are reciprocity (one typically reciprocates when presented with the hand of friendship) and transitivity (the friend of a friend is also my friend, or equivalently, an enemy of my enemy is also my friend). Examples of

[2] Note that these two types of network effect can co-exist in a given social network. The term "structural signatures" was employed by Faust and Skvoretz (2002) and Skvoretz and Faust (2002) in the context of using ERGM to statistically identify the distinct structural features in social networks that are associated with particular social roles. However, Welser et al. (2007) also used the term in reference to patterns of networking behavior that distinguish "answer people" from "discussion people" in Usenet discussion fora, and they did not use ERGM in this work.

actor-relation network effects are homophily (where two nodes sharing an attribute leads to a higher probability of a tie between the nodes) and sender (receiver) effects, where the presence or absence of an attribute leads to a higher probability of sending (receiving) a network tie.

3. Online collective identity

We define an *online social movement* as a grouping of websites of actors who are participants in a social movement. In this context, it is clear that an online SMO is, from a data collection and analysis perspective, simply a website that is run by an SMO.

3.1. Exchange of practical and symbolic resources via hyperlink networks

A *hyperlink network* is a directed network where the network nodes are websites and network ties represent hyperlinks between websites. The hyperlink is commonly seen as the essence of the web (Jackson, 1997; Foot et al., 2003) and can have many interpretations: Kleinberg (1999) refers to web hyperlinks as "conferrers of authority" or endorsement, while Davenport and Cronin (2000) argue that hyperlinks reflect trust. Rogers and Marres (2000) define them as inscriptions of communicative and strategic choices on the part of site producers. Hyperlinks are also said to facilitate a range of significant new and old communicative functions such as information provision, organizational alliance-building and message amplification (Park et al., 2004), connecting previously disparate groups and their audiences, and creating a sense of "critical mass" or authority for a message that may be lacking in the real world.

The various interpretations of the meaning of a hyperlink are symptomatic of the lack of a single "Theory of Hyperlinking" (Thelwall, 2006) that can explain the behavior of the various actors who form hyperlink networks. We contend that a single theory of hyperlinking is neither possible nor desirable, given the diversity of actors interacting on the web. Accordingly, our model of online collective identity proposes a theory of hyperlinking that can explain the online networking behavior of a specific type of actors – namely, social movement organizations.[3] While we regard a hyperlink network as enabling the exchange of both practical and symbolic resources, we do not contend that hyperlink networks proxy the exchange of real-world resources such as the exchange networks studied by Diani and Bison (2004) and Hoffman and Bertels (2007). It is reasonable to argue that a board interlock is a proxy for exchange of real resources such as information and funds; however, this is not the case for hyperlinks – as indicated above, there are too many potential reasons for the existence of a hyperlink between two sites, and we cannot assume a hyperlink is proxying the exchange of real-world resources.

If hyperlinks do not reflect the exchange of real-world resources, then what practical resources are exchanged? In our view, this resource is authority or status as measured by rankings on search engines such as Google. We refer to this as "index authority", since the authority of actors is being derived from their relative position in an index of web pages, which is the core component of search engines. Receiving hyperlinks is a form of endorsement, a practical benefit to be sought out even when appearing to be disinterested. The principal interest of activist groups on the net (as of any online actor) is to increase traffic to their sites, as increased traffic means increased "eyeballs" which may translate into increased support, financial or otherwise. The ranking of a website in a search engine such as Google is highly influenced by the number of incoming hyperlinks from other relevant sites.[4] It has been shown (see, for e.g. Hindman et al., 2003) that the amount of web traffic on a site is highly correlated with the number of inbound hyperlinks pointing to that site from the rest of the web.

Hyperlink networks also facilitate the exchange of symbolic resources. In the context of social movements, a hyperlink from organization x to organization y proxies the "one-ness" or "we-ness" that is central to many definitions of collective identity.[5] While the symbolic exchange that is proxied by hyperlinks may not be present in the context of the hyperlinking activity of other types of organizations, it plays a significant role with regards to social movements. This is because grassroots online actors can have direct control over their websites and connections, leading to the embrace by SMOs of the web.

3.2. Exchange of symbolic resources via online frame networks

While much has been written about frames, little work on developing systematic approaches for their identification has been undertaken (notable exceptions are Koenig, 2004; McCarty, 2007). Most empirical work on frames has occurred in the context of case studies, using approaches that rely heavily on the domain knowledge of the researcher and are not generalizable to other contexts. Our use of frames draws from "semantic networks" studied in organizational science, where network concepts are used in association with interpretive methods in order to understand organizational linkages based on shared interpretations (Monge and Eisenberg, 1987; Stohl, 1993).

We define a frame component as a word or a term that is part of a frame. An example of a frame component is the word "frankenfood" which emerged as an important component of the frame developed by the anti-GMO movement. A frame network is an undirected network where the nodes represent organizations and ties represent mutual use of a particular frame component. An online frame network is a straightforward extension of a frame network to the online world: if organization x and organization y both use the frame component "frankenfood" on their website then there will exist an (undirected) tie between the two organizations in the online frame network.

Frames are a key vector of online collective identity because their primary aim is not practical, such as contributing to launch a new campaign, for example, but symbolic: frames are used to communicate beliefs, a vision. It is of course possible that SMOs would purposefully use language on their site that is known to appear elsewhere, but generally speaking, frames can be characterized as a disinterested or "non-conscious" means of expressing collec-

[3] However, it may well prove to be the case that other online actors have similar characteristics to SMOs and thereby conform to our undestanding of hyperlinking. Another reason why there has been little progress to date towards the development of a theory of hyperlinking is the fact that much of the empirical work in hyperlink analysis has not explicitly involved network concepts nor focused on explaining the behavior of actors in forming a hyperlink to other actors, but rather on the characteristics of actors that lead to them acquiring hyperlinks from other actors.

[4] In the PageRank algorithm originally used by Google (Brin and Page, 1998), there was a deterministic relationship between the position of a page in the web graph and its ranking in the Google index. However, Google now use other information in addition to PageRank, for example the number of clicks that a page receives in the search results. Thus the Google index is now effectively a "black box" (and the algorithm is apparently regularly reviewed to improve results and combat spammers who attempt to manipulate the index) and it is not possible to know the exact role of link structure. Nevertheless, it is safe to assume that link structure (e.g. the number of inbound links from relevant sites) is still a key driver of a given page's Google ranking.

[5] In the context of collective identity, one could regard hyperlinking as part of the frame building process since by influencing search engine rankings, hyperlinking influences the number of "eyeballs" that will potentially view a frame. Our model of online collective identity considers frame building as a separate, though related, activity.

tive identity, and are thus particularly liable to indicate proximity between actors.

3.3. Informal online networks

That the Internet constitutes a "protected site" for actors who seek to enact social change has become a truism of contemporary research in this field, with the paradigmatic example being Castells' (2004) assertion that social movements swim on the Internet "like fish in water". What qualities have rendered the web a prime free space for collective identity formation? While aspects of Internet governance – for example, the laws that allow an organization to obtain a domain name and produce website content that can be read by other people – are obviously important, our concern here is with the architecture of the web. Following on from the above discussion of offline social movements, we focus on the informal nature of networking on the web, and particularly on the role of hyperlinks.

With regards to the ease of reconfiguring network ties, a defining characteristic of the web, in contrast to real-world organizational networks, is that it is trivial to create connections between nodes. Dysfunctional nodes that block the overall dynamic of the network can be switched off or bypassed, thus overcoming the traditional ailment of social movements so often engaged in self-destruction through factionalism. For Castells (2004) the Internet is thus theoretically and practically perfectly suited to the contentious nature of social movements, which becomes a source of strength, rather than weakness.

A product of the fact that hyperlinks can be easily made is that the absence of ties between actors involved in a social movement is a significant indication of how collective identity is formed online. In the online environment, where establishing a hyperlink is at once a very public, all-pervasive and costless exercise, *not* linking represents the means to establish boundaries of belonging. In the blogosphere for example, explicitly refusing to link to a source bloggers disapprove of is both an insult and a way to limit an enemy's index authority (O'Neil, 2009).

While a defining characteristic of large-scale networks such as the web is the existence of power laws (e.g. Barabási and Albert, 1999) which imply a high degree of network centralization, the empirical evidence on power laws has been based on analysis of large slices of the web, and it is not clear whether this is also a feature of hyperlink subnetworks consisting of particular actors, e.g. social movement organizations. In fact the relative ease with which hyperlinks can be reconfigured would suggest that hyperlink networks formed by social movements should be relatively decentralized, so that index authority is not concentrated in a few nodes.

Finally, the relative ease of creating hyperlinks is conducive to the presence of network effects or structures that are indicators of endogenous or self-organizing behavior, for example reciprocity ("I'll direct a hyperlink to your website, because you link to me") and transitivity ("I'll hyperlink to that site because they are linked to by another site that we already link to"). Lusher and Ackland (2011) found substantial evidence of such informal networking behavior in the hyperlink networks formed by refugee and asylum seeker advocates in Australia.

3.4. Structural signatures of online collective identity

The work of authors such as Castells (2004) would suggest that the belief systems of social movements have been literally institutionalised in the online environment. But if this is the case, then there should be some evidence of this in the digital trace data that can be collected from social movement organization websites.

Our theoretical framework rests on the notion that the web manifestation of collective identity is achieved via two processes: hyperlinking and online framing. We further contend that online collective identity can be fruitfully modeled using organizational networks and we have defined hyperlink and online frame networks where nodes are SMO websites and ties reflect hyperlinks in the former, and mutual use of online frame components in the latter.

This framework allows us to advance three hypotheses regarding the structural signatures of online collective identity. Assume a set of SMO websites from two or more sub-movements, where the sub-movement affiliations (i.e. SMO x belongs to sub-movement A, while SMO y belongs to sub-movement B) have been categorized in advance by the researcher.

Hypothesis 1. The hyperlink and online frame networks will both exhibit significant homophily (on the basis of sub-movement affiliations).

Assortative mixing refers to a positive correlation in the attributes of nodes that are adjacent in a network. While a measure of assortative mixing might tell us that nodes that share a particular characteristic have a higher probability of being connected, it gives no indication about the exact processes that have led to the formation of a particular network. There are three main reasons why a given social network might exhibit assortative mixing.[6] First, there might be *homophily*, which refers to actors having a preference to be connected to similar actors. Second, there are *opportunity structures* that influence social tie formation. Group size is an important example: the smaller a particular group (e.g. a racial category) the more likely (all other things considered) that its group members will form social ties outside of the group. Finally, there are the *endogenous or purely structural network effects* that were discussed above: differences in reciprocity and transitivity across different social groups (e.g. one race has a cultural tendency to reciprocate friendships or introduce friends to each other) will tend to obscure the cross-group comparison of homophily.

In summary, social networks researchers are faced with the problem that both opportunity structures and endogenous network effects can "mask" the true level of homophily in a social network. Furthermore, focus on a single attribute might lead to the spurious identification of homophily. For example, Wimmer and Lewis (2010) found that previously-identified homophily amongst Asian students was entirely due to "aggregation effects"; when ethnicity (e.g. South Asian, Chinese) was taken into account, Asian students were found to not display significant homophily as a group.

Drawing on the above discussion, Hypothesis 1 simply states that if the SMO websites comprise distinct sub-movements then there should be statistical evidence of homophily on the basis of sub-movement affiliation. That is, we should find sub-movement homophily even after controlling for the other factors that could be driving assortative mixing.

Hypothesis 2. The hyperlink network will exhibit significant evidence of informal linking.

We have proposed three measures of informal linking: ease of reconfiguration of ties, decentralized networks and purely structural network effects (as identified using ERGM). We suspect that the first measure, reconfiguration of ties, does not have practical significance in the case of hyperlink networks. Unlike friendships and organizational ties in the offline world, hyperlinks are cheap to make and even cheaper to maintain; for that reason, we do not expect to see much evidence of hyperlink network reconfiguration. Since there is no way of identifying the date that a hyperlink

[6] See Wimmer and Lewis (2010) for a detailed review.

was created, web crawlers pick up old and new hyperlinks and it is impossible to distinguish between them. Further, even if it were possible to distinguish old hyperlinks, it would not be possible (using automatic methods) to establish whether an old hyperlink was still current in that it reflects on-going association between the organizations.[7] For these reasons, we focus our exploration of the informal nature of social movement hyperlinking on the centralization of hyperlink networks and on the presence of purely structural network effects, as identified using ERGM.

Hypothesis 3. The hyperlink and online frame networks will exhibit different structural signatures, reflecting the differing levels of conscious behavior underlying their construction.

Online frame development does not put practical resources into play: it is a purely symbolic action and we contend that it expresses more "unconscious" behavior on behalf of the social movement actors. On the contrary hyperlinking also facilitates the exchange of a practical resource (index authority) and for this reason, we suggest that hyperlinking implies more calculation on the part of actors, making it a more "conscious activity". We expect that these differences will be reflected in the structural signatures of these two networks.

4. Data

We identified the homepages of the websites of 161 environmental activist organizations using a combination of search techniques proposed for researching "issue networks" (Rogers and Zelman, 2002): search engine crawls of key words, associative reasoning (whereby educated guesses are made about relevant issues and related websites), public trust logics (finding groups commonly linked to by players trusted to be important in the debate), and media stories (following links from an authoritative news source).[8] All active sites were included in the sample. In the case of transnational environmental organizations such as Friends of the Earth and Greenpeace, we attempted to draw a representative sample by identifying two national sites from each continent – such as Argentina and Brazil for Latin America, the United Kingdom and France for Europe, Thailand (or Indonesia) and India for Asia. The full list of websites is available in Table A1.

The "generic" top-level domain (TLD), for example, .com, .edu, and the country TLD (e.g. .au, .uk) were automatically identified for each of the websites. With regards to generic TLD, as expected for activist sites, most of the sites (85%) are ".org". Only 34 of the sites include the country TLD in their domain name; we manually coded the country of origin for the remainder, and as shown in Table A1, the majority of seed sites are US-based (71), 27 are from the UK and the remaining sites come from 26 other countries. Based on a detailed observation of site content, we placed organizations in one of three sub-movements. After the original development in the late 1960s and early 1970s of large-scale environmental organizations such as Friends of the Earth and Greenpeace who adopted a more radical stance than traditional conservation groups, the environmental field has witnessed the emergence of successive waves of organizations articulating new concerns, such as Environmental Justice in the 1980s and Biotechnology in the 1990s. Our classification reflects these historically-constituted divisions in the field (Lichterman, 1996). Organizations dealing primarily with issues such as climate change, forest and wildlife preservation, nuclear weapons, and sustainable trade such as Greenpeace, Friends of the Earth, Earth First, Amazon Watch, the World Wide Fund For Nature, and the Natural Resources Defence Council were grouped under the denomination of "Global". Organizations dealing primarily with pollutants and with Environmental Justice issues such as Green Action, the Center for Community Action and Environmental Justice, the Silicon Valley Toxics Coalition, Toxics Link, Scorecard, and Health Care Without Harm were classified into the "Toxic" submovement. Finally, organizations dealing primarily with genetic engineering, organic farming and patenting issues such as GRAIN, the Organic Consumers Association, GMWatch, Ban Terminator, and Food First were grouped under the appellation "Bio". Of our 161 seed sites, the majority (89) were classified as Global, 46 were classified as Bio and the remaining 26 were classified as Toxic (Table A1).

Hyperlinks and text data were extracted from the seed sites using a web crawler[9] that is part of the Virtual Observatory for the Study of Online Networks (VOSON) System (Ackland, 2010), which is a web-based application for collecting and analyzing online social and organizational network data. Our analysis uses page meta keyword data (meta keywords describing the main focus or purpose of a website are often embedded into the HTML to ensure appropriate ranking by search engines) and text content extracted from the body of the web page. While the web crawler picked up hyperlinks by crawling (where possible) the entire site, the meta keywords and text content were only extracted from the seed pages (which are typically the main entry page for the website). This reflects both pragmatism (data storage capacity would soon be exceeded if we attempted to collect text content from all pages in the seed sites; since some of these sites contain thousands of pages) and also our view that these organizations will place the most important (from an organizational positioning perspective) messages or statements on their homepages; rather than buried deep within their sites.

Additional preparation of the meta keywords included identification of synonyms, removal of capitalization and stemming (to take account of pluralization, for example). Proper nouns relating to the seed sites, e.g. "Greenpeace", were also excluded from the meta keyword, however organizations that might be the subject of protest or opposition (e.g. World Trade Organization, Monsanto) were not excluded.

In Table 1, meta keywords and their frequency of occurrence are presented for each of the three types of environmental activist groups (only those keywords occurring two or more times within each group are reported).

To construct the online frame network we used the Support Vector Machine (SVM) machine learning technique that provides a supervised learning method for classification and regression. The libSVM Support Vector Machine Library[10] was used to identify the meta keywords best able to predict whether sites are Global/Toxic/Bio. In the language of machine learning, each seed site ("instance") contains a "class label" (a binary variable indicating whether the site is Global/Toxic/Bio) and a number of "attributes or features" (dummy variables indicating presence/absence of meta keywords). libSVM selected five meta keywords with best explanatory power (the presence or absence of these keywords best predicted whether a site was Global, Toxic or Bio): genetically modified, toxics, food, pesticide, conservation. These five meta keywords were used to construct the online frame network.

[7] These data collection issues are less problematic when researching the blogosphere since it is easier to collect temporal data and therefore possible to define current hyperlinks as those made, for example, within the last year.

[8] The data were collected in March 2006.

[9] A web crawler is a program that automatically traverses a web site by first retrieving a web page (for example, the homepage of an activist group) and then recursively retrieving all web pages that are referenced (e.g. following hyperlinks throughout the site).

[10] http://www.csie.ntu.edu.tw/~cjlin/libsvm/.

Table 1
Meta keywords used by sub-movements.

Bios	genetically_modified:67, biotech:15, food:14, farmers:9, environment:9, agriculture:7, biodiversity:6, organic_farming:6, sustainable_development:4, biopiracy:4, seed:2, health:2, globalization:2, transgenic:2, canola:2, world_trade_organization:2, monsanto:2, crops:2, legislation:2, cotton:2, campaign:2, starlink:2, family_farms:2, uk:2
Globals	environment:42, climate_change:14, conservation:11, sustainable_development:10, nuclear:10, global_warming:8, pollution:7, genetically_modified:7, forests:6, news:6, activism:6, green:5, biodiversity:4, globalization:4, nature:4, wildlife:4, species:4, food:4, resources:3, kyoto_protocol:3, energy:3, headlines:3, human_rights:3, global:3, water:3, international:3, indigenous:3, dam:3, natural_resources:3, world_bank:3, technology:2, mining:2, wild:2, take_action:2, windows:2, red_list:2, green_energy:2, deforestation:2, software:2, india:2, environmental_organizations:2, agriculture:2, protection:2, brazil:2, new:2, amazon_rainforest:2, river:2, animals:2, waste:2, toxics:2, oil:2, arctic_refuge:2, campaign:2, union:2, renewable_energy:2, community:2, solutions:2, land_rights:2, information:2, action:2
Toxics	pesticide:16, environment:15, pollution:11, toxics:10, nuclear:5, nonprofit:3, biotech:3, africa:2, justice:2, afrique:2, community:2, dioxin:2, climate_change:2, phthalates:2

5. Analysis

In this section we present an empirical analysis of the hyperlink and online frame networks for the environmental activist organizations. The next section reviews the analysis with reference to the three hypotheses proposed earlier.

5.1. Network density and centralization

The hyperlink network has a density (number of ties expressed as a proportion of total possible number of ties) of 0.056. This indicates a relatively sparse network, but it is greater than what has been found in other research into the hyperlinking behavior of NGOs/SMOs – the density of the hyperlink network formed by the HIV/AIDS activists studied by Shumate and Dewitt (2008) was 0.027, while the comparable measure for the refugee and asylum seeker advocates network in Lusher and Ackland (2011) was 0.046. The density of the online frame network is approximately double that of the hyperlink network (0.107).

Centralization is a network-level property that broadly measures the distribution of power or prominence amongst actors in a given network. Centralization is calculated by first computing a particular node-level centrality measure (e.g. degree, betweenness, closeness) and then finding the sum of the absolute deviations from the graph-wide maximum (generally, the centralization score is also normalized by the theoretical maximum centralization score). In effect, centralization measures the extent to which the network "revolves around" a single node or small number of nodes. The classic example of a highly centralized network is the star network where the node in the centre of the star has complete centrality while the other nodes have minimal centrality (this network has the maximum centralization score of 1). In contrast, a circle network is highly decentralized since all nodes share the same centrality: such a network will have a centralization score of 0.

We compared the hyperlink and online frame networks on three measures of centralization: degree, betweenness and closeness. On the basis of degree and closeness, the online frame network is more centralized than its hyperlink counterpart; degree (closeness) centralization for the online frame network is 0.264 (0.235) compared with 0.193 (0.162) for the hyperlink network. The betweenness centralization scores for the two networks were approximately equal at around 0.1.

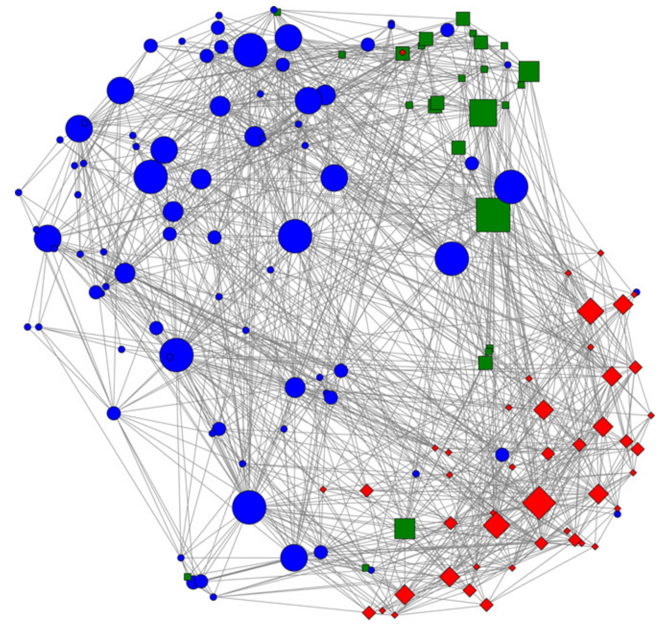

Fig. 1. Hyperlink network FDG map – node color reflecting sub-movements. *Note*: Bios (red diamond), Globals (blue circle), and Toxics (green square). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Table 2
Mixing matrix for hyperlink network, by environmental sub-movements.

	Bios	Globals	Toxics	Total
Bios	252	123	31	406
Globals	103	616	63	782
Toxics	40	112	104	256
Total	395	851	198	1444

5.2. Network visualization, assortative mixing and modularity clustering

Fig. 1 shows the hyperlink network map, drawn using the LinLog force-directed graphing (FDG) layout of Noack (2007).[11] There are 158 nodes in this map (three nodes are isolates and hence are not shown), with the size of the node reflecting indegree, and 1444 edges or links.

Fig. 1 reveals a strong community structure or clustering, evidence of network homophily that accords with our classification of the websites into the three sub-movements. Table 2 shows the mixing matrix for the hyperlink network, which provides information on the composition of hyperlinks between the three environmental sub-movements. The Bios and Globals sub-movements show a strong tendency towards linking to their own; 62 percent of the links made by Bios to other organizations within the environmental movement are made to other Bios while for the Globals this tendency towards in-linking is even higher, at 79 percent. Toxics show less tendency towards assortative mixing, with only 41 percent of their hyperlinks within the environmental social movement being directed to websites of other Toxics.

[11] In a FDG of a hyperlink network, websites are given initial random positions and modeled as electrostatic charges (repulsion forces that act to push nodes apart from one another). Hyperlinks between web sites are modeled as springs (attraction forces that act to pull together those sites that are connected to one another via hyperlinks). The algorithm shifts the position of nodes in an attempt to minimize the energy of the system (in general, the energy of the system will be smaller if two connected nodes are positioned near one another compared with if they are on separate sides of the map).

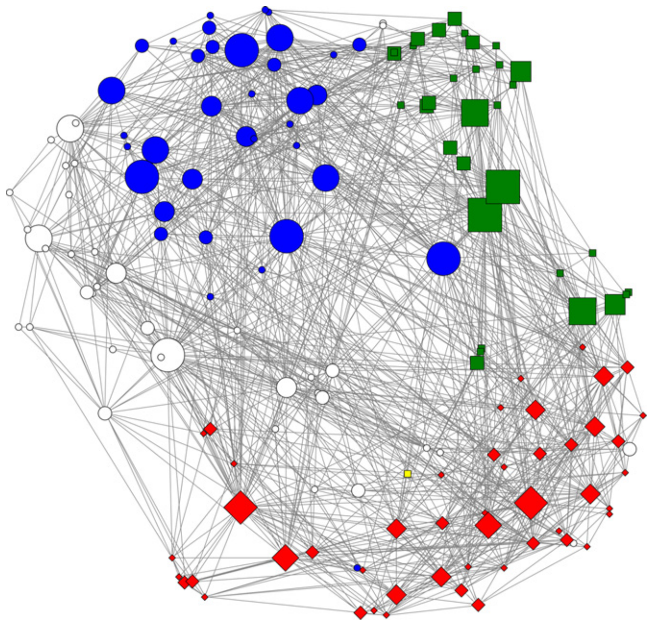

Fig. 2. Hyperlink network FDG map – node color reflecting modularity clusters. *Note*: cluster 1 (red diamond), cluster 2 (blue circle), cluster 3 (yellow square), cluster 4 (green square), and cluster 5 (white circle). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

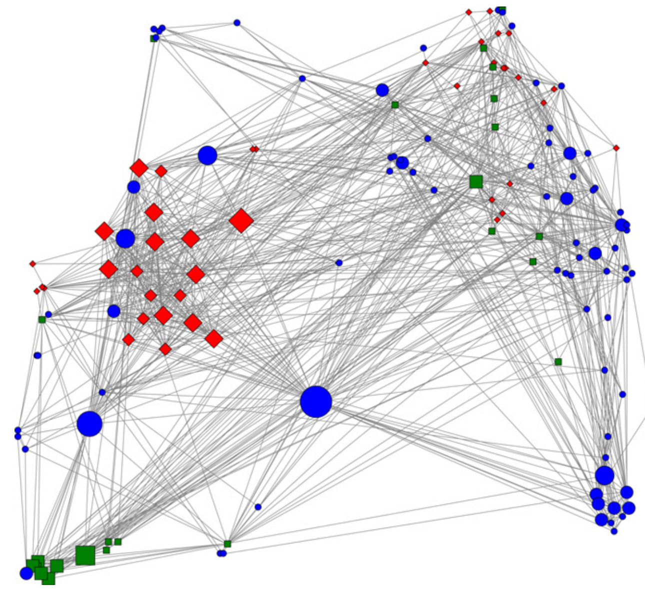

Fig. 3. Online frame network FDG map – node color reflecting sub-movements. *Note*: Bios (red diamond), Globals (blue circle), and Toxics (green square). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Table 3
Composition of websites, by sub-movement and hyperlink modularity cluster.

	Bios	Globals	Toxics	Total
Cluster 1	33	13	2	48
Cluster 2	0	33	3	36
Cluster 3	0	3	0	3
Cluster 4	6	5	21	32
Cluster 5	6	33	0	39
Isolate	1	2	0	3
Total	46	89	26	161

Table 4
Mixing matrix for online frame network, by environmental sub-movements.

	Bios	Globals	Toxics	Total
Bios	381	277	63	721
Globals	277	406	138	821
Toxics	63	138	117	318
Total	721	821	318	

While Fig. 1 reveals clusters that accord with our classification of the websites, "eyeballing" network maps for clustering is not particular rigorous since the shape of the clusters is dependent on the initial random positioning of the nodes. Further, the boundaries of the clusters are often hard to determine, and it can sometimes be difficult to see what cluster a particular node belongs to. To overcome this limitation, we applied the modularity clustering algorithm of Newman and Girvan (2004) to the hyperlink network, which automatically determines the number of clusters in a network and cluster membership.[12] The modularity clustering algorithm identified 5 clusters, and Fig. 2 shows the hyperlink network with nodes colored according to cluster membership.

Fig. 2 and Table 3 (which shows the composition of websites by sub-movement and modularity hyperlink cluster) indicate that there is broad consistency between our classification of the websites into sub-movements and the modularity hyperlink clusters. Cluster 1 can be labeled the Bios; 69 percent of the sites in this cluster are Bios and 72 percent of Bio sites are located in this cluster. The majority (61 percent) of sites in cluster 4 are Toxics, and this cluster contains 81 percent of the Toxics sites. The Globals are mainly located in clusters 2 and 5. If we use this assignment of clusters to sub-movements (cluster 1 – Bios, cluster 4 – Toxics, clusters 2 and 5 – Globals), then there is an inconsistency between our sub-movement classification and the modularity clustering for 25 percent of the 158 non-isolate sites. We contend that this is a relatively low level of mis-classification and thus validates of our sub-movement coding scheme, since there are likely to be other factors (e.g. country of origin) that are associated with hyperlinking behavior in addition to collective identity. The modularity clustering puts 13 of our Globals into the Bios cluster. In fact, what is connecting these 13 Globals sites to Bios sites is their country of origin, the United Kingdom.

Fig. 3 shows the online frame network, where a tie between two websites reflects mutual use of at least one of the five meta keywords identified using libSVM, again drawn using the LinLog FDG layout algorithm. There are 150 nodes in this map (11 nodes are isolates and hence are not shown), with the size of the node reflecting degree, and 1382 edges.

As was shown with the hyperlink network, Fig. 3 reveals clustering that broadly matches the sub-movement classification of websites. However Table 4 (the mixing matrix for the online frame network) indicates a lower level of homophily in the formation of links in the online frame network, compared with what was found in the hyperlink network: between 37 and 53 percent of online frame links are with websites within the same sub-movement.

Fig. 4 shows the online frame network with node color matching the modularity clusters and Table 5 presents the composition of websites by sub-movement and modularity online frame cluster. The online frame modularity clustering does not match the sub-movements as neatly as it did for the hyperlink network. While cluster 2 predominantly consists of Bios and cluster 3 is only Globals, the Toxics do not have a cluster of their own – they are split across cluster 1 where they are in the minority and cluster 4 which they share almost equally with the Globals. Cluster 1 is the largest (containing nearly half the sites in the sample) and an interesting

[12] Newman and Girvan's modularity clustering is implemented in the LinLog software, and Noack (2009) demonstrates that modularity clustering is in fact equivalent to force-directed graphing.

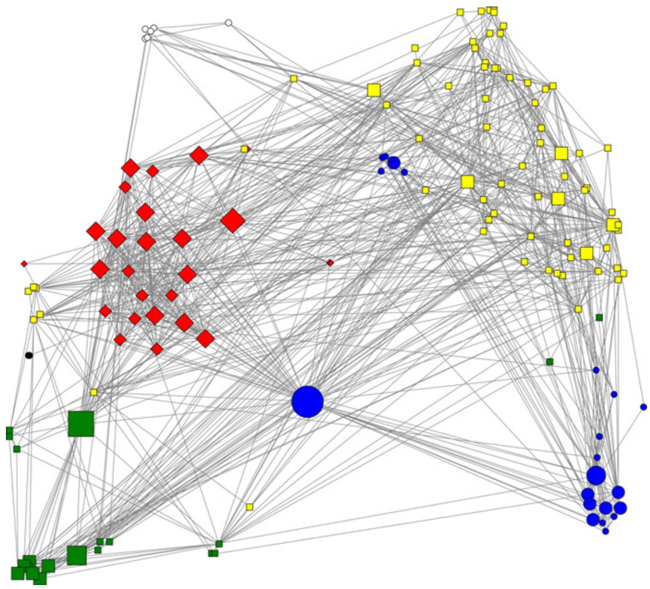

Fig. 4. Online frame network FDG map – node color reflecting modularity clusters. *Note*: cluster 1 (yellow square), cluster 2 (red diamond), cluster 3 (blue circle), cluster 4 (green square), cluster 5 (white circle), and cluster 6 (black circle). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

Table 5
Composition of websites, by sub-movement and online frame modularity cluster.

	Bios	Global	Toxics	Total
Cluster 1	22	40	11	73
Cluster 2	21	5	0	26
Cluster 3	0	22	0	22
Cluster 4	0	8	12	20
Cluster 5	0	5	1	6
Cluster 6	0	3	0	3
Isolate	3	6	2	11
Total	46	89	26	161

finding is that the sub-movements are represented in this cluster in proportions that are almost equal to their representation in the overall sample of sites.

5.3. Exponential Random Graph Models

We have observed the environmental activist hyperlink and online frame networks at a single point in time, and this makes it difficult to establish the social forces that have led to their emergence. Exponential Random Graph Modeling (Frank and Strauss, 1986; Wasserman and Pattison, 1996; Pattison and Wasserman, 1999; Robins et al., 1999) is an approach for statistically "unpacking" social networks.[13] ERGM is a technique for determining the likelihood of the observed network having emerged, out of all the possible networks that could have been formed by a random assignment of the observed number of ties across the observed nodes. It does this by deconstructing the network into its constituent network configurations or building blocks (combinations of small sets of nodes with particular attributes and ties) and then calculating

Table 6
ERGM results for hyperlink and online frame networks.

	hyperlink network	online frame network
Purely structural effects		
Density	−6.46 (0.05)***	−4.47 (0.24)***
Simple popularity (istar2)	0.16 (0.00)***	
Simple popularity (istar3)	−0.01 (0.00)***	
Reciprocity	1.22 (0.02)***	
GWESP (gwesp.fixed.0.2)	0.91 (0.01)***	0.58 (0.06)***
Actor-relation effects		
Homophily effects		
Bios	1.37 (0.08)***	1.71 (0.24)***
Globals	0.73 (0.06)***	0.47 (0.23)*
Toxics	1.33 (0.10)**	1.91 (0.27)***
North	0.95 (0.01)***	0.91 (0.02)***
South	0.80 (0.03)***	0.58 (0.09)***
Sender effects		
Bios	−0.06 (0.05)	
Toxics	0.31 (0.02)***	
South	−0.00 (0.02)	
Receiver effects		
Bios	−0.14 (0.07)*	
Toxics	−0.05 (0.07)	
South	−0.67 (0.02)***	
Connection effects		
Bios		−0.34 (0.21)
Toxics		−0.15 (0.20)
South		0.05 (0.03)

Note: Standard errors are in brackets. Significance levels: *** (0.1%), ** (1%), * (5%).

whether the frequency of these configurations is such that they have occurred with a likelihood that is greater or less than would be expected if the network had formed randomly. Similar to standard regression techniques, ERGMs produce parameter estimates and associated standard errors which can be used to establish whether the hypothesized network configurations or effects are consistent with the observed data. Statistically significant network effects can be regarded as structural signatures, or indicators of the particular social forces underlying the network.

Using the statnet (Hunter et al., 2008)[14] suite of packages for conducting social network analysis in the R statistical software environment,[15] we tested for a number of purely structural and actor-relation network effects in the environmental activist hyperlink and online frame networks. Lusher and Ackland (2011) have noted that the degree distributions that are commonly found in hyperlink networks (in particular, the presence of nodes with very high in- or out-degree) can cause problems with getting ERG models to converge. We experienced this problem with our online network data and while Lusher and Ackland (2011) were able to use longitudinal network data, which helped with attaining model convergence, we only have data for a single point in time. For this reason, we needed to be fairly parsimonious in terms of the network effects included in our final models, which are reported in Table 6.[16]

Looking first at the ERGM for the (directed) hyperlink network, we included the following purely structural effects (the statnet parameter name is in brackets): density (edges) – one actor nominating another actor, regardless of attributes (this is the baseline propensity to form ties, and is generally included in ERG models as a constant or intercept); reciprocity (mutual) – mutual ties between two actors; simple popularity (istar) – the propensity of a tie to be directed to an actor who is already in receipt of a tie[17] and geomet-

[13] While Shumate and Dewitt (2008) and Lusher and Ackland (2011) used ERGM to model the hyperlinking behavior of actors seeking social change, the present paper represents the first use of this approach in the context of modeling online collective identity. We do not offer here a technical description of this approach; in addition to the key references on ERGM noted above, the interested reader can consult Robins et al. (2007) and Monge and Contractor (2003) for an introduction, and Lusher and Ackland (2011) for an in-depth application to hyperlink network data.

[14] http://csde.washington.edu/statnet/.

[15] http://www.r-project.org/.

[16] Note that we estimated the models after removing the isolates from the networks, since their inclusion caused problems with convergence.

[17] Note that statnet allows popularity to be flexibly modeled as the propensity of a tie to be directed to an actor who is already in receipt of k ties, where k can be set by the researcher.

rically weighted edgewise shared partner (gwesp), which has been shown to be effective in overcoming problems of model degeneracy (see, e.g. Hunter et al., 2008). With regards to actor-relation effects, we included homophily effects (nodematch) for our sub-movement classification (Bios, Globals, Toxics) and geography ('north' – North America (not including Mexico), UK, Europe and Australia and 'south' – all other countries).[18] We also included sender effects (nodeofactor) and receiver effects (nodeifactor) which show the impact of the presence (or absence) of an attribute on the propensity to send and receive ties, respectively. A significant and positive sender effect for a particular attribute means that an actor possessing the attribute sends more ties than expected by chance, while a significant and negative effect indicates that actors *without* the attribute send more ties (i.e. it does not mean that actors with the attribute send less ties). Receiver effects are analogous to sender effects, except they reflect the impact of the presence (or absence) of a particular actor attribute on the propensity to *receive* ties.

All of the purely structural network effects are significant. The ERGM for the hyperlink network also provides clear evidence of homophily on the basis of the sub-movement affiliations, even after controlling for the purely structural effects and other actor-relation effects.

After controlling for all other effects, the log-odds of a tie between two sites increases by 1.37 if both sites are Bios and there are also significant and positive homophily effects for the other two sub-movement categories.[19] Toxics have a significantly higher propensity to send ties to other actors, while there is (weak) evidence that Globals have a higher propensity to receive ties (this is inferred from the fact that the receiver coefficient on Bios is negative and weakly significant, while the receiver coefficient on Toxics is insignificant). There is significant homophily on the basis of both the north and south classification, and sites from the north have a significantly higher propensity to receive hyperlinks.[20]

In the ERGM for the (undirected) online frame network, only two purely structural network effects were included – density and the gwesp parameter, and both of these were significant. The ERGM for the online frame network displays significant homophily within the Bios and Toxics, but this parameter is only significant at the 5% level for the Globals. There is significant homophily within the north/south categories. Connection effects, which are the undirected network analog of sender/receiver effects and hence measure the impact of the presence of an attribute on the probability of the node having a tie, were also included in the online frame ERGM but they are not statistically significant.

6. Discussion

We now discuss the preceding analytical results in relation to our three hypotheses.

6.1. H1: Homophily in hyperlink and online frame networks

The network visualizations, mixing matrices and ERGM results all indicate that there is significant homophily in the hyperlink and online frame networks, where homophily is defined on the basis of social movement categories (Bio/Toxic/Global). Not finding significant collective identity-related homophily in the hyperlink and online frame networks would have led to serious doubts about the existence of our hypothesized online sub-movements, perhaps making us vulnerable to criticism along the lines of Hunt and Benford's (2004, p. 414) admonishment that social movement scholars studying collective identity typically "appear to take for granted [its] existence without offering compelling evidence that [it exists] outside the minds of the social movement analysts".

6.2. H2: Informal linking in the hyperlink network

In the ERGM for the hyperlink network, all of the purely structural or endogenous network effects are significant. We point to this as support for our hypothesis that the hyperlink network of a social movement displays significant informality. However, a more robust test of this hypothesis would be to not just establish that there are significant purely structural network effects in the hyperlink network, but to compare the estimated parameters with those found for hyperlink networks formed by organizations that are not social movement actors, e.g. government agencies. It is our expectation that government agencies, for example, would engage in more formal and institutionally-driven hyperlinking, rather than informal linking based on reciprocity and transitivity, and this would be reflected in the ERGM parameters.[21]

While we are not in a position to compare the hyperlink network to similar networks formed by other types of organizations, we can compare this network to the frame network and notice that this latter network is much more centralized. We expand on this observation in the next section.

6.3. H3: Differences between hyperlink and online frame structural signatures

We can identify three major structural differences between the hyperlink and online frame networks which reflect the differing levels of "consciousness" of the expressive behavior being undertaken by the environmental SMOs.

First, it is notable that the density of the online frame network is approximately double that of the hyperlink network, indicating that the "unconscious" expressive behavior of the SMOs is leading to many more connections.

Second, the evidence of greater centralization in the online frame network, compared with the hyperlink network, also accords with our theoretical model that places the creation of online frames towards the more "unconscious" end of the continuum of human behavior. Because actors in social movement networks place such a premium on informality and horizontality, the comparatively more "conscious" quality of the act of hyperlinking results in the SMO hyperlink network being less centralized than the corresponding online frame network. SMOs are more likely to (unconsciously) adopt the frames of other sub-movements than to purposefully hyperlink to the relevant actors. The ideological commitment to decentralization that is one of the hallmarks of social movements is thus clearly evident in their hyperlinking behavior (at least in comparison to their online frame behavior). While the SMOs are consciously using hyperlinks to express affinity/proximity with

[18] We followed Shumate and Dewitt (2008) in using the geo-political north/south classification, since they found this to be a significant factor in determining hyperlink formation amongst HIV/AIDS activist sites.

[19] To provide some context for these parameter estimates, the base level log-odds of a tie in this network is provided by the density parameter (−6.46), which corresponds to a probability of a tie of $\exp(-6.46)/[1+\exp(-6.46)] = 0.002$. If both nodes are from the Bios sub-movement, however, the log-odds of a tie increases markedly to −5.09 (−6.46 + 1.37), which corresponds to a probability of a tie of 0.006.

[20] In contrast, Shumate and Dewitt (2008) found significant homophily for sites classified as being in the north, and significant heterophily for southern sites.

[21] For example, the Australian Department of Health and Ageing website links to the sites of a number of government agencies that provide health-related information and services. These links have been created for institutional reasons – they reflect the Department's goal of achieving portfolio outcomes in association with the portfolio agencies – and are not a result of social behavior.

other actors in the sub-movement, index authority is being distributed amongst the group in an equitable manner, rather than being focused only on a few SMOs.

Third, there is strong evidence that the forces of homophily are weaker in the online frame network, compared with the hyperlink network. We found that the clusters identified by the modularity clustering algorithm were very consistent with our sub-movement classification in the case of the hyperlink network, but that there was a significant discrepancy with the online frame network. We also found slightly weaker evidence for homophily (on the basis of sub-movement affiliation) in the ERGM for the online frame network, compared with the hyperlink network.

The differences between the hyperlink and online frame network in terms of homophily are particularly striking when we focus on the two smaller sub-movements. Our analysis suggests a much greater degree of coherence or closeness between the Bios and Toxics on the basis of (unconscious) frame collective identity, compared with their intentional expressive proximity displayed in the hyperlink network. In the frame network the Bios are split evenly across two clusters and the modularity algorithm has assigned 11 Toxics to one of these clusters (cluster 1). In other words, nearly one half of the Toxics have been assigned to a frame network cluster with the Bios. In contrast, in the hyperlink network only two Toxics were assigned to the main Bio cluster identified using the modularity algorithm. The mixing matrices for the hyperlink and online frame networks (Tables 2 and 4) also reveal a greater degree of connectivity between these two sub-movements in the online frame network, compared with the hyperlink network, both in terms of absolute numbers of ties and of the number of ties as a proportion of all ties made by each sub movement.

We interpret this as evidence that boundaries of belonging are weaker in the online frame network, compared with the hyperlink network. Despite their unconscious affinity as expressed through frames, Bios and Toxics are not consciously linking to one another in the hyperlink network. This points to the existence of a "structural hole" (Burt, 1992) between the Bios and Toxics in the hyperlink network, which is not evident in the online frame network. This hole is occupied by a small number of Globals sites as well as four sites from the Pesticide Action Network.[22]

This lack of hyperlinking between Bios and Toxics could be the result of ignorance by one sub-movement as to the existence of the other; alternatively, a dearth of linking may also signal the erection of boundaries. In fact, ignorance and boundary-building are not incompatible, as organizations are likely to ignore the existence of groups they disapprove of.

The Toxics sub-movement comprises Environmental Justice activists and organizations (Szasz, 1994; Brulle and Pellow, 2006), who protest against health risks to local residents identified on the basis of class/ethnicity. Any reluctance on the part of Toxics to link to the Bios could therefore be interpreted as representing Environmental Justice activists' anxiety that genetics and genomics will increasingly be used to individualize the focus of environmental health analysis and interventions, thus shifting the focus away from polluters (Shostak, 2004).

This stems from the fact that Environmental Justice represents the attempts of urbanized poor people, often members of ethnic minorities, to resist being made the target of environmental discrimination (Evans and Kantrowitz, 2002). In contrast, the contestation of biotechnology allowed activists–defined by some scholars as mainly originating from the educated urban middle class (della Porta and Rucht, 2002; Crossley, 2003)–to reconnect to their ancestral roots by forming an alliance with farmers. Biotech activism also emphasizes individualized and pleasurable practices such as the consumption of distinctive products (organic food, for example). Whereas some environmental activists believe that risks, like wealth, adhere to the class pattern, only inversely – wealth accumulates at the top, risks at the bottom (Beck, 1992) – others contend that risks are linked to developments which potentially affect everyone, such as biotechnology, and more recently nanotechnology. Lichterman (1996) had indeed noted the existence of a divide between Environmental Justice activists and other sectors of the Green movement. Despite claims that new social movements have rendered the issue of class obsolete (Touraine, 1981; Castells, 2004; Rucht, 2004), on the Internet, class distinctions may still be playing a role in structuring the collective identities of activist networks.

7. Conclusions

This paper has presented a theoretical model of online social movements which involves the adaptation of Diani's (1992, 2001, 2003) network-centric approach to social movements to the online world. We have demonstrated that it is not enough to simply conceptualize online networks as the cyberspace counterparts of the offline organizational networks formed by SMOs, empirically examined by authors such as Diani and Bison (2004) and Hoffman and Bertels (2007). Specific conceptual modulations have to be introduced, and our model emphasizes the importance for online SMOs of participation in informal networks and direct control over the means of communication, both of which favor the preeminence of expressive behavior leading to the formation of collective identity. This is particularly the case for hyperlinks to like-minded organizations which constitute an expressive and affective public signaling of affiliation with no possible guaranteed payoff.

We also introduce a delineation of exactly what symbolic and practical resources are transferred via online networks by establishing a distinction between wholly conscious expressive behavior (such as the creation of hyperlink networks) and potentially unconscious expressive behavior (such as participation in online frame networks). This leads us to formulate hypotheses relating to the existence of homophily in hyperlink and online frame networks, to the informal structure of hyperlink networks and to the differences in the structural signatures of hyperlink and online frame networks. An empirical application using digital trace data collected unobtrusively from 161 environmental activist websites provided strong support for these hypotheses.

By defining and empirically testing for the structural signatures of online collective identity, our approach renders possible the accurate and effective mapping of the contours of online collective identity, enabling large-scale comparative work across social movements and over time. Our approach also represents an important first step towards the development of empirical techniques that may be able to automatically distinguish online networks formed by SMOs from networks formed by other types of actors on the web such as corporations, government agencies, and research institutions.

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[22] The Pesticide Action Network North America site (http://www.panna.org) has the highest betweenness centrality of all sites in the study.

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Appendix A. Table A1: Seed sites

id	URL	Type	Country
1	http://www.centerforfoodsafety.org/	Bios	US
2	http://www.mst.org.br/	Bios	Brazil
3	http://www.nwrage.org/	Bios	US
4	http://www.organicconsumers.org/	Bios	US
5	http://ngin.tripod.com/	Bios	UK
6	http://www.biodev.org/	Bios	US
7	http://angelsagainstnanotech.blogspot.com/	Bios	UK
8	http://www.ifoam.org/	Bios	Germany
9	http://www.i-sis.org.uk/	Bios	UK
10	http://www.ddsindia.com/	Bios	India
11	http://www.ota.com/	Bios	US
12	http://www.gmwatch.org/	Bios	UK
13	http://www.grain.org/	Bios	Spain
14	http://www.bite-back.org/	Bios	Belgium
15	http://www.biosafety-info.net/	Bios	Malaysia
16	http://www.biotech-info.net/	Bios	US
17	http://www.agribusinessaccountability.org/	Bios	US
18	http://www.viacampesina.org/	Bios	Indonesia
19	http://www.biowatch.org.za/	Bios	South Africa
20	http://www.banterminator.org/	Bios	Canada
21	http://www.aseed.net/	Bios	Netherlands
22	http://www.biodiversidadla.org/	Bios	Argentina
23	http://www.biothai.org/	Bios	Thailand
24	http://www.caff.org/	Bios	US
25	http://www.genewatch.org/	Bios	UK
26	http://www.gmfoodnews.com/	Bios	UK
27	http://www.chemicalbodyburden.org/	Toxics	US
28	http://www.chicagothong.org/	Bios	US
29	http://www.cropchoice.com/	Bios	US
30	http://www.foodfunders.org/	Bios	US
31	http://www.geneticsaction.org.uk/	Bios	UK
32	http://www.genet-info.org/	Bios	Germany
33	http://www.gmfreeze.org/	Bios	UK
34	http://www.gmofree-europe.org/	Bios	Belgium
35	http://www.foodfirst.org/	Bios	US
36	http://www.vshiva.net/	Bios	India
37	http://www.percyschmeiser.com/	Bios	Canada
38	http://www.primalseeds.org/	Bios	UK
39	http://www.soilassociation.org/	Bios	UK
40	http://www.sunshine-project.org/	Bios	Germany
41	http://www.truefoodnow.org/	Bios	US
42	http://www.etcgroup.org/	Bios	Canada
43	http://www.farm.org.uk/	Bios	UK
44	http://www.foodcomm.org.uk/	Bios	UK
45	http://www.safe-food.org/	Bios	US
46	http://www.econexus.info/	Bios	UK
47	http://www.semillas.org.co/	Bios	Columbia
48	http://www.cleanwateraction.org/	Globals	US
49	http://www.climatesolutions.org/	Globals	US
50	http://www.cat.org.uk/	Globals	UK
51	http://www.foe.org.au/	Globals	Australia
52	http://www.foe.org/	Globals	US
53	http://www.foei.org/	Globals	Netherlands
54	http://www.ciel.org/	Globals	US
55	http://www.citnet.org/	Globals	US
56	http://www.ucsusa.org/	Globals	US
57	http://www.earthjustice.org/	Globals	US
58	http://www.chej.org/	Toxics	US
59	http://www.christian-ecology.org.uk/	Globals	UK
60	http://www.funam.org.ar/	Globals	Argentina
61	http://www.efl.lk/	Globals	Sri Lanka
62	http://www.enn.com/	Globals	US
63	http://www.rainforestinfo.org.au/	Globals	Australia
64	http://www.ewg.org/	Toxics	Australia
65	http://www.bushgreenwatch.org/	Globals	US
66	http://www.geocities.com/efdavao/	Globals	Phillipines
67	http://www.globalforestwatch.org/	Globals	US
68	http://www.foe.co.uk/	Globals	UK
69	http://www.envirolink.org/	Globals	US
70	http://www.environmentaldefense.org/	Globals	US
71	http://www.gaiafoundation.org/	Globals	UK
72	http://www.iatp.org/	Globals	US
73	http://www.amisdelaterre.org/	Globals	France
74	http://www.greenpeace.org/india/	Globals	India
75	http://www.insnet.org/	Globals	Netherlands
76	http://www.irn.org/	Globals	US
77	http://www.greenpeace.org.ar/	Globals	Argentina
78	http://www.ancetogo.globalink.org/	Globals	Togo
79	http://www.greenpeace.org.au/	Globals	Australia
80	http://www.ienearth.org/	Globals	US
81	http://www.greenpeace.org.br/	Globals	Brazil
82	http://www.amiterre.tg/	Globals	Togo
83	http://www.defenders.org/	Globals	US
84	http://www.direkte-aktie.net/	Globals	Netherlands
85	http://www.earthfirst.org/	Globals	US
86	http://www.earthliberationfront.com/	Globals	US
87	http://www.earthshare.org/	Globals	US
88	http://www.campaigncc.org/	Globals	UK
89	http://www.greenpeace.org/usa/	Globals	US
90	http://www.greenpeace.org.uk/	Globals	UK
91	http://www.greenpeace.org/france/	Globals	France
92	http://www.earthisland.org/	Globals	US
93	http://www.greenpeace.org/international/	Globals	Netherlands
94	http://www.greenpeace.org/seasia/en/	Globals	Thailand
95	http://www.nrdc.org/	Globals	US
96	http://www.naturalcapital.org/	Globals	US
97	http://www.rachel.org/	Toxics	US
98	http://www.polarisinstitute.org/	Globals	Canada
99	http://users.lmi.net/	Toxics	US
100	http://www.worldwildlife.org/	Globals	US
101	http://www.wri.org/	Globals	US
102	http://www.wrm.org.uy/	Globals	Uruguay
103	http://www.ran.org/	Globals	US
104	http://www.amazonalliance.org/	Globals	US
105	http://www.sehn.org/	Globals	US
106	http://www.seen.org/	Globals	US
107	http://www.nativeforest.org/	Globals	US
108	http://www.amazonwatch.org/	Globals	US
109	http://www.accionecologica.org/	Globals	Ecuador
110	http://www.seashepherd.org/	Globals	US
111	http://www.natbrasil.org.br/	Globals	Brazil
112	http://www.iucn.org/	Globals	Switzerland
113	http://www.planetark.org/	Globals	Australia
114	http://www.panda.org/	Globals	Switzerland
115	http://www.itdg.org/	Globals	UK
116	http://www.amigos.org.ar/	Globals	Argentina
117	http://www.sierraclub.org/	Globals	US
118	http://www.stopclimatechaos.org/	Globals	UK
119	http://www.sustainable-society.co.uk/	Globals	UK
120	http://www.newdream.org/	Globals	US
121	http://www.sur.iucn.org/	Globals	Ecuador
122	http://www.sgr.org.uk/	Globals	UK
123	http://www.timberwatch.org.za/	Globals	South Africa
124	http://www.earthfirst.org.uk/	Globals	UK
125	http://www.eraction.org/	Globals	Nigeria
126	http://www.walhi.or.id/	Globals	Indonesia
127	http://www.wcs.org/	Globals	US
128	http://www.wedo.org/	Globals	US
129	http://www.worldwatch.org/	Globals	US
130	http://www.wwf.fr/	Globals	France
131	http://www.wwf.org.uk/	Globals	UK
132	http://www.mpi.org.au/	Globals	Australia
133	http://www.wild.org/	Globals	US
134	http://www.wilderness.org/	Globals	US
135	http://www.wwf.org.au/	Globals	Australia
136	http://www.wwf.org.br/	Globals	Brazil
137	http://www.stopesso.org/	Globals	Canada
138	http://www.wwfindia.org/	Globals	India
139	http://www.wwf.or.id/	Globals	Indonesia
140	http://www2.eli.org/	Globals	US
141	http://www.pesticideinfo.org/	Toxics	US
142	http://www.pesticidereform.org/	Toxics	US
143	http://www.pan-germany.org/	Toxics	Germany
144	http://www.riverkeeper.org/	Toxics	US
145	http://www.svtc.org/	Toxics	US
146	http://www.pan-afrique.org/	Toxics	Senegal
147	http://www.toxicslink.org/	Toxics	India
148	http://www.space4peace.org/	Toxics	US
149	http://www.pan-uk.org/	Toxics	UK
150	http://www.oztoxics.org/	Toxics	Australia
151	http://www.airportwatch.org.uk/	Toxics	UK
152	http://www.no-burn.org/	Toxics	Philippines

153	http://www.ccaej.org/	Toxics	US
154	http://www.safecosmetics.org/	Toxics	US
155	http://www.ipen.org/	Toxics	US
156	http://www.greenaction.org/	Toxics	US
157	http://www.noharm.org/	Toxics	US
158	http://www.panna.org/	Toxics	US
159	http://www.scorecard.org/	Toxics	US
160	http://www.rap-al.org/	Toxics	Chile
161	http://www.citizenalert.org/	Toxics	US

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