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NETWORK SPILLOVER EFFECTS AND THE DYADIC INTERACTIONS OF VIRTUAL, SOCIAL, AND SPATIAL

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Does social media exist in space?

The proposition that online activity may be inconsequential to events transpiring on the ground stems from the suspicion that virtual communities are not organically tied to offline social networks. This assumption claims that online activism is ineffective, with no follow-through, as aggrieved individuals limit their outrage to online communities of acquaintances incapable of effecting change in the real world. This critique underpins much of the discussion about clicktivism and slacktivism, an assertion passionately advocated by Morozov (2013) and convincingly argued by Gladwell (2010), though a wealth of studies have since identified significant relationships between online activism and developments on the ground (Bastos, Mercea, and Charpentier 2015; De Choudhury et al. 2016; Freelon, McIlwain, and Clark 2018). While these studies found significant associations between online and offline activity, they rarely included granular spatial data accounting for the geographic dispersion of online activity.

The relative absence of granular spatial data is a perennial challenge in Internet research. Online communities are expected to operate by a set of social rules as complex as those observed offline, but multidimensional network data linking online activity to geographic areas is rarely available (Bailey et al. 2018). The literature has thus remained relatively ambiguous about the mechanisms through which online social networks interact with their offline, spatialized counterparts. These relationships are difficult to pinpoint and speak to the limited vocabulary available to address that which is social but formed largely online and that which is social but shaped largely offline. Additionally, there are situations where it may not be possible to extricate spatial social networks from online communities, including communities whose members are evenly connected to each other both online and offline (Subrahmanyam et al. 2008).

Space has thus been treated as a secondary force underpinning tie-selection and retention in online social networks, notwithstanding the large body of literature evincing the bidirectional association between geography and network formation (McPherson, Smith-Lovin, and Cook 2001). There is also evidence that geographic proximity affects tie-formation mechanisms associated both with opportunity and preferences, as physical places can be conceived of as a bundle of resources and opportunities constrained by spatial contiguity (Glückler 2007). Online communities may incorporate remote strangers who are activated and incorporated as organic members of one's social network (Rainie and Wellman 2012). Similarly, the relationship between spatial distance and social media interaction has been found to be significant (Laniado et al. 2017), with social ties on Twitter largely confined to distances shorter than 100 kilometers (Takhteyev, Gruz, and Wellman 2012). Other studies have suggested a spillover from in-person interaction patterns to online social media, further problematizing the hypothesis about the direction of homophily (Bastos, Mercea, and Baronchelli 2018).

The overlap between ties established online and offline also depends on the criteria employed to define online activity. Face-to-face interactions invariably take place offline, but phone networks, or the graphs derived from who talks to whom on the phone, can be defined as online networks despite the physical constraints imposed by the infrastructure of telephone wires and the higher billing rate associated with long-distance landline calls. Other disputed examples include the relationship one has with parents living far away; what was previously a network with clear physical and spatial boundaries can transition to a place that is largely virtual. As such, while one may communicate with their parents online, they invariably fall into a different category compared with one's Twitter followership. Indeed, the perennial tension between spatial and social can be traced to seminal studies on dining-table partnerships coded by Moreno (1953), as the seating choices of students in a classroom were also spatially and segregationally patterned.

But the differences between face-to-face and online interaction are usually straightforward, and never so clear-cut as when social media bots are activated. Due to the high overhead involved in growing sockpuppet accounts, botnets are often set to retweet and comment on other bots' messages, thereby triggering message cascades read by absolutely no actual person. Vast portions of the social media supply chain are conceivably colonized by automated posting protocols and quasi-autonomous parasites entirely detached from the geographies inhabited by users. Conversely, influence operations often resort to zombie accounts, promptly revamped with stolen profile photos, to feed communities where online interaction may depart radically from what is observed offline (Bastos and Farkas 2019). Twitterbots are nonetheless a rather extreme case, which may include sophisticated networks combining human and automated accounts to manipulate public deliberation. The worlds of real users and automated protocols feed from each other and it is not always possible to separate them.

The sudden outbreak of the COVID-19 global pandemic has paradoxically reinforced the differences and tightened the interdependencies between online

and offline social networks. The enforced policy of social distancing required businesses and governments to manage their workflow online, with e-commerce struggling to handle the unprecedented demand. As movie theaters suspended operations, Netflix and other streaming platforms registered record numbers of new customers. Universities and schools implemented measures to stream lectures and upload course materials to teaching platforms. Real life suddenly became detached from the physical world, with social relationships carried out over WhatsApp, work meetings moving to Zoom, and friends and colleagues socializing on Google Hangouts. This arrangement, however provisional, foregrounded the gregarious nature of human life and the perennial need to interact with real people in physical spaces. While the outbreak rendered network technologies instrumental in carrying out routine and critical work tasks, it also expounded the limitations of online interaction compared with the multisensorial, time-dependent, and irrevocably space-constrained social network interactions that take place offline.

Online communities are likely to continue triggering interactions that depart from those observed in face-to-face communities beyond the COVID-19 outbreak. This is particularly the case in view of the growing algorithmization of community governance implemented by social platforms. Smartphones and Internet-capable household devices continuously store individual trace data in the cloud, which is imperfectly processed by machine-learning algorithms with limited precision and recall, trained with incomplete datasets, and tailored for purposes that are indistinguishable from those of the company collecting the data. By aggregating digital trace data at individual and group levels, social platforms can offer advertisers granular targets benchmarked with incomplete data and limited precision. The business model is nonetheless sound, as imprecisions measured at the individual level are likely offset at the group level; yet, these imprecisions and incompleteness are then built into the system recursively. Eventually, social groups identified by and modeled with digital trace data can take on a life of their own on social platforms, with niche subcommunities that only partially match their physical counterparts.

Network spillover effect

The dyadic interactions between virtual ↔ spatial, virtual ↔ social, and social ↔ spatial reflect the largely unexplored connection between the online and offline dimensions of social activity. These dyads can reveal intricate relationships between physical ties and online interactions encapsulated in the problem of the directionality in social relationships, a sociological debate about the causal direction of homophily: the phenomenon that like-minded people with similar social characteristics are more likely to be connected with each other, be it online or offline. Causality may of course move in either direction, but previous research has focused mostly on the hypothesis that similarity causes interaction (McPherson, Smith-Lovin, and Cook 2001), likely a reflection of the divide separating social network analysis, leveraging social media data, and spatial analysis, exploring geographic data.

This is unfortunate because the primary and secondary effects associated with the scalable deployment of social technologies are situated at the junction of networks that are simultaneously social and spatial, but whose social/spatial relationship is not symmetric. Individuals can partake in online communities and be exposed to information diets with little similarity to their offline surroundings. At the limit, ideological orientation, identity formation, and feelings of belonging can be pieced together depending on the networks to which individuals find themselves embedded. Perceived social memberships based on age, race, income, and location can be reinforced, but also potentially rewired, as one connects with social networks online that may differ from their proximate communities. Network spillover effects happen not only when face-to-face networks are replaced with social media, but particularly when the embedding in online networks spills over to geographic communities. While these interactions are not trivial, the network spillover effect is relatively simple: seemingly unrelated social activities online and offline reinforce each other.

Network spillover is associated with neighborhood effects that were first described in the seminal studies of Butler and Stoke (1969) about the 1964 and 1966 United Kingdom General Elections. The election cycle consolidated the Labour Party's majority through a process of partisan reinforcement: the tendency of prevailing opinions to draw additional support to become dominant in local areas. The geographic or neighborhood component of network spillover was mapped by Miller (1977), for whom contact, largely structured by family, choice of friends, social characteristics, and locality such as neighborhoods, is a condition for consensus, with patterns of contact being predictive of political consensus within high-contact groups. The neighborhood effect is perhaps best described by Miller's (1977) assertion that locality is a better predictor of how people vote than their social characteristics.

Spillover effects are thus intrinsically linked to neighborhood effects due to homophilic interdependencies tying spatial and social cohesion. Locational decisions involve a considerable degree of social selection, whereby people choose to live in neighborhoods populated by people similar to themselves. This results in social networks that are geographically delimited and socially homogenous, not just in their socio-economic and demographic composition, but also ideologically, behaviorally, and culturally. Although geographic constraints and ideological homogeneity mutually reinforce each other, neighbors may come across attitudes and behaviors different from those held within the group. Particularly those holding a minority view in the group are more likely to come across new information, including new ideas, behaviors, and ideologies. New information may then rapidly break into the group majority, as social interactions are optimized to negotiate, and thereby spread, attitudes and behavior.

Johnston and Pattie (2011) provide an account of how neighborhood effects can be further amplified by other network externalities, a process that may trigger feedback loops and spillovers. For instance, if a political debate between individuals holding opposing views about the best candidate in an election can persuade

people to reconsider their own positions (conversion), then any social network with a majority of the population supporting a given candidate is more likely to switch to the minority candidate than the other way around. This contradicts the assumption of research on opinion evolution, but it is conceptually accurate because voting preferences are socially structured not only by the characteristics of the voter, but also by those with whom the voter discusses politics. Contact with voters in a given area influence not only the individuals directly connected, but also others in the neighborhood (Huckfeldt and Sprague 1995). On the other hand, and perhaps paradoxically, this process would render the majority view within the network even more prevalent, as dominance would be greater than expected from knowledge of the individuals' personal characteristics alone. If neighborhood effects can be observed whenever conversation networks are spatially constrained, then the political complexion of areas should be more polarized than their social composition implies.

Spillover effects are traditionally associated with exogenous policy interventions on subjects who were not originally targeted by the intervention, but who happen to be connected to those in the target population. Social media microtargeting can thus spill over to actors in local social environments who were not targeted by the message themselves. In this scenario, the spillover effect is the contagion effect on actors due to interventions targeting their friends. In contrast, endogenous peer effects stem directly from peers. In other words, actors in a network influence each other without being subjected to any microtargeting or intervention. While the source of exogenous effects is situated outside of the network, in reality it is difficult to separate endogenous from exogenous peer effects, as many of the endogenous peer effects could originally be generated by external forces unobservable to researchers (An 2011). Likewise, an exogenous peer effect such as microtargeting can be further compounded by endogenous effects such as the neighborhood effect, so that it is not always possible to untangle nested peer effects (Duflo, Dupas, and Kremer 2011).

These problems have long been studied in research on opinion evolution that highlights the non-linear patterns through which opinions and social change emerge from system interactions. While opinion dynamics progress fairly linearly over time, they often lead to nonlinearities and complex dynamic behavior, of which clustering (i.e., "bubbles") and the polarization of opinions are common outcomes (Nowak, Szamrej, and Latané 1990; Latané 1996). In other words, while changing public opinion is a process governed by intrinsic dynamics, the transition to a new prevailing opinion is likely linked to changes in extrinsic control factors that affect intrinsic dynamics (Nowak, Lewenstein, and Frejlik 1996). The negotiation of social values offline can be reinforced online, and vice-versa, thereby triggering network spillover effects and feedback loops typical of regulatory processes with a high density of connections.

In our study on echo chambers during the Brexit debate (Bastos, Mercea, and Baronchelli 2018), we found that social media echo chambers actually reflect real-life conversations that link to the geographic locations of users. The findings

contradict the prevailing narrative on echo chambers, arguing that social media interactions lead users to engage with political content that resonates with them (Sunstein 2007). The ideological clustering observed in politically homogeneous echo chambers would stand in contrast to the diversity of opinions found in offline, face-to-face interactions. Transposed to the network of tweets about the UK–EU membership referendum, and following the prevailing narrative in the literature, we would have expected to find echo chambers as a communication effect resulting from online discussions alone. Conversely, we did not expect the geographic location of users to play a significant role in politically homogeneous communication, as echo chambers reportedly result from social media interactions unaffected by geographic space.

Indeed, social anxieties surrounding echo chambers posit that social media is another force driving political polarization (Bessi et al. 2015), with a substantive body of observational evidence showing the role of social media in stratifying users across information sources (Conover et al. 2011). While the rapid growth of online social networks has fostered an expectation of higher exposure to a variety of news and politically diverse information (Messing and Westwood 2014), it has also increased the appetite for selective exposure in highly polarized social environments (Wojcieszak 2010), with the sharing of controversial news items being particularly unlikely in these contexts (Bright 2016). The filter bubble hypothesis encapsulated these claims by postulating that social platforms deploy algorithms designed to quantify and monetize social interaction, narrowly confining it to a bubble algorithmically populated with information closely matching user preferences (Pariser 2012).

The results of our study show that although most interactions are within a 200-km radius, echo chamber communication predominantly takes place in neighboring areas within a 50-kilometer radius. However, the geographic trend of echo chamber communication was different between the Leave and Remain campaigns, with pro-Leave messages covering much shorter distances compared with pro-Remain tweets. The trend was also reversed for non-echo chamber communication, which covered shorter distances on the Remain side. In other words, Leave-campaign messages were chiefly exchanged within ideologically and geographically proximate echo chambers. Although echo chambers also prevailed on the Remain side, the trend was inverted: as the distance between the sender and receiver increased, echo chambers became more common and covered increasingly larger areas compared to non-echo chamber communication. This reverse trend was captured by the mean distance covered by Leave messages, at 199 km for echo chambers and 234 km for non-echo chambers ($\tilde{x} = 168$ and $\tilde{x} = 208$, respectively). For Remain tweets, inversely, the mean distance of echo chambers was 238 km versus 204 km for non-echo chambers ($\tilde{x} = 209$ and $\tilde{x} = 184$, respectively).

The study indicates that online echo chambers result from conversations that spill over from in-person interactions and call into question the assumption that echo chamber communication is driven by online interaction alone, suggesting instead that people bring their pub conversations to online debate. The findings

also appear to confirm the hypothesis that similarity causes interaction, as politically homogenous network interactions would be triggered by or from geographical proximity. Correspondingly, studies have found that radicalization on YouTube stems from the same factors that persuade individuals to change their minds in real life—that is to say, absorbing and interiorizing new information, but at scale (Munger and Phillips 2019). Instead of depending on algorithms that increasingly radicalize audiences, political media on YouTube would be driven by supply and demand, with the increased supply of right-wing videos tapping a latent demand previously constrained by limited offer offline.

Online–offline coordination

The extent to which online social networks overlap with the boundaries of their offline communities is of course an empirical question hindered only by the challenges in collecting relational data that can be mapped onto geographic boundaries while also preserving metrics of online activity. In subsequent attempts to address the problem, we validated the use of social media signals to model the ideological coordinates underpinning the Brexit debate. Geographically enriched Twitter data was coupled with a machine learning algorithm that identified tweets along the ideological space of populism, economism, globalism, and nationalism. The granular spatial data amassed for this study allowed us to map the political value space of users tweeting the referendum onto Parliamentary Constituencies (Bastos and Mercea 2018).

The study required the extensive collection of Twitter data supplemented by multiple queries to Twitter API to identify the location of users tweeting the UK–EU membership referendum. After adding geographic markers to the database, we calculated the ideological inclination of users and mapped them onto voting constituencies in England, Wales, Scotland, and Northern Ireland. The research was informed by suggestions of a geographical and socio-demographic patterning of voting preferences in the referendum explored in the literature (Rennie Short 2016; Hanretty 2017). The geography of the vote, it was proposed, reflected a socio-economic imbalance between an affluent metropolitan elite clustered around London who voted to remain and parts of England and Wales that were economically worse off and voted to leave the EU. Following this line of inquiry, the political geography of the vote was unpicked at the level of local authority areas (Becker, Fetzer, and Novy 2016) to assess the extent to which users tweeting nationalist and populist content would overlap across geographic enclaves—and conversely, whether such patterns could be observed in relation to users tweeting globalist or economist content.

While we succeeded in identifying the geographic location of 60% of users who tweeted the referendum, a considerable portion of their locations could be identified only up to city level, but not postcode level. Upon identifying the location of users, we removed user accounts located outside the United Kingdom or whose location we could not identify up to postcode level. This

reduced the database to 565,028 messages or 11% of all collected messages. Despite the multiple efforts to maximize the collection of geographic information about users, research seeking to explore the overlap between online and offline networks must contend with smaller data samples. In this study, the various sampling techniques applied to the data, particularly the geographic rendering of user locations up to postcode level, reduced the universe of collected tweets to only 11% of the data.

Another challenge in this type of research consists of defining the unit of analysis. In this specific case, we selected council wards and parliamentary constituencies because they provided optimal granularity relative to online and offline data sources. Twitter data was aggregated first at user level and then at constituency level, which was the unit of analysis employed in the study. The resulting dataset included multiple streams of Twitter data consolidated into a single database of online and offline activity at constituency level. A scaled Poisson regression model was applied to incorporate demographic information from lower-level geographies, thereby aggregating the results at the ward or constituency level, along with voting estimates at the level of council wards for authorities that did not disclose the results at such granular levels (Huyen Do, Thomas-Agnan, and Vanhems 2015; Hanretty 2017). The resulting referendum database was relatively granular with data down to the ward level in England, Scotland, and Wales and Local Authority District in Northern Ireland.

Mapping geographically rich social media data onto census area or electoral districts is another challenge due to the hierarchical subdivision of UK local government areas into various sub-authority areas and lower levels such as enumeration districts. As council wards comprise the most granular level to which we could retrieve results or estimates for the referendum vote, we mapped referendum-related Twitter activity to this unit of geographic analysis. User locations were geocoded and reverse-geocoded to match postcodes to wards and Parliamentary Constituencies using the database provided by National Statistics Postcode Lookup (ONS Geography 2011). Twitter users were thus simultaneously matched to the fields OSLAUA, OSWARD, and PCON11CD (Local Authority, Ward, and Constituency codes, respectively). The first field includes Local Authority District (LAD), Unitary Authority (UA), Metropolitan District (MD), London Borough (LB), Council Area (CA), and District Council Area (DCA).

Upon geocoding the self-reported location of users, we found that only 30% of them were based in the UK, with 19% of users who participated in the Brexit debate based in the United States and nearly 30% in other EU countries. This is of course another marker of the differences in political discourse online and offline, as the former allows individuals from different locations to participate, albeit in a restricted capacity, in the public discourse on an issue circumscribed to the UK. Also surprising was the large geographic spread of the British Twitter userbase, with London accounting for 14%, Lancashire 7%, Kent, Essex, West Yorkshire, and West Midlands ranging 3–4%, and South Yorkshire, Hertfordshire, Cheshire, Merseyside, Surrey, and Hampshire at 2% each. Taken together, each of these

geographic groups are of comparable size to London in the share of users who tweeted the referendum.

The results somewhat upset our expectations. Apart from London, globalist messages were relatively underwhelming. Nationalism was indeed quintessential to the referendum debate, with three-quarters of messages (74%) displaying nationalist sentiments, as opposed to 26% that expressed globalist values such as international cooperation. We did not find that economically fragile northern England, an area generally supportive of Brexit, was any more likely to embrace nationalist content. In fact, it was Remain-backing Scotland that appeared as a fertile ground for nationalism. Though nearly 40% of tweets contained populist sentiments, these messages were concentrated in a small number of constituencies. In only 10% of the constituencies did populist sentiments prevail, compared with economic issues, and in less than 5% did globalist sentiments dominate. All 72 constituencies with overwhelming support for Leave presented predominantly nationalist sentiments. Conversely, only 17 of these constituencies had a Twitter debate predominantly defined by populist sentiments, with 55 of them discussing mostly the economic outlook.

Conclusions

One possible explanation for the conflicting evidence on the geography of echo chambers is that politically homogeneous communication may reflect the imprint of deliberation driven by offline social networks. These homophilic preferences can coexist with social media platforms that provide ideologically diverse networks (Barberá 2014). As such, the boundaries of one's network can be simultaneously permeated by echo chambers rooted in offline relationships while being exposed to competing opinions on polarizing topics that circulate on social media. Similar associational effects have been reported in the literature (Laniado et al. 2017), suggesting that the geographic dependence of echo chambers would result from the physical clustering of fundamentally disparate social networks.

Instead of incorporating remote strangers who are activated and incorporated as organic members of one's social network (Rainie and Wellman 2012), the results suggest a spillover from in-person conversations to online social media interaction. In other words, echo chambers connect homophilous dependencies in physical social networks that are relatively independent of social media activity. This is also consistent with the differences in echo-chambers observed in the Leave and Remain campaigns, as the demographic makeup of these subgraphs is considerably different. In other words, the significant geographic variation found in the data would be driven not only by the locations where the two groups were clustered, but also the social positions embedded in the geographical location of Leave and Remain constituencies.

The different social positions occupied by Leavers and Remainers are consistent with the geographical splintering of the country expressed in the referendum and reflect the socio-economic imbalances separating urban loci of political and

economic power, clustered around London, which voted Remain, and economically fragile parts of England and Wales, where the Leave vote prevailed. With city-dwellers spending more time shopping and exploring areas outside their neighborhoods, as well as living and working in hubs of the national and global economy (Storper 2018), it is unsurprising that the resulting social networks of Remain urbanites would cover larger geographic areas. The distances covered by their interactions should likewise be lengthier compared with those inhabiting rural or low-density areas of the country. This is of course only one aspect of the intricate relationship connecting existing physical ties and online interactions, with others likely at play (Takhteyev, Gruz, and Wellman 2012; Laniado et al. 2017).

In summary, while research on the directionality of homophily between online and offline social networks is still forthcoming, there is growing evidence for the spatial dependencies of social media. This body of work also contradicts Facebook's assumption that social platforms necessarily strengthen existing communities; that they invariably help individuals to come together online and offline; or that they enable groups to form completely new communities that transcend physical location (Zuckerberg 2018). Indeed, the assumption that social platforms merely connect individuals online to reinforce their physical communities tends to ignore the complex and multidirectional association between geography and tie-selection and retention in online networks. It also fails to consider that the diffusion of information on social media platforms may differ from patterns observed offline, and that these interactions can make or break the fabric of society. In other words, while interaction across social platforms can evolve in the absence of physical ties, the network externalities arising from interactions developed online may impinge on our very sense of what is real offline.

References

- An, W. E. 2011. "Models and Methods to Identify Peer Effects." In *The Sage Handbook of Social Network Analysis*, edited by John Scott and Peter J. Carrington. London: SAGE Publications.
- Bailey, M., R. Cao, T. Kuchler, J. Stroebel, and A. Wong. 2018. "Social Connectedness: Measurement, Determinants, and Effects." *Journal of Economic Perspectives* 32 (3): 259–280. doi: 10.1257/jep.32.3.259.
- Barberá, P. 2014. "How Social Media Reduces Mass Political Polarization. Evidence from Germany, Spain, and the US." Paper prepared for the 2015 APSA Conference, New York University.
- Bastos, M. T., and J. Farkas. 2019. "'Donald Trump Is My President!': The Internet Research Agency Propaganda Machine." *Social Media + Society* 5 (3). doi: 10.1177/2056305119865466.
- Bastos, M. T., and D. Mercea. 2018. "Parametrizing Brexit: Mapping Twitter Political Space to Parliamentary Constituencies." *Information, Communication & Society* 21 (7): 921–939. doi: 10.1080/1369118X.2018.1433224.
- Bastos, M. T., D. Mercea, and A. Baronchelli. 2018. "The Geographic Embedding of Online Echo Chambers: Evidence from the Brexit Campaign." *PLoS ONE* 13 (11): e0206841. doi: 10.1371/journal.pone.0206841.

- Bastos, M. T., D. Mercea, and A. Charpentier. 2015. "Tents, Tweets, and Events: The Interplay between Ongoing Protests and Social Media." *Journal of Communication* 65 (2): 320–350. doi: 10.1111/jcom.12145.
- Becker, S., O. T. Fetzer, and D. Novy. 2016. "Who Voted for Brexit? A Comprehensive District-Level Analysis." 1–69. Coventry: Centre for Competitive Advantage in the Global Economy, University of Warwick. www2.warwick.ac.uk/fac/soc/economics/research/centres/cage/manage/news/305-2016_becker_fetzer_novy.pdf.
- Bessi, A., F. Petroni, M. D. Vicario, F. Zollo, A. Anagnostopoulos, A. Scala, G. Caldarelli, and W. Quattrociocchi. 2015. "Viral Misinformation: The Role of Homophily and Polarization." In *Proceedings of the 24th International Conference on World Wide Web*, 355–356. New York: ACM.
- Bright, J. 2016. "The Social News Gap: How News Reading and News Sharing Diverge." *Journal of Communication* 66 (3): 343–365.
- Butler, D., and D. Stoke. 1969. *Political Change in Britain: Forces Shaping Electoral Choice*. London: Macmillan.
- Conover, M. D., J. Ratkiewicz, M. Francisco, B. Goncalves, F. Menczer, and A. Flammini. 2011. "Political Polarization on Twitter." 5th International AAAI Conference on Weblogs and Social Media (ICWSM11), Barcelona.
- De Choudhury, M., S. Jhaver, B. Sugar, and I. Weber. 2016. "Social Media Participation in an Activist Movement for Racial Equality." 10th International AAAI Conference on Web and Social Media.
- Duflo, E., P. Dupas, and M. Kremer. 2011. "Peer Effects, Teacher Incentives, and the Impact of Tracking: Evidence from a Randomized Evaluation in Kenya." *American Economic Review* 101 (5): 1739–1774.
- Freelon, D., C. McIlwain, and M. Clark. 2018. "Quantifying the Power and Consequences of Social Media Protest." *New Media & Society* 20 (3): 990–1011.
- Gladwell, M. 2010. "Small Change: Why the Revolution Will Not Be Tweeted." *The New Yorker*, 4 October 2010. www.newyorker.com/reporting/2010/10/04/101004fa_fact_gladwell.
- Glückler, J. 2007. "Economic Geography and the Evolution of Networks." *Journal of Economic Geography* 7 (5): 619–634. doi: 10.1093/jeg/lbm023.
- Hanretty, C. 2017. "Areal Interpolation and the UK's Referendum on EU Membership." *Journal of Elections, Public Opinion and Parties* 27 (4): 466–483. doi: 10.1080/17457289.2017.1287081.
- Huckfeldt, R. R., and J. Sprague. 1995. *Citizens, Politics, and Social Communication: Information and Influence in an Election Campaign*. New York: Cambridge University Press.
- Huyen Do, V., C. Thomas-Agnan, and A. Vanhems. 2015. "Spatial Reallocation of Areal Data—Another Look at Basic Methods." *Revue d'Économie Régionale & Urbaine* 1–2: 27–58. doi: 10.3917/reru.151.0027.
- Johnston, R., and C. Pattie. 2011. "Social Networks, Geography and Neighbourhood Effects." In *The Sage Handbook of Social Network Analysis*, edited by John Scott and Peter J. Carrington. London: SAGE Publications.
- Laniado, D., Y. Volkovich, S. Scellato, C. Mascolo, and A. Kaltenbrunner. 2017. "The Impact of Geographic Distance on Online Social Interactions." *Information Systems Frontiers*: 1–16.
- Latané, B. 1996. "Dynamic Social Impact: The Creation of Culture by Communication." *Journal of communication* 46 (4): 13–25.
- McPherson, M., L. Smith-Lovin, and J. M. Cook. 2001. "Birds of a Feather: Homophily in Social Networks." *Annual Review of Sociology* 27 (1): 415–444. doi: 10.1146/annurev.soc.27.1.415.

- Messing, S., and S. J. Westwood. 2014. "Selective Exposure in the Age of Social Media." *Communication Research* 41 (8): 1042–1063. doi: 10.1177/0093650212466406.
- Miller, W. L. 1977. *Electoral Dynamics in Britain since 1918*. London: Macmillan.
- Moreno, J. L. 1953. *Who Shall Survive? Foundations of Sociometry, Group Psychotherapy and Socio-Drama*. Oxford, England: Beacon House.
- Morozov, E. 2013. *To Save Everything, Click Here: The Folly of Technological Solutionism*. New York: Public Affairs.
- Munger, K., and J. Phillips. 2019. "A Supply and Demand Framework for YouTube Politics." Preprint.
- Nowak, A., M. Lewenstein, and P. Frejlik. 1996. "Dynamics of Public Opinion and Social Change." In *Modelle sozialer Dynamiken: Ordnung, Chaos und Komplexität*, edited by Rainer Hegselmann and Heinz-Otto Peitgen. Wien: Hölder-Pichler-Tempsky.
- Nowak, A., J. Szamrej, and B. Latané. 1990. "From Private Attitude to Public Opinion: A Dynamic Theory of Social Impact." *Psychological Review* 97 (3): 362–376.
- ONS Geography. 2011. "National Statistics Postcode Lookup UK." In *Office for National Statistics*. London: ONS.
- Pariser, E. 2012. *The Filter Bubble: What the Internet Is Hiding from You*. London: Penguin.
- Rainie, L., and B. Wellman. 2012. *Networked: The New Social Operating System*. Cambridge, MA: MIT Press.
- Rennie Short, J. 2016. "The Geography of Brexit: What the Vote Reveals About Disunited Kingdom." *The Conversation*. <http://theconversation.com/the-geography-of-brexit-what-the-vote-reveals-about-the-disunited-kingdom-61633>.
- Storper, M. 2018. "Separate Worlds? Explaining the Current Wave of Regional Economic Polarization." *Journal of Economic Geography* 18 (2): 247–270. doi: 10.1093/jeg/lby011.
- Subrahmanyam, K., S. M. Reich, N. Waechter, and G. Espinoza. 2008. "Online and Offline Social Networks: Use of Social Networking Sites by Emerging Adults." *Journal of Applied Developmental Psychology* 29 (6): 420–433. doi: 10.1016/j.appdev.2008.07.003.
- Sunstein, C. R. 2007. *Republic.Com 2.0*. Princeton, NJ: Princeton University Press.
- Takhteyev, Y., A. Gruzdt, and B. Wellman. 2012. "Geography of Twitter Networks." *Social Networks* 34 (1): 73–81. doi: 10.1016/j.socnet.2011.05.006.
- Wojcieszak, M. 2010. "'Don't Talk to Me': Effects of Ideologically Homogeneous Online Groups and Politically Dissimilar Offline Ties on Extremism." *New Media & Society* 12 (4): 637–655. doi: 10.1177/1461444809342775.
- Zuckerberg, M. 2018. "Building Global Community." *Facebook*. www.facebook.com/notes/mark-zuckerberg/building-global-community/10154544292806634.