Why Study Media Ecosystems?

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Abstract

Much as ecology emerged from biology as scientists began studying the complex interactions between organisms in their environments, a shift is happening in communication and media studies regarding analysis of social media. The complex relationships between user-generated social media and professionally-created news media are best understood as a complex media ecosystem with its own emergent behaviors that only become visible when studied from a perspective broader than considering a single medium in isolation. Some of the key debates regarding social media's effects in spreading mis- and disinformation can be studied in richer ways by applying quantitative methods that integrate information across multiple types of media using a media ecosystem model. Understanding these characteristics of media ecosystems could help political parties, activists and others who depend on media to advance their messages.

The invention of the ecosystem

Arthur Tansley was one of Britain's foremost scholars of ecology. Sherardian Professor of Botany at the University of Oxford, chair of the British Ecological Society and founding editor of the Journal of Ecology, Tansley's opinions carried great weight in scientific societies, and especially around the complex and "polymorphic science" (Cooper, 1957) of ecology (McIntosh, 1986).

His 1935 paper, "The use and abuse of vegetational terms and concepts" (Tansley, 1935) introduced the term "ecosystem", which he defines as "...the whole system (in the sense of physics), indicating not only the organism-complex, but also the whole complex of physical factors forming what we call the environment of the biome - the habitat factors in the widest sense. Though the organisms may claim our primary interest, when we are trying to think fundamentally we cannot separate them from their special environment, with which they form one physical system."

In offering this definition, Tansley pushed his colleagues to view their field's horizons more broadly than those of the disciplines ecology emerged from: natural history, botany, zoology. Ecology's special role was the consideration of these broad systems, understood through the movement of materials and energy through living communities. Scholars would continue to examine individual species of plants and animals, Tansley believed, but "the systems we isolate mentally are not only included as parts of larger ones, but they also overlap, interlock and interact with one another. The isolation is partly artificial, but is the only possible way in which we can proceed." (Tansley 1935)

While Tansley's definition was influential within ecology, discussions of "ecosystems" did not reach broader audiences until the 1960s when a wave of activism around ecological issues, particularly Rachel Carson's *Silent Spring* (Carson, 2002), began a widespread conversation about systemic threats to the environment as a whole. Carson's documentation of the risks to human and environmental health that could come from the bioaccumulation of DDT within food

webs introduced a new way of thinking about human impact on the environment to millions of readers. Environmental activist Bill McKibben credits Carson as "the very first person to knock some of the shine off modernity," (Griswold, 2012) confronting readers with the uncomfortable truth that the celebrated lab-produced chemicals that characterized modern life could alter an entire ecosystem, eventually threatening human life itself.

If Carson's call to arms was the key event bringing the idea of ecosystems to wide popular understanding, a trio of related events in 2016 may serve as the Silent Spring moment to inspire broad study of media ecosystems. In June 2016, Britain stunned much of the world in voting to leave the European Union. In November 2016, the United States elected the supremely unqualified Donald Trump to the presidency, shocking political prognosticators globally. Journalists began to focus on political disinformation and its possible effects as a way to explain the surprise of the Brexit and US presidential elections. This narrative gained traction in 2018 with news of a massive leak of Facebook profile data by Cambridge Analytica, a political consulting firm that had worked for Leave.EU and also the Trump 2016 presidential campaign. The emergent narrative about the dangers of social media ecosystems is summarized in a phrase uttered by everyone from Roger McNamee (Tucker, 2020), an early investor in Facebook, to Derrick Johnson, the president of the NAACP (Thornbecke, 2020): "Facebook is a threat to democracy."

This line of thought about the power of a media system leads directly back to ideas articulated in the 1960s by Marshall McLuhan and Neil Postman. Postman adopted McLuhan's term "media ecology" and established the Program in Media Ecology at NYU in 1971, positing that "Media

ecology looks into the matter of how media of communication affect human perception, understanding, feeling, and value; and how our interaction with media facilitates or impedes our chances of survival" (Postman, 1970).That perspective informed Postman's best known work, *Amusing Ourselves to Death* (Postman, 1985), in which he argues that the shortcomings of television as a medium make rational argumentation difficult or impossible.

It is dangerous to extend Postman's work to include technologies invented after his death, but it is likely he would have echoed those worried about Facebook and democracy, as he was sufficiently skeptical of a computation future to tell the German Informatics Society in 1990, "Through the computer, the heralds say, we will make education better, religion better, politics better, our minds better - best of all, ourselves better. This is, of course, nonsense, and only the young or the ignorant or the foolish could believe it" (Postman, 1990). Postman would not have been surprised to see a narrative emerge in which social media made politics and civic dialog worse, and might have gone further to argue that these tools make some forms of responsible political discussions impossible.

Yet while McLuhan and Postman argue for "media ecology" as the practice of understanding media's effects on society more broadly, the concept of a "media *ecosystem*" as a complex but quantitatively analyzable set of relationships and flows, offers a lens to understand our Facebook/Cambridge Analytica/disinformation moment. Media is the environment in which we understand, feel and value, and Postman and McLuhan might agree that ads and content microtargeted to us based on previously expressed preferences have the power to shift our political positions.

But it is Tansley who gives us the tools to understand the anxieties and suspicions of social media and their effects on contemporary society. It is not just the ways individuals have received propaganda and misinformation on Facebook that should give us concern for democracy: it is the complex interactions between digital media, conventional media, politicians, voters, advertisers and platforms that we need to investigate to understand the contemporary moment. Much as the weakening of condor eggshells implicated not just DDT, but the broader project of better living through chemistry, the 2016 Facebook/Cambridge Analytica/misinformation scandal suggests a need not just to look closely at Facebook but at the complex relationships between digital media and citizenship.

The concept of the media ecosystem is not a new one - we see references to the changing media ecosystem in studies of the relationship between blogs and mainstream media in the early 2000s, and the term is applied particularly to the structure of media in specific geographic areas, i.e., the Muslim world (Eickelman & Anderson, 2003). Recent work exploring the different behaviors that occur within a single social media platform, using ethnographic and historical techniques, present a deeply helpful foundation to build upon for broader studies of relationships between platforms and networks (Burgess and Baym, 2020; Mailland and Driscoll 2017).

In this sense, earlier discussions of media ecosystems parallel the use of ecosystem to describe physical environments, applying first to specific geographical areas before discussing the environment, in totality, on scales up to the planetary. The term has gained significant traction in the past ten years, as the rising power of platforms like Facebook, YouTube and Twitter and the

waning influence of newspapers and television have forced a re-examination of the complex relationships between pre-digital media, digital native media and their collective interactions with public opinion formation, voting and other civic behaviors.

What We Study When We Study Media Ecosystems

In positing ecosystems as a study of "the whole system (in the sense of physics)", Tansley encourages us to think in terms of large-scale flows: how energy and nutrients flow through an ecosystem from photosynthesis to consumption, to predation, to decay. Media ecosystems operate on flows as well: the flow of attention. The pioneer in identifying attention as the key currency of the media ecosystem was the wildly interdisciplinary thinker, Herbert Simon.

Simon won both the Nobel for economics in 1978 and the Turing Award for computer science in 1975. Simon's expertise was diverse, and he was sought out as a collaborator in many fields. That Simon was so widely celebrated and in demand may explain his interest in the limits of human attention. In 1969, Simon gave a lecture to the Brookings Institute titled "Designing Organizations for an Information-Rich World" (Simon, 1969). Simon opens the lecture with a story about his neighbors, who bought a pair of rabbits for their daughters as a Christmas present. One was male and one female, and the neighbors now have many rabbits. Too many? Simon answers the question in ecological terms: "…we might judge the world as rabbit rich or rabbit poor by relating the number of rabbits to the amount of lettuce and grass (and garden flowers) available for them to eat." (Simon, 1969, p.6) A surplus of rabbits exists if there is a surfeit of grass, and vice versa.

"What information consumes is the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it." (Simon, 1969, p. 7) Designing Organizations for an Information-Rich World Simon uses this idea of surplus and scarcity to encourage us to understand information not in terms of bits and bytes, but in terms of time: "We can measure how much scarce resource is consumed by a message by noting how much time the recipient spends on it." (Simon, 1969, p.7) In those terms, subscribing to a daily newspaper is an extremely expensive habit: we pay not only the subscription cost but the time we need to read and comprehend it.

Simon did not believe we could multitask our way free of this problem. Instead, he offers as a solution the careful use of market mechanisms to ensure that "free" information does not overwhelm the finite capacities of organizations to consume, analyze, compress and pass on relevant information to those who might need it. Simon warns that this is far harder than it might seem – simply computerizing systems accelerates the flow of information without addressing our finite capacity to understand the information flowing back and forth.

Unfortunately, very little of the technology assessment Simon prescribed has been applied to media technologies. Innovators in the space have worked to make it easier to create and disseminate "content" – new information – with little consideration for the scarcity of attention to encounter and understand that information. Different waves of innovation have made the problem worse. The breakthrough technology of Simon's day, the photocopier, led to an

explosion in the production of text, and a wave of "information overload" concerns in the American workplace. Word processing and desktop publishing allowed individuals to create sophisticated-looking publications without the involvement of a print shop or a publisher. Email and the early web allowed content to be published to a theoretically global audience. The "social media" paradigm turned the process of socializing with friends into a publication activity, creating waves of content intended for small audiences, but with the possibility of "going viral" to a vast crowd.

One effect of these technological changes – and the increased scarcity of attention brought about by this surfeit of digital rabbits – is a tendency to overfocus on the importance of these new technologies at the expense of older ones. Despite the rise of cable television news, the birth of countless digitally native news publications and the emergence of platforms like Facebook as powerful disseminators of news, print-based newspapers continue to be the most important producers of investigative journalism in many countries. Local television news broadcasts and talk radio remain enormously influential in American politics, despite the rise of countless other spaces for political and civic conversation (Mitchell et al., 2016).

An understanding of media as an ecosystem helps us overcome this tendency: we can see how often the topic of digital discussions are the reporting conducted by "elite" media outlets, and how powerful those digital discussions can be in cueing offline journalists towards what topics deserve their attention. Ecosystem approaches let us look beyond flows of attention between different media types and towards larger-scale shifts: from fixed-time media (the morning newspaper, the 10 o'clock news) to asynchronous media (streaming video, text posted on the

web); from professional content creators to amateurs; from a text-centric media to a video-centric one.

Understanding how media ecosystems operate offers a set of powerful new tools for political parties and activist movements who learn to navigate and manipulate these new spaces. Social change is, in part, a battle for attention: media attention makes the issues a movement advocates for visible to the public, raises the profile of a movement's leaders, can help raise funds for a movement and can help inject movement issues into political debate (Andrews & Caren, 2010). Political parties similarly compete for attention, both in traditional and digital media (Cogburn & Espinoza-Vasquez, 2011), seeking "earned media" to complement advertising, and seeking signals from media as to public opinion on controversial issues (Green-Pedersen & Stubager, 2010). As a consequence, the dynamics of contemporary media ecosystems are of deep interest to scholars and practitioners of social movements and political parties.

Here is one of several possible models we might use to understand a media ecosystem where attention is the central commodity, as "energy" is central to an ecological food web. (I outline this model in more detail in a 2018 essay (Zuckerman, 2018).

In a pre-digital information ecosystem, the power to direct attention was controlled primarily by entities that could disseminate information to large audiences: printers and broadcasters. These entities created vertically integrated businesses that produced news and entertainment, solicited advertising, and delivered an integrated package of content – some explicitly requested, some along for the ride – to their audiences. By delivering this content, they claimed a huge swath of

attention. In the 1980s and 1990s, the top performing news and entertainment programming on US television networks claimed audiences of more than 20 million people watching simultaneously (https://en.wikipedia.org/wiki/Nielsen_ratings#Top-rated_programs_in_the_U.S.). Sixty million households subscribed to at least one daily newspaper. By renting part of that attention to local and national advertisers, publishers and broadcasters operated businesses that were often wildly profitable. In the mid-1990s, publicly traded newspapers boasted close to a twenty percent margin at a time when the margin for the average US manufacturing business was 7.6% (Nieman Reports, 1999). In the following decade, broadcasters and cable providers operated wildly profitable businesses, with cable operators running at 38% profit and television broadcasters at 16% (Ernst and Young, 2011).

That position of economic power came from the concentration of attention. A local newspaper offered perhaps the only way to tell people in a specific geographic area that peaches were on sale at the local supermarket. That local newspaper – always a combination of news and entertainment - is now a less reliable way to reach that audience, particularly because there are so many more demands on their attention, including both other news sites and hybrid spaces like YouTube and TikTok. What newspapers and local broadcasters had going for them as businesses were their near monopoly on attention – if you wanted to get in front of local audiences, they were the only game in town.

There is significant power that comes from this position of concentrated attention. Newspapers and broadcasters were not just brokers of attention. The profits of that business allowed them to produce news and information that made it possible for their audiences to participate in society

as informed citizens. In the process, newspapers and broadcasters got to determine what issues and questions were most appropriate for discussion. As Max McCoombs and Don Shaw found in their seminal 1972 study, "The Agenda-Setting Function of Mass Media", there was strong correlation between what issues local media in a small town (Chapel Hill, North Carolina) reported on most often and what citizens identified as the key issues in an upcoming election. The authors quote a memorable take from Bernard Cohen a decade earlier, who noted that the press "may not be successful much of the time in telling people what to think, but is stunningly successful in telling its readers what to think *about*" (McCombs & Shaw, 1972).

 With an explosion of media options available to audiences, newspapers and broadcasters no longer hold this monopoly position as brokers of attention. We are paying attention to Facebook, to Twitter, to a thousand different websites, all of which are trying to further broker our attention, to the advertisers who support their platforms. In such a divided landscape, power over directing attention - and the political power associated with that attention - falls to "discovery engines", tools that help us discover interesting and relevant content, either through choices we make or through carefully engineered serendipity.

Google is one of the most powerful of these discovery engines, using our search queries to direct our attention to their varied web properties as well as countless other websites. Facebook is another, directing our attention to posts made by our friends, but also pages across the web they recommend – the logic of Facebook's discovery engine is that we will be interested in what our friends are interested in, while with Google, we tell the search engine what we want to know about. It is no surprise that these two discovery engines are now enormously economically

successful, aggregating ad space and data about user behavior on their own properties, and on vast networks of other websites. Jointly, Google and Facebook now represent 70% of the global digital ad market (Marketwatch, 2020).

This shift in power from publishers and broadcasters as brokers of attention to discovery engines has several consequences for the broader media ecosystem. As broadcasters and print publishers lose their supply of concentrated attention, their revenues are falling. Print newspapers in the US had 59 million daily subscribers in 2000 and fewer than 29 million in 2018 – revenues have fallen accordingly, with $48.6 billion in advertising revenue in 2000 and $14.3 billion in 2018 (Pew Research Center, 2019). The drop in revenue has been even more stark than the decline in subscription because online advertising has pushed down ad prices in print. As a result, the newspaper industry employed almost 72,000 people in newsroom jobs in 2004, and only 38,000 in 2018. These reduced staffs cover fewer stories in less detail, leading to warnings that accountability journalism, especially outside of major cities, may be threatened.

As newspapers and broadcasters lose their gatekeeping and agenda-setting capacity, an interesting phenomenon unfolds. If discovery engines saw themselves as successors to publishers, choosing topics and sources of information to favor over others, they would inherit the agenda-setting capabilities of newspapers and broadcasters. Instead, Google, Facebook and others portray themselves as neutral platforms, making as few judgements as possible about what information should be featured or suppressed. This stance comes in part from vagaries of US law: Section 230 of the 1996 Communications Decency Act limits the liability of these discovery services, stating "No provider or user of an interactive computer service shall be treated as the

publisher or speaker of any information provided by another information content provider."
Google is not liable for pointing users to information published on another site, and Facebook is
not liable for information a Facebook user posts – that user instead is liable. Platforms are
reluctant to take actions that make them look like publishers, favoring some content over others,
for fear of taking on this liability.

Instead, platforms use algorithms to favor content, deciding what items appear in your Facebook
feed or search results. By relying on opaque technical processes, these platforms hope to insulate
both from liability and from accusations of political bias. (This often fails – Facebook is
criticized by the right in the US for "censoring" their speech and by the left for amplifying
extremist voices).

By moving the power of agenda-setting from human publishers to algorithms, individual users
gain power in two interesting ways. The algorithms that govern discovery services depend on
feedback from users. If friends "like" your post on Facebook, Facebook's feed will conclude
your post is interesting and feature it in more of your friends' feeds. As a result, users of these
systems gain a new power: they can direct attention to pieces of content by amplifying and
sharing them. At scale, this process causes content to "go viral", but it is a powerful dynamic
even for content that never reaches mass audiences. The effect has a second order as well. If
users share a piece of news content, for instance, helping it reach a wider audience, they signal to
a publisher that users might be interested in additional content like this, spurring creation of
similar content.

This power has been harnessed by social movements as well, through processes called "brigading", where groups work in concert to amplify or suppress specific pieces of content, often on platforms like Reddit where user voting determines what content gains recognition and attention (Carman et al., 2018). Reddit expressly forbids brigading as a form of "vote manipulation", recognizing its power (Reddit, n.d.).

In addition to amplifying (or suppressing) information by signaling relevance to discovery engines, individuals create their own content in response to content already circulating online. That content enters into the ecosystem much the same ways content from a professional publisher does competing for attention, amplification and recommendation.
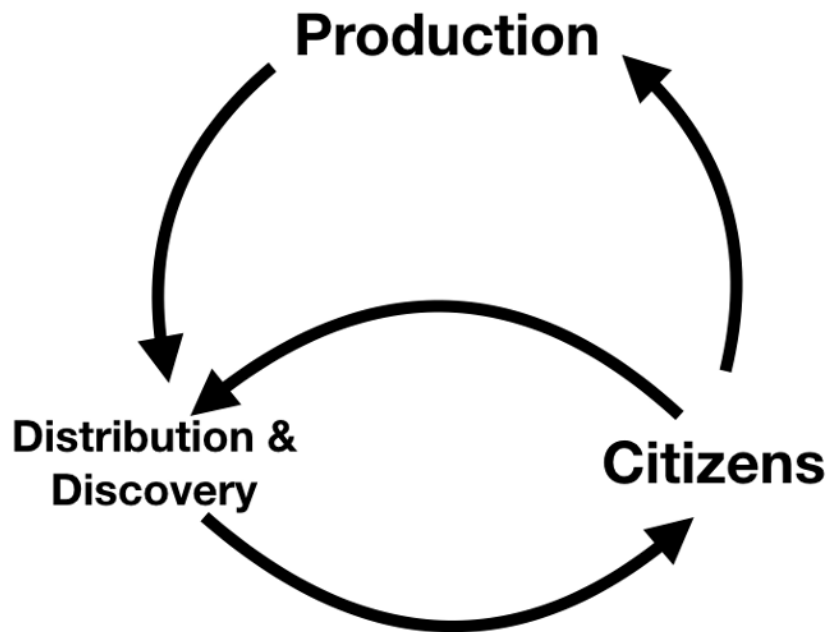
Figure 1: A model of attention flows

Rather than a linear model in which writers create news, publishers package and deliver it to audiences, who have limited influence over the production cycle, this understanding of media includes two feedback loops, shown in Figure 1. Feedback loops are one of the characteristics of complex systems, systems that can exhibit unpredictable, disparate behavior given very similar starting conditions (Sterman, 1994). The challenges we experience unpacking why one bit of content goes viral and another flops, why one user becomes an influencer and another disappears from view may reflect the difficulties of making predictions in a model where feedback loops can amplify weak signals through positive feedback.

This model for understanding the flow of attention in a media ecosystem looks a bit like a food web, a graphical representation of what eats what within an ecosystem (Elton, 2001). This is not by accident – a food web is at heart a visualization of how energy moves through an ecosystem – from the sun to plants to herbivores to predators to decomposers. Attention moves in similar paths in our web: producers of content – often inspired by content elsewhere on the web – seek attention for the content they have created. Discovery engines feed on this content and direct attention from their vast audiences to this newly created content. Consumers of that content amplify or dampen it, sending signals back to the discovery engine (and via second-order effects to the content creator) about its popularity. Some may go beyond paying attention to the content and amplifying it by creating their own content in response, re-entering the attention web at the top of the cycle.

Food webs help ecologists diagnose problems within an ecosystem: a declining fox population might reflect a scarcity of rabbits due to insufficient lettuce. Similarly, our model suggests insights about some of the problems that affect contemporary media ecosystems, shown in Figure 2.
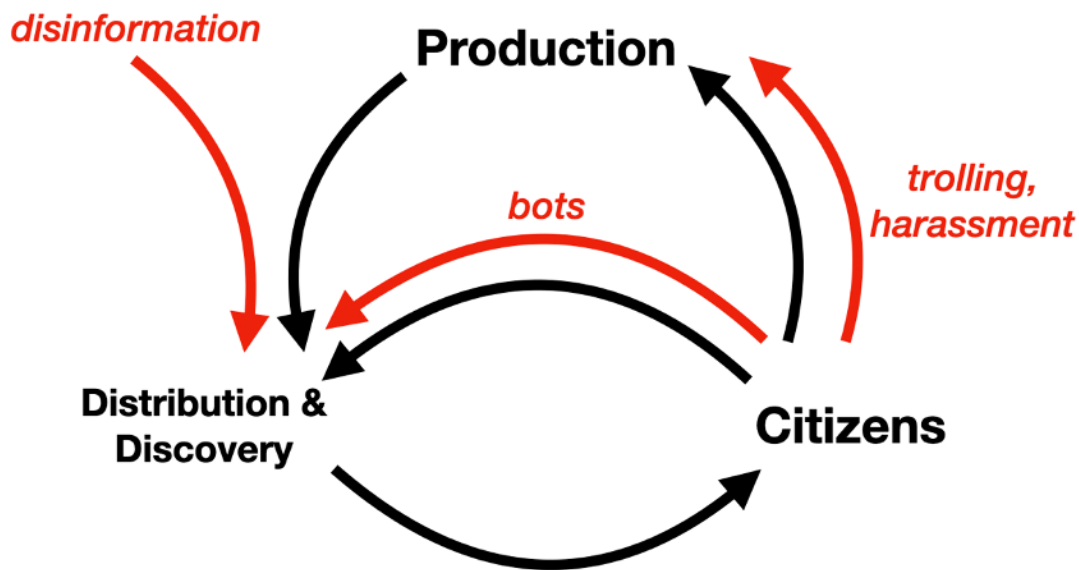
Figure 2: Vulnerabilities of the attention feedback model

 "Bots", computer programs that "like" or amplify content en masse, seek to hijack the feedback

cycle between citizens and discovery engines. They are common online – academic studies find

between 10 – 66% of links on Twitter were posted by bots. (The wide variation is explained by

different methodologies in these studies.) (Rauchfleish and Kaiser, 2020). If 5000 people like my

post, perhaps, Twitter concludes that it is popular and worthy of attention. If those 5000 people

are created by a program controlled by a Russian bot farm, the attention artificially directed to

my content is a form of attention hijacking. Brigading, mentioned above, accomplishes the same

goal as bots, using coordinated human action rather than computer programs. Brigading has been

used by political movements, notably by the Digg Patriots, who coordinated downvoting of

liberal-leaning articles on the Digg website, to promote conservative points of view (Peterson,

2016), and Twitter reported that 4.25% of all tweets promoting Donald Trump in the last weeks of his 2016 political campaign came from Russian-linked bot accounts (O'Sullivan, 2018).

Other vulnerabilities of this ecosystem focus on dampening, not amplifying, signals. Posting content often opens an author to hostile reactions. Performative hostility, sometimes termed trolling, is a longstanding tradition in some online spaces. But sustained harassment has the effect of driving users offline, or at minimum, making them less likely to share their opinions. A recent study of online harassment in Norway found that while men experienced some form of harassment online even more often than women, women in particular reacted to sustained harassment by silencing themselves (Nadim & Fladmoe, 2019). Given the cycle through which some readers respond to content by creating their own content, this can act as dampening a feedback cycle. In many complex systems, dampening of feedback loops helps make systems more stable and predictable; in this case, the effect may be that those unwilling to engage in speech in hostile environments drop out, leaving only those who can tolerate – or enjoy! – combative speech in the conversation.

Discovery engines are a particularly vulnerable node in this attention web. Disinformation – information created specifically to misinform – can be presented to discovery engines and may be amplified and spread by readers who believe it to be true. (The definitions of disinformation, misinformation and malinformation offered by Claire Wardle and Hossein Derakhshan make clear that mis and disinformation are interdependent – the same piece of information could be either depending on the intent of the person spreading it, Wardle & Derakhshan, 2017).

Discovery engines have become much more aggressive in weeding out disinformation during the COVID-19 pandemic, taking down a video titled "Plandemic" that advised viewers not to wear masks, within three days of publication (Frenkel et al., 2020). Generally, the platforms have been less willing to eliminate political disinformation, fearing accusations of political bias. President Trump's assertions of voter fraud in the wake of the US presidential election in 2020 were allowed to stand on Twitter with warnings that the claims they make are disputed until the attack on the US Capitol on January 6, 2021. The debates over platform responsibility for disinformation are a reminder of the sensitivity of this part of the attention ecosystem. Asking corporations to decide what speech is acceptable is uncomfortable. But so is asking governments to moderate speech, or accepting the unchecked spread of disinformation.

A hope for this (simple, incomplete) model of attention flows is that it might apply independent of the affordances of any particular tool or platform. Flows of attention are understood as unfolding across many different media channels simultaneously. Content from the New York Times is amplified and commented on across social media. Snarky tweets on Twitter might inspire a blogger to write a response, or offer feedback to the Times on whether peas are ever appropriate in guacamole (Anderson, 2015). Ideas first posted on social media inspire reactions from traditional press or television as well as commentary online. Since there is no consistent answer to the question "which came first, the article or the tweet?" we are best served thinking in terms of cycles: this time, the idea started online and spread through traditional media; the next time, the cycle began in print or broadcast.

This need to understand media holistically, particularly through quantitative analysis of flows from one part of an ecosystem to another, may ultimately result in a Tansleyian shift in media. In particular, while we will and should continue to study individual species – Twitter, YouTube, Facebook, broadcast television, talk radio – we also need to study them in the context of "the habitat factors in the widest sense" to understand their effects on social movements and political parties.

Researching media ecosystems

As the internet became a mainstream technology and millions of users began adopting email, social scientists realized they had a massive new source of data on which they could test existing theories, replicating Stanley Milgram's "six degrees" experiment with email, for example (Dodds, 2003). The massive adoption of social media combined with the fact that data was already digitized promised a new era for computational social science.

 It is likely that the level availability of data from various platforms has contributed to their popularity as a topic for study. Twitter, in particular, has become an enormously popular medium to research, despite having a much smaller online audience than platforms that are less well studied. Between 2008 and 2019, Google Scholar indexes an average of 577,167 papers per year that mention Twitter, just slightly more than mention Facebook (552,917 papers per year on average). What is remarkable is that Twitter has only 330 million monthly users (Twitter, 2020) while Facebook has roughly eight times the audience, around 2.7 billion monthly users (Statista, 2020). The only social media site that challenges Facebook's user numbers is YouTube, with a

reported 2 billion monthly users (Youtube, 2020). Yet YouTube is vastly less studied, averaging

308,167 papers per year between 2008-2019, or 53% of the papers Twitter inspired.[i]

Scholars love Twitter because it is easy to study - it is the drosophila of social media. Shortly

after it launched, Twitter opened an API for researchers that allowed scholars to collect a 10%

sample of all tweets posted. Because tweets were under 140 characters, even an enormous

collection of tweets was relatively small. Network theorists were able to build graphs of Twitter

communities, looking to see who followed each other, and who retweeted or quoted each other.

Hashtags made it easy to study the emergence of topics, and indexing the text of tweets made it

easy to quickly identify what users were talking about what subjects. While Twitter has restricted

access to researchers over the years, it remains perhaps the easiest social media platform to

study.

Facebook, by contrast, provides very little data to researchers, activists and others who would

seek to understand it, citing its privacy model. Most Facebook posts are not public - they are

shared with a person's friends, not with the general public. To protect the privacy of users'

speech, Facebook's tools primarily allow researchers to study Pages, public-facing collections of

posts mostly maintained by brands and celebrities. Of course, some scholars found ways to study

Facebook by joining the "Facebook ecosystem" as app developers, using their status to collect

data on users - the Cambridge Analytica scandal unmasked a scholar violating research norms by

collecting data for academic study and transferring it to a political consultancy (Wong et al.,

2018). More recently, scholars have entered into complex negotiations to access carefully

constrained and anonymized sets of data from Facebook.[ii]

YouTube presents different challenges for researchers and activists. While well-developed tools exist to study text, many researchers are unprepared to study large sets of videos. Videos are large, which makes it difficult to store them, and extracting text from them is expensive, whether conducted via automated tools or via transcription. While YouTube provides an API that allows researchers to query the entire site, the results available are limited and make it difficult to assemble large data sets.

Each platform within the broader media ecosystem presents different barriers to study, and studying the spread of ideas or trends across multiple platforms magnifies the technical difficulties associated with research. Reddit, which Alexa's traffic comparison service sees as having much higher engagement than Twitter, was difficult to study quantitatively until 2015, when Jason Baumgartner launched Pushshift.io, a comprehensive archive of posts made to the service (Baumgartner et al., 2020). Other important services have no dedicated indices or archives, or are technically challenging to collect data from. Chat-like services like Whatsapp advertise end to end encryption, which should make it impossible even for the platform operator to study the content of conversations through fully automated methods. Some researchers have had success studying publicly-advertised WhatsApp groups, declaring their presence as researchers, though half of the groups they joined refused to participate (Narayanan et al., 2019).

Despite these barriers, ambitious work that tracks phenomena across multiple platforms is emerging. Some is ethnographic, focusing on phenomena like extremist speech, which flows across many platforms and sometimes demands that a researcher go "undercover" to infiltrate

these groups. In her book, The Rage, Julia Ebner (2017) infiltrates right-wing extremist groups and tracks their discussions across closed platforms like Telegram onto more traditional, public social media platforms. Her colleagues at ISD Global, which monitors Islamic extremists as well as white nationalist groups, routinely use cross-platform ethnographic and quantitative methods to trace ideas like the "holohoax" across Facebook, Twitter, YouTube and Reddit. This and other work demonstrate the ways disinformation spreads between platforms and how platform policies regarding speech can chase dialogs from one platform to another (Guhl and Davey, 2020). The idea of a Digital Influence Machine developed at Data & Society (Nadler et al., 2018) makes clear the ways attention flows between extremists and media outlets is a system that is actively gamed and manipulated.

Other work uses quantitative methods to demonstrate linkages between attention in digital media and traditional news coverage. Deen Freelon and colleagues demonstrated that the intensity of Twitter traffic focused on the Black Lives Matter (BLM) movement correlated with increased attention to the deaths of unarmed people of color in mainstream news (Freelon et al., 2016). Freelon's team demonstrated the power of correlating multiple timelines to show possible causality - a spike in Twitter attention preceding a wave of news coverage suggests that one may cause the other. Based on Freelon's work and the broader successes of BLM in bringing attention to under-covered issues of police violence, it is reasonable to predict that social movements will study BLM's use of social media as a possible model for attention-driven social change.

Timelines have proven a popular way of demonstrating the unfolding of social phenomena across multiple media, looking for ecosystem effects as different media focus on an unfolding

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story. Keith Collins and Kevin Roose, reporters for the New York Times, have turned cross-media attention patterns into a powerful visualization to understand the flow of an idea across different media over time. In one examination, they follow the phrase "Jobs Not Mobs" from a video shared on Twitter to amplification in pro-Trump Reddit groups, to widespread visibility on Facebook and in mainstream media. By tracking the attention paid to different posts, the authors are able to demonstrate how a phrase becomes a meme, and then later a central theme of how Republicans differentiated Trump's policies from those of Democrats (Collins & Roose, 2018). The visualization, a vertically scrolled timeline illustrated with multicolored bubbles has become a feature for the Times as they visualize online campaigns and their influence on broader dialogs.

While Collins and Roose studied a single case using quantitative methods, the iDrama team (a large research collective) tracked URLs shared on Twitter, Reddit and a subset of 4chan image boards to examine the spread of information from "alternative news sources", including sites that feature conspiracy theories and Russian disinformation. They find that this news is often shared first on Twitter, perhaps because bots appear to be highly active in promoting this content. 4chan, often celebrated as a powerful source of subcultural memes, is well behind Twitter and Reddit in spreading most of this political content, suggesting that conventional wisdom about the roles of different services in amplifying content requires re-examination (Zannettou et al., 2017).

Timelines are only one way to study the complexities of internet ecosystems. In the wake of the 2016 US presidential election, Yochai Benkler and his team at Harvard University conducted ambitious quantitative research that offered a comprehensive analysis of media roles in that surprising contest (Benkler et al., 2018). Benkler and team used Twitter to identify news media

most often shared by political partisans on the left and the right. They identify partisans based on their retweeting of visible political figures in their parties, then examined what media outlets those partisans amplified. They constructed a classification of hundreds of English-language media sources favored by different political groups, demonstrating which ones were popular on Twitter.

What emerged was evidence of two disconnected media ecosystems, one followed by the far left through the center right, the other followed entirely by the far right. Attention to media when ranked from far left to center-right followed a normal distribution, with higher attention to sources favored by the center and center-left than those favored by the far left or center right. Far-right media followed an entirely different distribution, with disproportionate attention to media most favored by the far-right, especially Breitbart, which played a critical role in the media ecosystem leading up to the 2016 election. Benkler and team called this phenomenon "asymmetric polarization" and suggested that while left-center media was behaving in normal and predictable ways, this new right-wing media ecosystem displayed new and important dynamics.

Through both network analysis and case studies, Benkler and team illustrated a path from far-right media like Gateway Pundit that amplified conspiracy theories, through Breitbart, which served to "clean up" and legitimate these stories, to Fox News, which demanded these stories receive broader attention. Often mainstream news sources like CNN or the New York Times would respond to these prompts, if only to demonstrate their falsity. Using Media Cloud to analyze stories at scale, the team was able to demonstrate that narratives favored by far-right

media - notably stories about Hillary Clinton's email server - dominated overall media coverage of the 2016 election.

Benkler and team's work is important because it considers social media not as a proxy for public opinion - where it is an imperfect proxy at best - but as a channel for injecting ideas into the public sphere and "upcycling" them from the fringe to the mainstream. As the Republican party reorganizes around Trump's claims to have won the 2020 election, this has become a deliberate strategy by activists within the Republican Party and will likely affect political party relationships with media going forward.

My team in conjunction with a team at Sciences Po replicated Benkler's work to study whether similar dynamics were emerging from the French media ecosystem. (Institute Montaigne, 2019) We used similar methods to develop a map of the ecosystem, and identified clusters of elite and mainstream media similar to what the Benkler team found on the left and center, and a cluster of extremist and conspiracy theory media that was disconnected from the mainstream dialog.

But similarities ended there - in the French media ecosystem, ideas from the more extreme parts of the web seldom, if ever, crossed into mainstream media dialog. The critical difference was the gatekeeping function of elite media, which linked to left- and right-leaning elite media sources, but never to the conspiratorial outsiders. This elite firewall has advantages and disadvantages. While it means that French media is less vulnerable to the injections seen in US media, it also means that elite media may be blind to popular movements that begin online. We found evidence that French elite media was late in their understanding of the Yellow Vests movement, which

was better and more thoroughly understood in regional and local media, while elite media understood it almost entirely in terms of implications for the government in Paris.

These projects of understanding the broad structure of a nation's media ecosystem suggest the intriguing possibility that the same social media platforms may have different effects in different contexts. Fabio Giglietto and colleagues are using similar methods to understand the Italian media ecosystem's responses to coordinated disinformation efforts during elections in 2018 and 2019 (Giglietto et al., 2020). We are likely to discover that it is unwise to generalize about the effects of any given platform as the ways each works in the context of a nation's ecosystem is likely to be different from how they work in the United States. Indeed, studies of national ecosystems have already demonstrated their value in overturning established wisdom. A deep dive into the Chinese media ecosystem by Harsh Taneja and Angela Wu suggests that an overfocus by western researchers on the effects of censorship on Chinese internet users blinds us to the simple truth that language barriers likely shape online behavior more than the Great Firewall (Taneja & Wu, 2014).

Some of the most ambitious recent work seeks to understand ecosystems that cross national borders, united by ideology rather than language or geography. A team at the Freie Universität Berlin has investigated links between alternative right-wing news sources in Germany, Austria, the UK, US, Denmark and Sweden, finding shared agendas across the different nations, with large US sites serving as hubs for information (Heft et al., 2020). An investigation by anti-extremism thinktank ISD Global confirmed the centrality of US far-right sites in extremist media circles in France and Germany, but suggests that extremist media is more likely to influence

mainstream media in the US than in Europe (ISD Global, 2020). This work suggests we might understand extreme right-wing media as a transnational ecosystem interacting with local media ecosystems in unique and specific ways, and offers a route to study other international movements.

What we need to understand media ecosystems

This incomplete overview of Media Ecosystem research suggests that considering media as an integrated ecosystem can lead to novel and unexpected results. However, this sort of multiplatform research is challenging to conduct. As we understand from the heavy research focus on some platforms over others, media ecosystem research is likely to struggle for viability until tools and methods improve significantly.

If the shift from studying individual media organisms to studying integrated ecosystems through quantitative methods is the right one, we will need at least four developments to make the method more viable.

We need archives, search engines and other tools that help us understand a broader range of media. Projects like Pushshift that have made Reddit, Telegram, Gab and others searchable by researchers deserve widespread support and funding to allow them to expand. Efforts like the Internet Archive Television offer the possibility for more thorough linkages between digitally native and traditional media (Internet Archive, n.d.). Efforts by Deb Roy and other scholars to

collect and transcribe talk radio offer the possibility to study ephemeral but broadly influential media (Beeferman et al., 2019).

But in recognizing these efforts, there is a grave need for tools that enable better research on critical parts of the new media ecosystem. YouTube is an enormously important and influential platform and remains difficult to research at scale. Platforms like WhatsApp are likely critical in understanding political dynamics in many nations, and the encrypted nature of conversations means that we face significant privacy and technical challenges in archiving and studying material. (Mosca, L. & Quaranta, M., 2021) We need both better tools to understand some platforms, and methods that accept that some important data will never be accessible to researchers.

We need better tools that allow scholars and other researchers to examine words, phrases, URLs and ideas across multiple platforms at the same time. Media Cloud enables comparisons of terms across different collections of media, allowing researchers to see how terms appear in newspapers, digital publications and talk radio, for example. Some commercial tools allow comparison across different social media platforms. For research to be accessible to people unable to afford commercial data sets and tools, open source systems like Media Cloud will need to expand to incorporate new data sets and encourage cross-comparison.

We need a clearer understanding of how different social media platforms report data about information shared on their systems. Facebook, for example, makes information available about "high engagement" pages through its Crowdtangle tool, but insists that this information is not

reflective on what most users see in their newsfeed (Schultz, 2020). Putting aside how confusing this is - Facebook is telling researchers that their own tool does not provide an accurate picture of what is popular on their platform - this reflects a larger problem researchers encounter when they conduct studies across platforms. Can we compare the visibility of a URL on Twitter, where most posts are public, to that visibility on Facebook, where most are restricted to a small set of users? How do we consider a platform like 4chan, where most content is ephemeral? Could tools designed to help advertisers determine if they are reaching their audiences help researchers better estimate audiences for social media content?

As media ecosystem studies go forward, we need to find ways to integrate tools that investigate individual users' experience of social media with the broad view offered by search engines and archives. Such work builds on existing audits conducted using panels of users (Sandvig et al., 2014) to study search engines (Robertson et al., 2018) , Facebook ads (Silva et al., 2020), or YouTube videos (Chen et al., 2021). Mozilla's Project Rally data donation program (Mozilla, n.d.) offers one way this data might become available to researchers, through the cooperation of users who opt into a study. The Markup is taking a different approach, recruiting a panel of representative users to power their "citizen browser" program, auditing the behavior of platform algorithms (The Markup, 2020).

In addition to these technical changes, we need a shift in attitudes and approaches. For media ecosystem studies to gain prominence, we need an increased understanding from the field that data that comes only from one platform, or even just from social media, has limitations. Yet, this work is also foundational. The deep understanding of a single platforms, or of the use of multiple

platforms by a single subculture or community, developed through quantitative or qualitative methods, provides a basis for understanding global cross-platform flows. But this valuable work should be complemented with tools and techniques that seek to analyze flows of attention across many platforms and communities.

My hope is that we can build on the discoveries made of particular linguistic or national media ecosystems and start to better understand fundamental dynamics and patterns that recur in different contexts. The "upcycling" that Benkler and team identified in their election study is likely to be tried in different linguistic or national ecosystems - can we identify attempts to use this technique and examine their successes or failures? Can we identify other patterns that recur across different linguistic and national ecosystems? Can we begin to understand how ideas spread from one ecosystem to another, across lines of language and culture? Could identifying those common patterns bring us closer to an understanding of media dynamics that is closer to physics than our current piecemeal understanding?

Beyond these scholarly questions is a broader question about political parties, activist movements and other civic and social actors: how will increased understanding of media ecosystem dynamics change political participation? Will the phenomena that appear novel abuses of the system be stamped out by platform moderation and rule changes, or will armies of trolls, bots and brigades become as much a part of political campaigns as television ads and door knocking?

Arthur Tansley's call to focus on ecology, "...the whole system (in the sense of physics)", led to a fundamental shift in biology, allowing for the scholarly consideration of complex systems. Could understanding media ecosystems be a fundamental shift in how we understand our complex media environments? We need such a shift if we want to understand pressing topics, like the harnessing of conspiratorial thinking for political gain, as we are seeing in the United States. So long as those who govern are powerful media manipulators, understanding the complex dynamics of media ecosystems will be fundamental to understanding our political, social and economic systems as well as our communications.

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[i] I searched Google Scholar for the terms "Facebook", "Twitter" and "YouTube", restricting results to a specific year between 2008-2019. I also noted the most cited paper for each year, which shows a pattern similar to the total number of papers, with YouTube underperforming Twitter and Facebook.

[ii] See Social Science One, https://socialscience.one