Digital Rhetorical Ecosystem Analysis

Sensemaking of Digital Memetic Discourse

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A B S T R A C T

This paper makes a case for integrating frameworks from two different knowledge domains, rhetorical studies and ecological studies, to catalog, monitor, and study digital image meme data, in order to support a more robust understanding of how memes produce and disseminate online narratives. In the digital public sphere, the primacy of image-based communication motivates an over-reliance on the image meme for public argumentation. Despite its ubiquity, the image meme format is currently understudied in large scale digital data analyses, relative to text-based formats such as natural language and hashtags. We argue that using a rhetorical approach (which emphasizes message form and audience) in large-scale analyses of multimedia and other digital artifacts can enhance analytic tools for categorizing, indexing, searching, and modeling online discourse. Further, by integrating a rhetorical and an ecosystem approach to studying digital discourse, we can formally trace multimedia rhetorical artifacts like image memes across platforms, media types, and languages. Combined rhetorical and ecosystem analyses can reveal how digital artifacts like image memes create, sustain, and disrupt public narratives and, thereby, socio-political dynamics. Three key elements of our approach are a) recognizing how parsimony and polysemy give image memes narrative power, b) focusing on how image memes engage audiences through identity construction, and c) applying "Rhetorical Ecosystem" mapping, based upon toolkit transfer and system design implications. Drawing from concepts in rhetoric, ecology, and complex systems analysis we introduce a Digital Rhetorical Ecosystem three-tiered model (DRE3) to explain how memes impact public narratives and beliefs. We then explore implications of this DRE3 model for the design and development of systems for computational analysis of digital discourse.

Contents

I. A Rhetorical Approach to Understanding the Impact of Image Memes

We are in the throes of a widespread epistemic crisis that is damaging individual and collective sensemaking function and capacity ([1,2]). The crisis, articulated as "a state of affairs in which partisans disagree not simply on policy, but on facts themselves" [3], is attributed to a set of conditions including a "combination of political polarization, declining trust in media institutions, and asymmetric media ecosystems" ([3], para. 1). Concern about fake news, alternative facts, and misinformation has been escalating. Despite legitimate concerns about the degradation of public information due to the infusion of spurious content, we argue that viewing the information crisis as a competition between truth and falsity obscures the nature of the digital information crisis we are facing and, worse still, hamstrings efforts to restore trust and rework social consensus, which are essential for collective social action. Rather than approach the digital information problem as a battle between true and fake information, we urge attention to the rhetorical conditions and processes that contribute to eroding trust in established channels of information, and mainstream institutions and publics.

Framing the crisis as a battle between true and fake information has not proved effective in regaining the trust of those disaffected by mainstream channels of information. A simplistic true/fake dichotomy ignores the rhetorical conditions that have allowed competing narratives to displace mainstream ones. The hyper-complexity of digital information ecosystems is one such condition that makes achieving consensus on facticity and truth highly challenging [4], a condition that has, indeed, been exploited by malevolent actors. Nevertheless, addressing our epistemic crisis requires more than targeting and neutralizing sources of misinformation. We advocate a framework that combines rhetorical analysis with an ecosystem approach to trace the ebb and flow of narratives across digital publics. A rhetorical approach to understanding the information crisis focuses on message features that target audience vulnerabilities. An ecosystem approach goes beyond analysis of specific messages and audiences to highlight complex and long-term message-audience interactions, which can illuminate the changing web of narratives that influence public beliefs, opinions, and actions. Accordingly, we recommend addressing the epistemic crisis by developing a fine-grained understanding of the rhetorical forms and processes through which information circulates in

the digital public sphere and introducing rhetorical intervention as needed, rather than focusing exclusively on source control.

Contemporary digital information ecosystems create particular burdens on individual and collective capacities for reliable sensemaking and robust public discourse. The increased volume and diversity of information on the Internet create unprecedented cognitive complexity, and challenge clarity and social agreement on issues of public concern [5]. The default mode of online engagement—rapid surfing through endless streams of information, rather than focused deep immersion in selective limited information—further curtails information-processing capacity. Platform affordances and constraints, such as limited expressivity in communication (e.g., being encouraged to use a "like" reaction button in lieu of natural language elaboration on a post), the ability to rapidly scroll on digital screens, and the glut of emotionally charged material can also encourage peripheral rather than central processing of information [6–8].

Digital infrastructures also shape digital artifacts. The rhetorical features of these artifacts further encourage superficial engagement with online information. In our paper, we focus on one particular online artifact form—the image meme—that has played a crucial, yet understudied role, in destabilizing former epistemic foundations and traditional sources for public sensemaking. As we demonstrate below, the image meme has evolved into a ubiquitous unit of public discourse. Moreover, image memes function consistently as quasi-arguments in digital public spheres.

The word "meme" has gathered a great deal of semantic elasticity at this point [9,10], stretching from a general "unit of culture" to the specific genre and form of the image-macro [11,12]. We adopt a narrow definition of the image meme that allows us to capture and trace its role in public sensemaking. While the image macro refers to "captioned images that typically consist of a picture and a witty message or a catchphrase" [13], we use the term "image meme," instead, because many specimens that draw from the image macro genre are devoid of text. In those cases, a juxtaposition of images within the meme compensates for its lack of textual elements. In image memes, configuration of the images themselves create meaning by making or implying arguments. We define the image meme by two features—form and function. The form of the image meme is established by the rectangular box frame which circumscribes one or more rhetorical elements, demarcating the meme as a discrete communication unit on platforms like Facebook, Instagram, and Twitter. While image memes perform a variety of rhetorical functions [14,15], we restrict our

attention to image memes that play a particular rhetorical role—i.e., they participate in public argumentation by advancing claims [9]. In sum, the rhetorical artifact at the center of our paper is the ubiquitous rectangular box that is deployed to make a claim about a public issue.

The image meme has proved remarkably effective as a currency for public discourse, especially on Facebook and Instagram [16]. In particular, image memes have become integral to the destabilizing projects of the digital radical. They have been deployed strenuously in efforts to challenge and disrupt official and institutional discourses. The rhetorical dominance of image memes can be attributed to their ability to function argumentatively and, thereby, persuasively in the public sphere, constituting radical communities of discourse that are engaged in decoding, sharing, and amplifying their contents [17].

What does a rhetorical approach to the study of memes entail?

Aristotle defined rhetoric as "the ability to see what is possibly persuasive in every given case" [18]. Rhetorical study emphasizes the *how* of persuasion. Therefore, a rhetorical approach to addressing our epistemic crisis moves us past solutions like banning digital sources of information or playing fact-check whack-a-mole with spurious message content, to focus on the persuasiveness of the message medium. While rhetorical critics are invested in analyzing message content, they are also invested in analyzing message form. The digital artifact at the center of our paper, the image meme, is a powerful example of the persuasiveness of rhetorical form. Repetition of form contributes to the crystallization of a rhetorical genre [19]. The widespread and increasing deployment of the image meme in digital public spaces has elevated the image meme into a rhetorical genre, one that is capable of charging a large scope of content with persuasive appeal.

Image memes have immense rhetorical power to shape online and offline sensemaking and action. During the 2016 United States election, Internet memes "enabled users to rapidly take a stand on and react to developing political events in real time; they provided alternative parallel discourses to mainstream media viewpoints; and they enabled mobilizing voters outside of official political discourses" [20]. The rhetorical power of multimedia memes has strengthened since 2016 [21,22]. Therefore, we argue for treating these artifacts as serious agents that shape public narrative and action.

A rhetorical approach to analyzing image memes can advance our understanding of their persuasive influence beyond the current

practices of syntactic tagging of memes, for example by text recognition [23]. A rhetorical approach fills in the gaps endemic to tagging practices by enriching analysis of image memes with rich semantic information embedded in the parsimonious combination of the meme components. Symbolic cues in the memes not only advance logical claims but also encode ambiguous yet intense emotional charge that could spur public action. Interpreting cues within the meme against contextual knowledge surrounding the meme is vital for the process of rhetorical analysis, and, as we will discuss later, computational analysis of digital discourse using a rhetorical approach.

A rhetorical approach encourages attention to the ways in which memes galvanize specific audiences to change their thoughts and actions. Image memes have constitutive potential; that is, they simultaneously call into being (constitute) audience groups while influencing audience thinking and possibly action—a process which rhetoricians call interpellation [24]. This constitutive potential is contained in the argument potential of the meme—its ability to advance claims, provide/imply evidence, and rely heavily on a discursive community to supply the necessary warrants (assumptions) to complete the argument [17]. The capacity of image memes to compel audience participation in semantic decoding contributes to the persuasive appeal of memes because the act of figuring out the meme's claim constructs the experience of truth-seeking, and consequently a sense of shared in-group identity, for the audience. Having successfully completed the decoding effort, audiences are interpellated as truth-seekers which enhances their investment in the meme's claim.

Another rhetorical feature of image memes that makes them conducive to interpellating audiences as truth seekers is that image memes are often free-floating. They seem to appear out of nowhere and do not typically disclose their sources unlike other digital content. As such, image memes represent an epistemic break. They gain credibility not because they arise from authoritative sources but precisely because they claim no source. The rejection of source credibility makes image memes a very powerful parallel discourse to more formal media channels and, in many cases, a direct challenge to information, claims, or narratives that emerge from publicly-vetted sources. When interpellated audiences decode and share image memes and engage in discourse about memes on forum threads, they build credibility for the meme in the absence of authoritative source credibility.

Therefore, tracking image memes (the claims they advance and the audiences they interpellate) in digital public spheres has become essential. Robust and far-reaching alternative and counter narratives

circulate through social media platforms displacing mainstream narratives and flow under the radar of traditional mechanisms for capturing public belief and opinion. These online parallel currents of public discourse grew on social media platforms in relative obscurity between 2016 and 2020. The 2020 pandemic year, however, surfaced the proliferation of underground narratives when they started to manifest as widespread overt resistance to official COVID-19 narratives and policies, among large noticeable sections of the public. Towards the end of 2020, the galvanization of digital memetic energy around the visible public agitation against the 2020 US election results, culminating in the events at the United States Capitol on January 6 2021, initially caught public officials and mainstream media off guard but subsequently drew further attention to the robust discursive spaces in which competing narratives have been spawning and flourishing. Competing narratives have had and continue to have global impacts, as digital public spheres transcend the national boundaries of mainstream and official media channels. As researchers and organizations, interested in improving the immunity of digital public spheres to misinformation, invest in understanding the emergence of competing narratives, we urge attention not simply to the content of the narratives but, equally, to understanding of how those narratives are constructed through the circulation of digital artifacts, such as image memes. The philosopher Bruno Latour has noted that "whether or not a statement is believed depends far less on its veracity than on the conditions of its 'construction' — that is, who is making it, to whom it's being addressed and from which institutions it emerges and is made visible."[25] To Latour's list, we add the importance of attending to the rhetorical form in which the statement is packaged, i.e. the form of the image meme . Understanding the rhetorical form and function of image memes is crucial for any effort to observe, model, and respond to memetically-driven narratives.

Rhetorical Anatomy of an Image-Meme

Although digital image memes can be used to circulate official narratives online, they have more successfully been deployed disruptively, across the political spectrum. Their truncated or compressed form is well-suited to inject targeted challenges to mainstream claims. The parsimonious form of the image meme provides a great deal of capacity for semantic encoding to advance persuasive claims while diminishing burdens of proof and elaboration that other rhetorical artifacts, like news articles, require. Various image meme formats such as text-only, image-only, screenshot, and image-text juxtaposition can all create polysemic affordances [26]; that is, the

possibility of extracting multiple and multi-layered interpretations within a range of meanings. The strategic ambiguity inherent in memetic artifacts allows for rich semantic encoding. At the same time, the structural features of the memetic form (i.e., the containment of its content in a box, and the text/image syntax) strategically constrain meaning-making by setting up the key elements of an argument and cutting off counter-arguments. Below, in Figure 1 we illustrate the construction of an argument contained in one sample image-text meme.

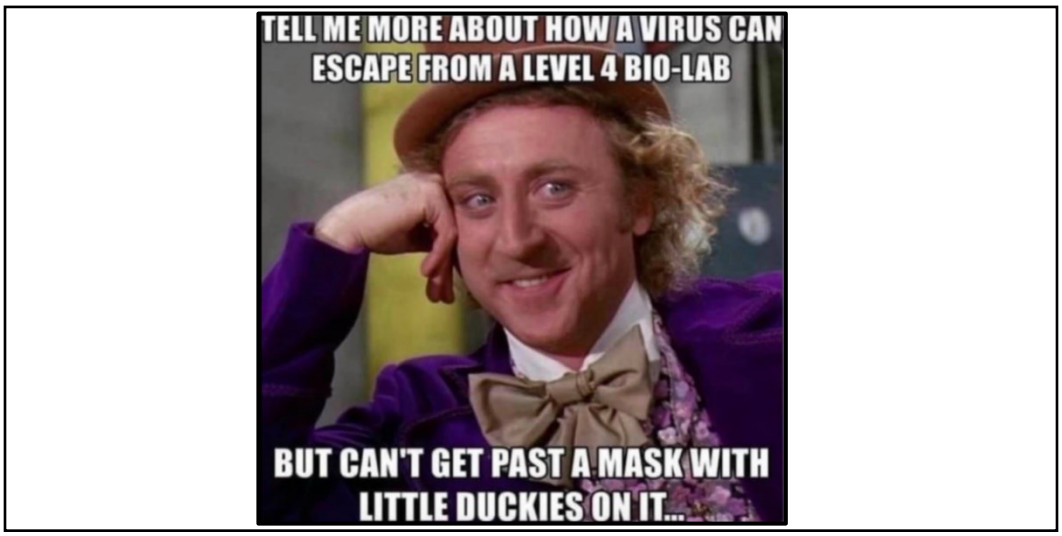

Figure 1. Rhetorical analysis Example 1. A "Condescending Willy Wonka" image meme, with top text reading "Tell me more about how a virus can escape from a level 4 bio-lab", and bottom text reading "But can't get past a mask with little duckies on it..."

Figure 1 above constructs an argument with the simple juxtaposition of two lines of text above and below a stock photo. The choice of the photo combined with the double textual framing relies on the contextual knowledge of discursive communities to decode the argument. While the explicit memetic content is sparse, its signifying layers are rich, thus allowing the meme to argue a clear and persuasive claim.

The primary claim distilled from this image-text meme is that the official narratives about the origins of the SARS-CoV-2 virus, and the official masking policies to combat the virus, are not to be trusted. The rhetorical power of the meme draws from its strategy of juxtaposing two official narratives that appear to be mutually exclusive—that is, if the virus is virulent enough to escape the strict safety protocols of a world-class laboratory, then it can definitely penetrate the ordinary masks that the public has been asked to wear to stem the spread of the virus. The meme simultaneously alleges dissonance in official claims and expresses a snide disdain for those who accept the official narratives and are oblivious to the dissonance. The meme carries

content designed to appeal to audiences' logical reasoning as well as to activate an emotional charge in the audience. The logic and emotion evoked by the meme are abetted by the meme's use of the "Condescending Wonka" image deployed memetically since 2011 to convey patronizing sarcasm [27].

The two lines of text interspersed with the image interpellate an audience into the persona of Condescending Wonka, questioning with disdain, not only the official COVID-19 narratives but also the intelligence of those who have not yet figured out the contradiction. The meme positions the audience that agrees with its claim on one side against lying officials and people that trust official narratives on the other. The rhetorical deftness of this particular image text meme lies in its ability to swoop an audience, in the course of a single engagement with the meme, into both the line of reasoning set up by the meme and into an interpellated audience identity. That is, even as a viewer might be encountering the meme's reasoning for the first time, having followed the reasoning and accepted it, the viewer comes to embody the persona of the one questioning the official narrative and condemning the naiveté of those who don't. The semantic decoding effort demanded by the meme works to enhance the credibility of the meme's claim by interpellating audiences as truth-discoverers. By advancing claims, memes not only shape public beliefs but also constitute powerful rhetorical audiences, knitting together discursive communities that share memes and bond over decoding and accepting memetic claims.

Furthermore, the boundedness of the image meme above (i.e. its containment with the rectangular box frame) and the parsimony of the rhetorical elements within the meme inhibit central processing and encourage peripheral processing of the meme's claim. The particular rhetorical form of the meme thwarts further questioning into possible reasons why the two supposedly contradictory claims may, in fact, not contradict each other. The success of the meme's argument relies on its ability to evoke the assumption that the initial event of the virus's escape signals its inability to be contained in any way. The possibility that initial spread was virulent because the virus encountered an unsuspecting maskless population is elided by the memetic structure. Likewise the claim that masks only mitigate but do not necessarily prevent infection, entirely, is also obscured by the certainty evoked in the meme's juxtaposition of claims. Memes often simultaneously function as assertive yet weak arguments. Their weakness lies in the fact that their parsimonious form limits elaboration. However, this form feature is also responsible for obscuring the weakness of memes. The limited information, visually bounded by the meme's rectangular

box, seals a particular conclusion while deflecting attention from warrants (assumptions) that could challenge the meme's claims.

A second image meme example below in Figure 2 illustrates the profound intertextuality that undergirds memetic sensemaking. Image memes are richly polysemic, despite their minimalistic rhetorical elements, because elements within the meme often produce meaning through intertextuality, that is, by their reference to and association with cultural symbols that gain significance, themselves, through memetic spread.

Figure 2. Rhetorical analysis Example 2. The image foreground has hands that are using a pencil to write in a small book. The image background is blurred and appears to show a person on the left. The top text of the image reads: "So is 'Antifa' in the room with us right now, Karen?".

In the second example (Figure 2), we see intertextuality of memetic discourse at work because of the ways in which the image meme deploys another previously established meme, namely the Karen persona. This image meme attacks the claims that Antifa are responsible for some or most instances of violent unrest in the United States, for example during 2020. The primary claim available for decoding by an interpellated audience is that right wing hysteria both deludes and fuels itself by using Antifa as a bogeyman. The claim and inherent interpellation of a left-wing audience are achieved through multiple semiotic layers encoded in the meme's rhetorical choices.

The image features a male hand writing in a notebook, in the foreground, while the blurred figure of a reclining woman occupies the background of the meme box. The image by itself is polysemic and does not induce a clear interpretation. However, the addition of the text above: "So is 'Antifa' in the room right now with us, Karen?" performs complex rhetorical work to constrain the interpretation of the image

and make multiple claims about the political right-wing. For example, the use of the name Karen is an indexical cue meaningful to anyone aware of the cultural meme of referring to white women who demonstrate hysterical fears about people of color and liberal causes as "Karens." The choice of name combined with the choice of a white woman in the image is salient. The visual cue and the textual cue operate in tandem to activate a semiotic network of meanings that guides the interpretation of the rest of the image. The text caption leads the viewer to interpret the image as a therapy scene. The enclosure of Antifa in quotation marks and the use of a familiar phrase to question someone who might suffer from hallucinations constructs the claim that the concern over Antifa is merely a figment of the hysterical imagination of the political right. The gender-coding in the image is another semiotic layer. While plenty of male politicians on the right have publicly announced their anxieties over Antifa, the choice to feminize that fear is a rhetorical move meant to draw on associations of femininity with hysteria and lack of rationality or sanity. The question: "Is 'Antifa' in the room with us right now?" might be asked of adults suffering from hallucinations, but it is also reminiscent of a question that might be asked of a child whose imagination is running rampant. Thus the text infantilizes the concern as well as feminizes and pathologizes it. Since Karens are typically framed as immature women, the infantilization is consistent with the contextual cues that would be provided by the left-leaning discursive community interpellated by this meme. In this case, the audience is not interpellated as truth-seekers but rather into an intellectual and moral superiority that is antithetical to the hysteria of a Karen. As such, memes are incredibly rich sources of meaning that can shape public opinion and create and strengthen discursive communities in which claims and narratives become sedimented over time.

Whether the memetic content is sombre or lighthearted, explicit or implicit, memes are overwhelmingly deployed in the digital public sphere to assert and persuade through claim-making. The foundational intertextuality of memetic discourse demands that any study of memes as public sensemaking needs to go beyond rhetorical analysis of individual memes and consider how memes interact with and draw from each other to constitute, sustain, or destroy claims, and thereby narrative patterns, in response to unfolding events over time. Therefore, applying an ecosystem framework becomes essential to understanding how memes produce public sensemaking. Our next section details the rich potential in leveraging the ecosystem as a metaphor for studying the production and circulation of memes.

Ultimately, we coalesce a rhetorical analysis of memes and a digital ecosystem framework into our proposed Supervisory Control and Data Acquisition (SCADA) model for meme analysis. The SCADA focuses on identifying key claim(s) embedded in image memes and the connections between memetic claims in order to trace the emergence, proliferation, and demise of public narratives on issues of public concern. The proposed SCADA system would provide a rich, real-time monitoring and analysis of narrative formation and propagation that circumvents limitations imposed by syntax and natural language-focused approaches. Further, open access to such a system would provide a counterbalance to both coordinated narrative influence campaigns and organic perturbations in memetic ecosystems, and provide more reliable analytic foundations for considering interventions to quell their effects.

II. Ecological Extensions of Rhetorical Analysis: Trends and Theory

Ecological metaphors for socio-technical systems have been applied productively to describe the physical and information aspects of the global operating environment, and recently notions of narrative, digital, and rhetorical ecologies are also gaining in popularity (Figure 3) [1,28–30]. Ecological or ecosystem metaphors for digital systems are applied as an integrative framework in different systems such as large-scale data analytics [31], “app ecosystems” [32] corporate strategy [33], and interactive role-playing games [34]. Across these diverse fields, ecosystem metaphors can encourage holistic analysis and connect abstract concepts to tangible systems and accessible experiences.

The idea and terminology of a “digital ecosystem” has been used since at least the 1980s, and has seen exponentially increasing use since the early 2000s (Figure 3B). A search using Google Books Ngram viewer revealed the recent growth of research interest in applying the ecosystem metaphor to online discourse (Figure 3A). While there is new interest in "digital ecosystems" as a term, as well as "narrative ecosystem" perspectives, the term "rhetorical ecosystem" is entirely absent from the literature corpus (Figure 3B).

Multiple previous works have applied the ecosystem metaphor to address questions related to digital discourse and memes. For example, empirical work on various popular websites has deployed the ecosystem metaphor to study the dynamics of the “meme ecosystem”. These studies have analyzed copyable plain text memes, sometimes referred

to as "copypasta", [35] as well as shareable image memes [36]. In these studies, the text and/or image data are downloaded en masse from publicly-accessible platforms. The ecosystem metaphor stands in the background referring more to the broad scope of data collection, rather than in the foreground as an appeal to see the data emerging from an ecosystem (e.g., analyzing the data in terms of interaction types among agents in an ecosystem).

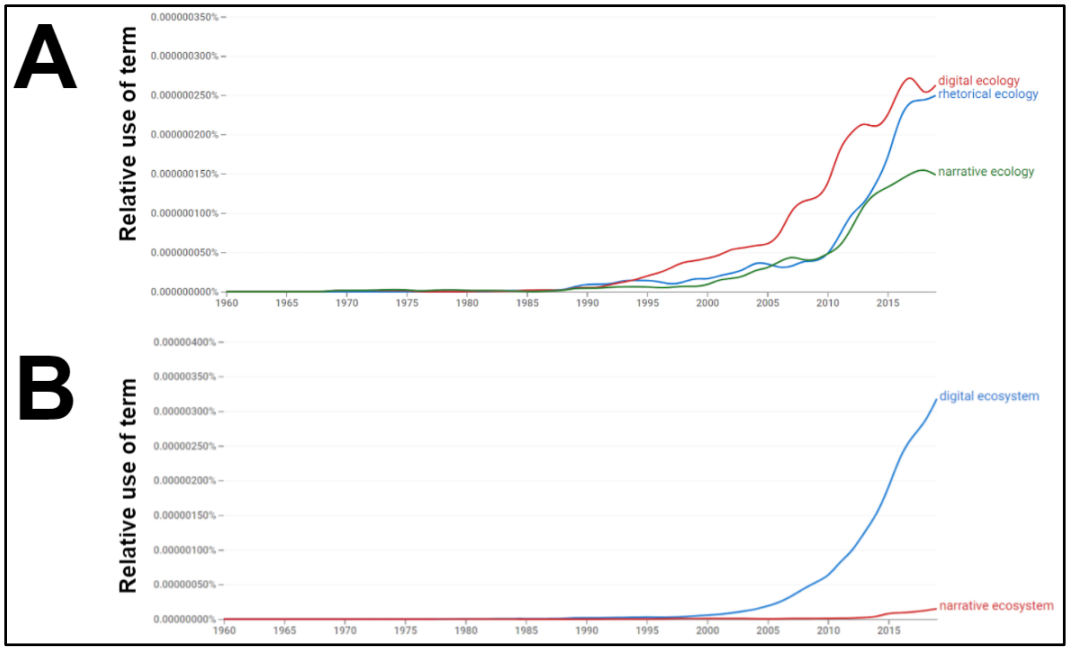

Figure 3. Trends in the usage of keywords in the Google Books Ngram search engine. Search terms used were (digital/rhetorical/narrative) + (ecology/ecosystem).

A) Google Books Ngram search for "rhetorical ecology" (green), "digital ecology" (blue), and "narrative ecology" (red), from 1960-2019.

B) Google Books Ngram search for "rhetorical ecosystem" (green), "digital ecosystem" (blue), and "narrative ecosystem" (red), from 1960-2019.

This suggests that the ecological metaphor applied to rhetoric (especially online rhetoric) has been conceptual and qualitative, drawing on conceptual similarities with ecology but not formulating ecosystem models or deploying recent developments in ecological toolkits. Thus we worked from the assumption that pragmatic implications for high-throughput rhetorical analysis of online discourse might be found in ecology, if the connections could be drawn out more clearly.

III. The Digital Rhetorical Ecosystem Three-Tier (DRE3) Model: Mappings, Applications, and Implications

For research into socio-technical systems and digital discourse, the field of ecology provides much more than qualitative metaphors. Others have offered a variety of fundamental points of contact between ecology and rhetoric, noting that both fields explore how systems exhibit multiscale patterns of organization arising from interactions among many subunits [37]. Both rhetoric and ecology study how information is communicated through time, and how agents interact with or modify their context. In the case of rhetoric, this is through the production, perception, and interactions with artifacts and social entities, and in the case of ecology, this is the phenomena of niche modifications or stigmergy [38]). Here we extend the interface between rhetoric and ecology to argue that the mapping between these two domains can find productive application in the monitoring and design of digital ecosystems. The specific implications of ecosystem metaphors for digital discourse are explored in the following section.

"Rhetorical ecology" is an established term (Figure 3A) that refers to the context-dependent rhetorical implications of texts as they are deployed in changing spatio-temporal contexts. The concept of "rhetorical ecologies" has been used to describe the level of modeling and abstraction that generalizes above any given rhetorical situation or element [39]. The ecological framework surfaces relationships between texts. For example, in ecology, the concept of a predator-prey relationship refers broadly to a type of behavioral interaction between two species, where one species consumes the other. Understanding that two species are in a predator-prey relationship helps make sense of an otherwise-disconnected set of questions and observations in the world, for example the daily activities of both species and their bodily morphology. In the case of rhetoric, we can also imagine predator-prey type relationships—for example two digital communities connected because one systematically follows and attacks the other, through memes. Additionally, online ecosystems may present totally new kinds of relationships among interacting agents; so any framework for rhetorical ecosystems should be able to infer novel types of relationships without being limited to the archetypes present in wild ecosystems (e.g., predator-prey as above, symbiosis, mutualism, parasitism). We hypothesize that with appropriate ecological-rhetorical mappings in hand, new sets of frameworks and tools developed to study ecosystems could become rapidly useful for analysis of online discourse.

Here we introduce the Digital Rhetorical Ecosystem three-tier (DRE3) model (Figure 4) which expands previous work on the ecosystem metaphor for online systems and builds towards system design implications for analysis of memetic discourse.

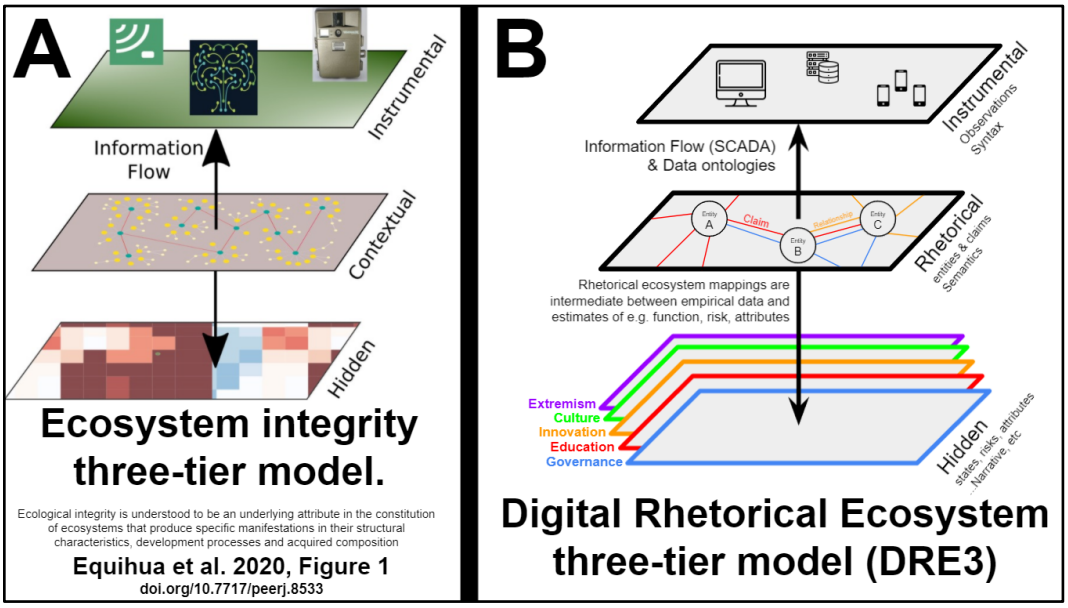

Figure 4. Ecosystem integrity model & the Rhetorical Ecosystem three-tier (DRE3) model. A) Figure 1 reproduced from Equihua et al. 2020 [40]. B) Digital Rhetorical Ecosystem Three-tier model.

The DRE3 model was inspired by the three-tier model of ecosystem integrity (3TEI) developed by Equihua et al. 2020 [40] (Figure 4A). In their 3TEI, the topmost tier is the Instrumental tier, reflecting measurements from the world, for example by sensors or cameras. The middle tier of the 3TEI is the Contextual level, reflecting the network of interacting agents in the niche that give rise to the observed information at the Instrumental tier. The bottom tier in the 3TEI are the Hidden variables of the ecosystem, such as risk of fire or capacity for agriculture. These variables are not directly observable through the use of any kind of physical instrument—hence statistical tools must be used to infer these states from the Contextual states that are in turn estimated from the empirical data at the Instrumental tier.

For the DRE3 model applied to digital ecosystems (Figure 4), we translate each of the tiers from the 3TEI into corresponding domains related to online discourse. The Instrumental tier of the DRE3 reflects the empirical observations of digital activity, for example rhetorical artifacts such as image memes, as well as metadata and other platform information (e.g., traffic logs, user ratings or responses to content). The middle tier of the DRE3 is the Rhetorical tier. This Rhetorical tier reflects the networks of entities, claims, and warrants evoked by artifacts at the Instrumental tier.

The bottom tier in the DRE3 reflects the multiple possible Hidden layers which might be significant targets of analysis, for example the risk of extremism, production of subcultures, degree of innovation, quality of public information, trust in government, and process of governance.

Importantly, the information in the Instrumental tier is mediated and augmented by a Rhetorical tier in the process of Hidden State inference. The direct mapping from rhetorical artifacts to hidden state inferences can be challenging and noisy (e.g., in the case of hashtags or syntax-driven analyses used to identify conspiracy theories [41]), or essentially impossible (in the case of image and multimedia artifacts). A better approach to high-throughput analysis of multi-media digital discourse is needed. We suggest that the introduction of a rhetorical layer (consisting of entities, claims, and warrants) in between the instrumental and hidden layers is a useful direction to pursue.

Ecology: Key Concepts and Mappings

This section applies the DRE3 model in the context of the modern global information environment. Like insights gleaned from regional ecosystems [42], analyses of rhetorical ecosystems ideally should be use-oriented, in close-to-real-time, and able to be represented differently for different stakeholders. Contemporary and future analysis of online discourse will involve the use of heterogeneous data to detect, monitor, and perturb discourse. This requires a significant amount of actionable and estimative intelligence regarding the real-time state of online discourse, especially if the goal is to ameliorate the aforementioned epistemic crisis and increase the capacity to understand and respond to the use of image memes in online discourse.

In this work we do not present any formalisms or explore all possible ecosystem-rhetoric connections, but rather focus on deriving implications for rhetorical analysis and online system design by focusing on three key areas of ecological theory and application:

- Multiscale perspective on ecosystems
- Ecosystem antifragility
- Ecosystem services

For each of these three ecological topics, we 1) define the term, 2) clarify the mapping from ecology to rhetoric, 3) consider which concepts might transfer from ecology to rhetoric, and 4) provide a preliminary investigation of the implication of these mappings in terms of systems design.

Multiscale perspective on Ecosystems

What is the Multiscale perspective on ecosystems?

- Modern ecological frameworks are built around the idea that biological systems present as nested scales of organization [43]. At each scale of organization such as cell, organism, and population, the system consists of interacting agents of various types [44,45]. System subunits can interact in non-linear ways, and the integrated function of the ecosystem as a whole can be considered as cognitive in its own right in that the system can learn, integrate information, display persistent memory, and act in an anticipatory fashion [46].

What is the mapping from the multiscale perspective on ecosystems to online digital discourse?

- Today's digital landscapes consist of human and non-human agents, interacting with each other and with textual artifacts, as if they were on rhetorical landscapes. Ecosystems and landscapes are rich and generative metaphors that help capture the many ways in which agents of various types and in various roles interact massively in parallel. These distributed rhetorical interactions contribute to information integration, collective decision making, memory, education, and anticipation across the digital public sphere. Rhetorical ecosystems exhibit structure and regularities across multiple scales of analysis, for example the individual, relationship, group, and community. Thus digital rhetorical ecologies can be considered as an integrated multiscale cognitive system.

- The case of an image meme posted on a social media platform can be seen as a niche modifying action of mobile agents, with the intention of signaling to similar or dissimilar agents, resulting in functional consequences for the further evolution of the biosemiotics of the niche. These stigmergic processes in nature, such as an ant depositing

pheromone, or large mammal making territorial markings [47,48], are essential for ecosystem function. Digital platforms present affordances for niche modifications, whether extremely limited (e.g., only a "like" button"), or more extensive (e.g., a Wiki model where content can be edited, or even a platform where the code and affordances can be modified by users). The availability and incentives for using different kind of digital affordances will be user-, platform-, and context-specific. This corresponds to ecosystem contexts where contextual niche modification processes play out over rapid behavioral timescales versus slower evolutionary timescales.

Which key ideas and tools from the multiscale perspective of biological ecosystems transfer to digital discourse spaces?

- Ecosystems around the world vary in fundamental ways but still can be modeled with common frameworks. Similarly, in the case of online discourse, we are interested in the similarities and differences across languages, platforms, and settings. The multiscale perspective in ecology highlights how interacting agents and situations can generate emergent patterns that are stable (or metastable/oscillatory) within acceptable attractor states, rather than causing cascading failures [49,50]. In ecology, even antagonistic interactions such as predator-prey may be stabilizing at the macro scale. In the case of online rhetoric, we might map individual-level interactions to behavioral ecology, and group-level dynamics to macroecological outcomes. For example, a pairwise relationship might be unstable or antagonistic among two users of an online platform (behavioral ecological scale) yet be a part of a stable broader online community of users (macroecological scale).

- The idea of niche modification from ecology translates to the kinds of changes that agents make to their information niche. In the case of online communication, this is known as digital stigmergy

[51,52]. Just as the behavior of individual animals is nested within (and in feedback with) surrounding ecosystem dynamics, rhetorical agents are actively exploring and modifying their informational niche.

- Various ecological toolkits exist to infer agent states and actions across spatial-temporal scales and use these inferences to understand how agent behavior is in feedback with broader trends. These toolkits include software packages and approaches related to movement tracking, multi-scale network analysis [53], system simulation [54], and characterization of the relationship between animal behavior and the animal's niche [55–57]. In the case of online discourse, agents are moving across informational landscapes, updating their models of the world, interacting with other agents, and increasing or decreasing their likelihood of engaging in different kinds of action. In both ecological and rhetorical settings, one may be interested in modeling how interaction among agents influence individual and collective behavior, as a function of context in the niche.

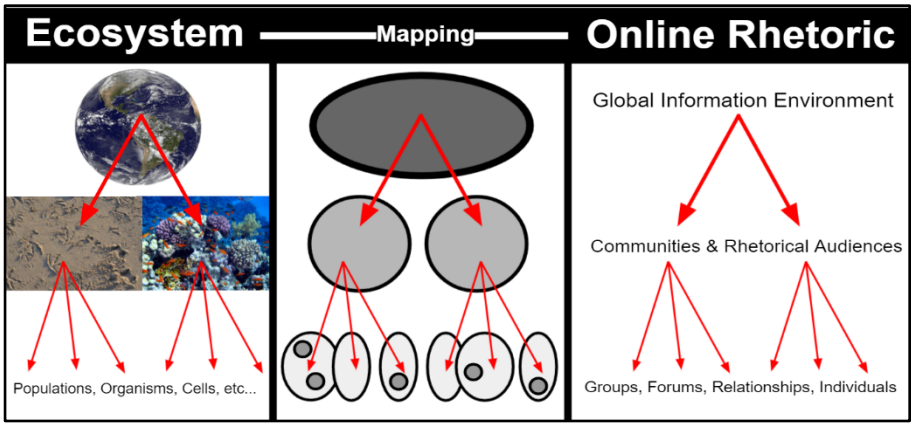

Figure 5. Representation of the multiscale perspective on Ecosystems. At left, ecological modeling of the world can proceed via decomposition into disparate ecosystems. At right, online rhetoric occurs within the global information environments, via increasingly-fragmented platforms, channels, and chats. The common mapping, in the middle, is the notion of overlapping and nested systems.

Ecosystem Antifragility

What is ecosystem antifragility?

- Ecosystem antifragility refers to the vibrancy, stability, and dynamic variability of a system. Recently, Equihua et al [40] have used various approaches from Complexity science to describe ecosystem antifragility as "beyond resilience and integrity". Their working definition is that an "ecosystem is antifragile if it benefits from environmental variability" [40]. Antifragility is similar to the notion of resilience, which captures how a system resists change or returns to functional capacity after a perturbation [58]. However, antifragile systems are those that actively grow or increase in capacity after stressors, as opposed to merely returning to previous operating modes.

What is the mapping from ecosystem antifragility to online digital discourse?

- **Health**. The stability and flourishing of the rhetorical commons is a primary goal for participatory communities and societies. This is akin to the concept of ecosystem health: even where different regions or seasons may have distinctly different healthy modes, maintenance of ecosystem vitality may be an overarching regional goal. While humans have long relied on qualitative or felt measures of ecological health, quantitative data collection allows for entirely new measurable notions of health only enabled by instrumentation and modeling [59–61]. We highlight the need to develop statistical indicators for the health and vitality of digital ecosystems so that policy for and management of digital commons spaces can be driven by shared empirical understanding rather than the potentially discordant experience of individuals.

- **Resilience**. The resilience of a rhetorical ecology might be defined in terms of the system's maintain function during a crisis, informational update, or structural change. The resilience metaphor draws attention not just to the regular or functional operating modes of rhetorical ecosystems, but also to the emergency and recovery modes available to these systems. Ecosystem resilience is critical when humans have

a vital dependence on continued ecosystem function, as in the case for agriculture [62]. Increasingly, online communications are a lifeline, and thus also need to be managed carefully with uninterrupted service and content integrity in mind. Disruption of internet services can occur through physical damage to infrastructure, as well as software intrusions (e.g., ransomware, denial of service attacks). Even when hardware and software are running according to performance standards, breakdowns of sensemaking (e.g., due to spam, targeted disinformation) can lead to perturbations on digital platforms and breakdowns in their typical functioning.

Which key ideas and tools from antifragility perspectives of biological ecosystems transfer to digital discourse spaces?

- Ecological antifragility has several kinds of ideas and tools to offer to the domain of rhetoric. Equihua et al. [40] characterize antifragile systems as those that benefit from variability, which provides a valuable parallel for measuring the health of the rhetorical commons by its type and extent of diversity (here of rhetorical claims and perspectives, rather than, for example, a species number). That the variability of rhetorical claims can be a source of collective vitality provides a helpful starting point for viewing online discourse and dissuades approaches that promote total consensus as a goal, or reflexive suppression of alternative viewpoints.

- Some approaches towards ecosystem antifragility feature participatory roles for ecosystem inhabitants, for example local cleanup events, long-running citizen science projects related to birdwatching [63] and regional ecosystem biodiversity events like a BioBlitz ("an event that focuses on finding and identifying as many species as possible in a specific area over a short period of time" [64]). In the context of digital ecosystems, these kinds of local programs for ecosystem improvement can scale to include large numbers of participants, for a Wiki editathon, for example [65,66]. Coordinated efforts to "fix trails" in digital ecosystems could contribute to antifragility by providing a scalable approach for reducing risks from cascading or complex failure modes related to out-of-date information, fragile network structures, or incapacity to deal with anomalous system usage.

- Quantitative tools also exist to help stakeholders measure and model ecosystem antifragility from a Complexity perspective [67]. Dynamic models allow for simulation and analysis of various kinds of systems and their stability in different situations [68,69]. In the context of ecosystem health, these kinds of analysis ask how it might be possible to build stable networks rather than network structures. An exclusive focus on network structures might lead to fragility of network function when edges are lost or nodes change. Modeling ecosystem health as a phenomenon arising from interacting networks, offers new and potentially more-effective ways of thinking about how multiple ecosystem stressors interact [70]. Network models also can be expanded to include "games on graphs" models, which use the tools of game theory to explore how strategies interact on landscapes and how information propagates through groups [71,72]. In the context of digital ecosystems these kinds of models could provide descriptive, prescriptive, and proscriptive information on the general function and well-being of digital platforms.

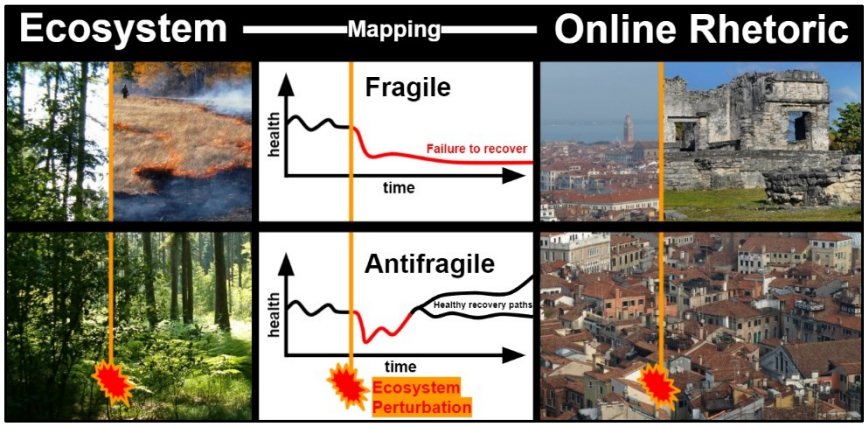

Figure 6. Representation of the concept of Ecosystem antifragility. At left, a forest experiences a perturbation such as a fire event. This event may either lead to devastation of the forest (top), or result in a forest that either burns completely and/or grows back stronger (bottom). At right, using a city as an analogy for the online rhetorical commons, a perturbation event can result in a destroyed commons (top), or a strengthened and vibrant community (bottom). The common mapping, in the middle, connecting biological ecosystem antifragility to digital ecosystems is that complex systems can undergo various recovery or response dynamics in response to perturbations, broadly classified as fragile (failure-prone, top) or antifragile (resilient and regenerative, bottom). For digital discourse platforms, fragility would refer to the inability to adapt or recover function following technological or rhetorical perturbation.

Ecosystem services

What are Ecosystem services?

- Ecosystem services are the functions that ecosystems provide which are useful for humans directly or incidentally, for example the provision of food, erosion control, composting of decaying matter, recreational spaces, or generation of natural resources, [73]. As is the case with ecosystem antifragility and health, many types and measures of ecosystem services exist.

What is the mapping from ecosystem services to online digital discourse?

- If we imagine rhetorical ecosystems to encompass the biotic and abiotic aspects of the system that contribute to its function and regulation, "rhetorical ecosystem services" could include a broad range of outcomes, including education, communication, innovation, and development of cultural norms and practices. Just as high-level biological ecosystem services, like the production of food, arise from direct interactions among many kinds of actors (e.g., plant, pollinator, microbes), and might be influenced by indirect factors as well (e.g., noise/light pollution, presence of predators), rhetorical ecosystem services emerge from the direct and indirect interactions of many actors and artifacts in the space. Understanding these influences can support modeling and management of the valuable outputs of a rhetorical ecosystem.

- We can consider image memes as a special case of ecosystem services, in that image memes are valued or relevant products of an underlying ecological process. The image meme format reflects the intersection of digital content production affordances, and the rhetorical cross-pollination occurring online. The services that image memes provide in the rhetorical ecosystem can include advertising, information sharing, governance, entertainment, persuasion, and more– essentially any functional outcome of the deployment of image memes that can be tracked and valued.

- Other studies have investigated the dynamics by which images memes originate and diffuse through time among communities [36]. This is akin to a source-sink analysis common in ecology: source locations are net exporters (of image memes on digital platforms) while sink locations are net importers (on digital platforms reflecting image meme consumption) [74]. This source-sink analysis of image memes can link the dynamics of memetic spread to their function for different audiences, and thus shed more light on the causes, context, and consequences of particular image memes for the rhetorical commons.

Which key ideas and tools from ecosystem services transfer to digital discourse spaces?

- Conservation & management of ecosystem services is an area of practice with a long history of analyzing the intersection of human individuals, human groups, and the rest of the biotic and abiotic surroundings. Some of the legal, mathematical, scientific, and game theoretic approaches to ecosystem services might transfer usefully to cases of online rhetoric. For example, when considering the design or regulation of digital platforms, various areas of law and policy interact, for example finance, business, and privacy. Framing digital platforms (and the functions they perform) as ecological commons introduces precedent for addressing legal dimensions of individual/public/private ownership, and processes for dispute resolution related to common resources [75].

- Ecosystem antifragility (discussed above) plays directly into the stability and accessibility of vital and valuable services [76]. Healthy rhetorical ecosystems will display variability in productivity through time. However, an ecosystem at high risk of catastrophic failure cannot be considered as valuable as a dependable ecosystem (e.g., a forest at risk of destructive fire presents higher uncertainty about its future productivity). The relationship between ecosystem health and productivity provides an economic motivation for policies that balance multiple contrasting requirements, by thinking about system function through time.

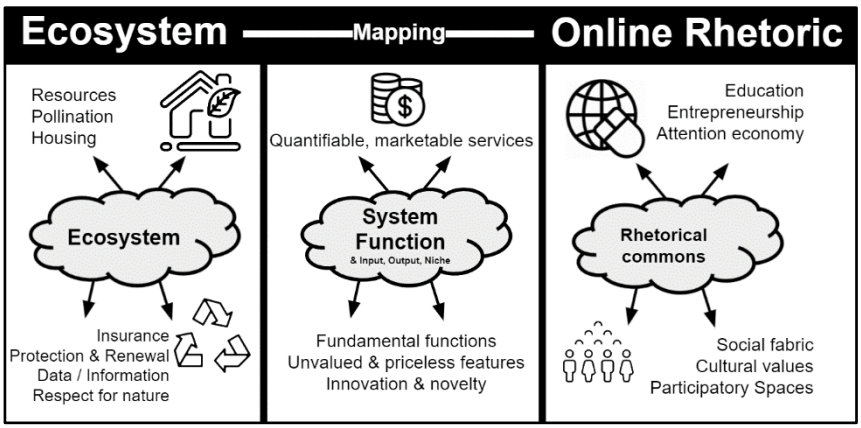

Figure 7. Representation of the concept of Ecosystem services. At left, physical ecosystem services such as natural resources and pollination are enacted by various actors within ecosystems. At right, online rhetorical commons can be considered to enact or emit services such as education and innovation. The common mapping, in the middle, is that value and valuable outcomes are generated through the function of the target system. Putting quantitative value on "intangible" outcomes can be challenging. Seeing online outcomes as analogous to ecosystem services is not a solution in and of itself, but rather a framework for approaching system management and design.

Implications

We argue that insights from modern Ecology can help scaffold the future of computational systems for rhetorical analysis. Ecological perspectives can retain the semiotic insights from rhetoric analysis while tracing meanings and their interactions within a quantitative framework [37]. At this time, manual rhetorical analysis requires trained experts who identify how artifacts produce meanings for different audiences, or, in the case of image memes, how memes generate claims. This process of rhetorical analysis is analogous to a natural historian observing a species operating skillfully in their niche, in that a specific occurrence (observation of a bird, or a digital text) is modeled in terms of its relationship to the context and niche (whether biological or rhetorical). Computational frameworks for rhetoric provide a set of ideas and tools that, if properly designed, could help accelerate rhetorical claim analysis. This type of "next-generation natural history" [77] for rhetorical ecosystems would integrate well with existing computational frameworks, apply well to the multimedia setting, and also work toward grounding analysis of digital discourse in rhetorical principles. Functionally, Ecology is the bridge that would allow rhetorical information to play a more central role in the computationally-aided analysis of contextualized digital discourse. We suggest that, in addition to the quantitative tools it provides (such as network analysis, sparse sampling, agent-based modeling, meta-community dynamics), Ecology can supplement rhetorical analysis by foregrounding concepts

like ecosystem health, biodiversity, anti-fragility, and more. Below are some possible implications arising out of the application of the Ecological perspective to online rhetorical commons (by no means comprehensive).

- Create and adapt within the niche. Online platform and systems designers can ask what services they are providing to stakeholders and the broader ecosystem (defined as the entities, audiences, and cyberphysical systems constituting the stakeholders and zone of influence of the target platform). Platforms provide and interact with the rhetorical commons, and thus services of value are being provided or modified by them. As digital platforms require inputs from the broader ecosystem in terms of energy, attention, and other resources, platforms must be anticipatory and responsive to changes in their operating ecosystem.

- Trace artifacts and claims to understand function. The DRE3 model of digital discourse has the capacity of creating clustering, detecting thresholds, or permitting inference at the level of rhetorical claims, an extension of approaches built solely on syntactic inputs (e.g., hashtags, keywords) or lexical semantics (e.g., natural language processing, sentiment analysis). We need to integrate artifacts and claims (beyond, or instead of tracking individuals) for effective sensemaking of digital discourse. Thinking of claims in terms of functional patterns in the ecosystem, platform designers could analyze the relative fitness and spreading/mutation/co-occurrence dynamics of memetic claims, across communities, languages, media formats, and platforms.

- Consider dynamics, not just snapshots. Some of the dynamical systems and network analysis tools developed for ecosystem management could generate models that may transfer directly to online datasets. Similar kinds of observations can be made in the ecological as well as digital situation (e.g., about the movement or communications among agents through a space described as a network) and similar kinds of questions might be asked (e.g., which initial conditions and patterns of

relationships might result in stable vs. unstable regimes). For example, migration can occur among geographical distances as well as among digital communities on social media. Complementary tools and perspectives for the analysis of migrations might be found across research on patterns of ecological and digital migrations [78,79].

- Design for multiscale interactions. Online platform design could take the multiscale perspective directly into account, for example by making certain peer-to-peer interaction mechanisms transparent, so that agents at various scales (e.g., individuals, groups, communities) are aware of how user-level affordances influence the niche and system as a whole. Top-down (e.g., platform-dictated) and bottom-up (e.g., user-generated) signaling mechanisms could be clearly marked (or if not marked, could be annotated as such by analytics platforms).

- Fit generative models (of rhetoric) that can deal with sparse as well as complete data. The task of ecosystem characterization is to go from sparse and heterogeneous observations (for example ambient conditions and bird sightings through time), to a useful and communicable model. This task of ecosystem characterization, depending on the scope of the analysis and desired level of detail, may require multiple kinds of models to be specified: the cellular, organismal, social, community, and ecosystem. For online discourse, integrating the multiple scales at which decisions are made (human internet user, community, networks of networks), ecologically-informed models might provide a principled path for modeling various phenomena of interest.

- Think about the ecosystem's leverage points and failure modes when designing an intervention. Ecosystem modification efforts are famously non-linear—careless interventions may be ineffectual or even have deleterious effects (as in the case of using broad-spectrum toxins in an attempt to eradicate the fire ant in the Southern USA [80]). For social

discourse, influence operations used to be evaluated in terms of a direct rhetoric source, such as centralized media. Now the operating landscape is much more akin to a complex ecosystem, contextualizing diverse social strategies as types of social ecosystem modification [81]. Modifications of the rhetorical ecosystem through various means (e.g., algorithmic distortion, misleading information) might have behavioral consequences rippling out far beyond the locus of direct action, akin to the introduction of a new species to an ecosystem. The relative efficacy and risk of different ecological interventions is variable across different regions. Proactive, long-term interventions such as restoring native habitat are often at odds with short-term interventions like intentional introduction of novel predators (as in the case of the cane toad in Australia [82]) or application of broadly-acting chemicals. Ecosystem interventions are irreversible, and often have non-linear consequences for different kinds of actors and audiences [83,84].

- Consider humans in the design of platforms, as well as non-human and computational actors. Taking a human-centric perspective on ecosystem function would be incomplete or even fallacious, depending on the region and goals of ecological modeling. Similarly, today for online discourse, given the prevalence and influence of purely-computational agents or computationally-augmented humans, it is essential that platforms be designed for use by human and non-human agents. Already a significant fraction of internet activity is carried out by purely computational agents or networks (e.g., chatbots and automated accounts). While the exact amount of human and computer activity likely varies among destinations, already in 2016 it was estimated that certain types of internet activity might be majority non-human [85,86]. The multiscale cognitive perspective on ecosystems provides a framework for modeling rhetorical ecosystems consisting of only human actors, only computational actors, and any conceivable composition in-between [87].

Already falling within this scope are existing tools that distinguish the activity of human vs. bot actors online in games, forums, and other platforms [88,89].

- Frame healthy and antifragile rhetorical ecosystems as a common pursuit. Promoting antifragility is a broad social goal that can apply across systems and scales. Ecosystem health as a concept helps humanize otherwise-unrelated environmental phenomena and might be able to play a similar role in making online rhetoric more tangible. Exact specifications of "health" for the digital commons may differ, just as they do for ecosystems. Analyzing the health of a given ecosystem might require the consideration of the abundance, composition, diversity, function, and tolerance of various kinds of life forms in the system (such as microbes, invertebrates, plants, etc.) [60]. And even in this case, individuals may still disagree on the health of a given ecosystem, if for example they diverge on the optimal usage of the region (e.g., for development vs. recreation vs. agriculture). When designing platforms for digital discourse, it would be valuable to consider how differences in opinion about "what is healthy" among users could be harnessed and channeled, rather than lead to system failure.

- Use rhetorical measures as a diagnostic when modeling digital discourse by framing the resulting artifacts and functions in terms of ecosystem services. Failure of rhetorical ecosystem services could occur from an adversarial or unhealthy dynamic, such as an inability to communicate leading to breakdown of trust among otherwise-cooperative individuals. To thwart, or recover from, such failures, it could be helpful to search for analogous situations in ecology. For example, ecosystem services could be threatened by the introduction of an invasive new species, a toxic chemical, habitat fragmentation, light/sound pollution, or loss of biodiversity [90,91]. In the case of rhetorical ecosystems, being able to connect failures of services to past ecosystem interventions

or modifications (influx of new users, introduction of toxic rhetoric, alteration of platform affordances, etc.) could provide a useful lens for protecting the valuable outcomes of digital discourse.

IV. The Digital Rhetorical Ecosystem three-tier model

The Digital Rhetorical Ecosystem three-tier (DRE3) model (Figure 4) integrates enriched rhetorical analysis of multimedia discourse with ecological theory and modern computational analytics pipelines. In this section, we present examples of rhetorical analysis using the DRE3 model. Specifically, we describe three analytic phases in the context of "boutique meme analysis" using two examples. At the end of the section, we provide a bridge between the traditional methodology of rhetoric and the types of computational representations that are useful for modern digital sensemaking systems.

There is a lack of usable platforms for computational rhetorical analysis, although several prescient calls have been made for such frameworks and tools [92–94]). Partially, this gap exists due to the challenge of accurately and effectively scaling expert rhetorical analysis. While multiple complicated sub-tasks are required for rhetorical analysis, digital tools exist today to carry out some similar functions (such as face-, voice- and text-recognizing algorithms, and natural language processing). We suggest that modern software algorithms are adequate to perform many of the sub-tasks required for the rhetorical analyses of image memes, and that crowd-sourced annotations (via participatory research, or micro-task platforms) could be used to support algorithms where the software alone are as yet insufficient. Already in the case of digital discursive ecosystems today, some fraction of users contribute their time and energy to improving discourse, for example by providing context or reporting behavioral violations. Approaches for online platforms that combine gamified participation with behind-the-scenes machine learning have been successful in advancing research in biochemistry and a variety of other fields. These crowd sourced projects can take a variety of forms, and can be designed to operate directly on the engaging digital platforms that people already use [95].

Here we present what a case-by-case rhetorical analysis of image memes might look like, within a framework that is ultimately designed to scale

up to high-throughput ecosystemic annotation, while retaining the semantic richness afforded by case-by-case rhetorical analysis. These analyses are performed in three phases:

> **Phase 1. Entity Identification.** The first phase of analyzing the rhetorical function of a meme entails recognizing visual entities embedded in the meme. Entities can be of different types and are interchangeable across memes.
>
> **Phase 2. Rhetorical Analysis.** The second phase of decoding the function of a meme entails identifying its semantic and consequently persuasive potential. This phase begins with tracing relationships between the entities implied by their arrangement within the meme. The relationships will typically synthesize into an implied (or stated, if the meme includes text) claim, sometimes accompanied by evidence included in the meme. The claim often rests on implied warrants (assumptions) supplied by the viewer who is aware of the rhetorical context that the meme invokes.
>
> **Phase 3. Hidden State Identification.** The third phase of decoding the function of a meme is hidden state identification. The exact nature of the hidden state inference will be situational and depend on what the analyst is attempting to reduce their uncertainty about; for example, the extent to which the image meme in context is consistent with social values, providing specific valuable services, or eliciting violence. What distinguishes the various possible hidden state inferences from rhetorical inferences in Phase 2, is that hidden states are deeper than specific claims about entities, and reflect underlying attributes of the rhetorical ecosystem that gives rise to and are strengthened by such claims.

Two examples below (Figure 8 and Figure 9) represent the qualitative application of the DRE3 model to shareable image memes. The rhetorical analyses below uncover preferred readings of these image memes [96], and are not exhaustive in terms of entity or claim identification. Memes, as identified earlier, are polysemic. They are able to generate multiple and varied interpretations. A rhetorical analysis cannot comprehensively decode all meaning possibilities embedded in an image meme. Nevertheless, by following the rhetorical use of symbolic content within the meme, attending to the discursive contexts in which a meme may be harvested (such as a Facebook post thread or

a Twitter thread), crowdsourcing the claims advanced by memes, and determining interpretation consensus across trained rhetorical analysts, we can identify likely, core, or agreed-upon, in other words the preferred arguments that memes advance [96]. In this case, we define preference by what a meme was originally designed to argue or the meanings that are most easily accessible (obvious) to the target audience. Even though the meaning of a meme can be altered by its discursive context (i.e., a meme can be deployed ironically to undermine its own message), such a subversive reading of the meme relies on consensus about its dominant meaning. Therefore, despite inherent polysemy, we believe it is both possible and useful to identify the dominant argument(s) that are encoded in an image meme.

Example I

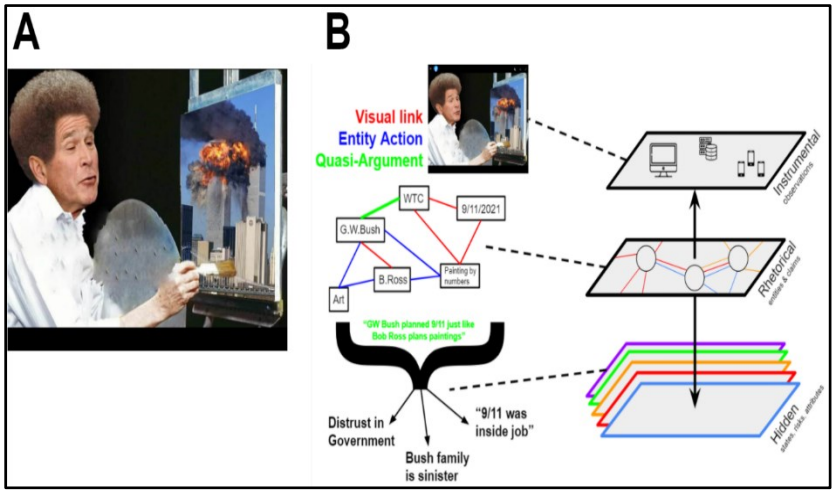

Figure 8. Illustration of the DRE3 model as applied to an image meme without text. A) a target image meme under analysis. B) Application of DRE3 model, breaking down the meme in terms of the Instrumental tier (what was observed), the Rhetorical tier (entities, warrants, claims), and the Hidden State tier (implications and use-specific inferences).

Phase I. Entity Identification

In the above meme, the following entity categories are rhetorically significant:

Persons: Bob Ross, G.W. Bush

Attributes: Hair, shirt, hand of Bob Ross, Face of G.W. Bush

Objects: Twin Towers of the World Trade Center, Painting materials (palette, paintbrush, canvas, easel)

Location: New York City skyline

Action/Relationship: Individual painting on canvas

Phase II. Rhetorical Analysis

In the above example, decoding the meme rhetorically by analyzing relationships between entities requires distinction between host images and parasitic images. The incorporation of the parasitic images to replace parts of the host images produces a parodic relationship between host and parasite entities. The insertion of G.W. Bush's face into the identifiable hair of the artist Bob Ross parodies the parasitic entity—Bush. The host image is the one that dominates the meme. An enculturated viewer recognizes the image as a still from the iconic Bob Ross televised painting class. Ross's hair, shirt, hand, palette, brush, and canvas on the easel are easily recognizable attributes/objects and constitute the majority of the image. The viewer is clear that it is G.W. Bush's face that is intruding within the Bob Ross image rather than reading the artist entity as the intruder. Having identified the host-parasite relationship, the viewer must now extract the semantic implications of this parody.

In deciding what the host-parasite parody means, the viewer recognizes that the visual juxtapositions in the meme are meant to paint former president G.W. Bush as an artist. The parasitic image that has taken over Ross's typical placid landscape scene on the canvas provides a stark contrast to what those familiar with Ross expect him to paint. The peaceful landscape of a Ross painting is replaced by a real scene of terror (the fall of the Twin Towers on 9/11) that is also highly recognizable because it has become widely circulated memetic content.

The face of G.W. Bush and the destruction of the World Trade Center towers in New York City are clearly linked in the rhetorical context available to the enculturated and interpellated viewer. The structuring of entities within the meme, however, superimposes an additional relationship that emerges out of the parodic analogy between G.W. Bush and Bob Ross. The parody is underscored with the use of an exaggerated expression on the face of G.W. Bush. This is the point at which the viewer arrives at the

claim embedded in the image structure of the meme. The claim could be articulated as follows: Like Bob Ross paints a landscape from imagination, G.W. Bush fabricated the 9/11 terror attacks. In this case, the memetic argument advances only a claim. The meme contains no evidence. Instead, the meme operates intertextually. To unpack the meme's claim, the viewer must be aware of multiple rhetorical contexts, such as the 9/11 truther movement that has sought to expose the terrorist attacks of 9/11 as a plan of the United States' own government, and the imputed role of the Bush family within the construct of a global cabal that controls worldwide events. In this way, the rhetorical analysis of memes leads us to identifying salient hidden states (e.g., social, political, and cultural beliefs/practices) that both influence and are shaped by memetic arguments.

Phase III. Hidden State identification:

A rhetorical decoding of the Bob Ross-G.W. Bush meme both relies on and perpetuates claims about the Bush family, the G.W. Bush administration, the events of 9/11 and other global destructive events. Memetic argumentation analysis is ultimately useful to the extent to which it permits tracing evolving public beliefs and practices that could have real-world implications. We expect that, over time, the identification of rhetorical claims from varied memes will reveal patterns of connected beliefs that correspond to higher-order hidden states such as confidence in the government, or beliefs about the causes of past events. A hidden state in our framework refers to an implicit and volatile state of public belief, sentiment, or action. A belief that the United States government lies to its people is an example of a hidden state. This higher-order claim represents a public belief that produces a sentiment of distrust in the government. Tracing hidden state dynamics is useful because they can activate overt action in unrelated contexts, such as vaccine refusal because of a previously established distrust in government. Such a relationship between hidden states and public action can potentially be identified by tracing co-occurrence of memetic claims within networks.

Example II

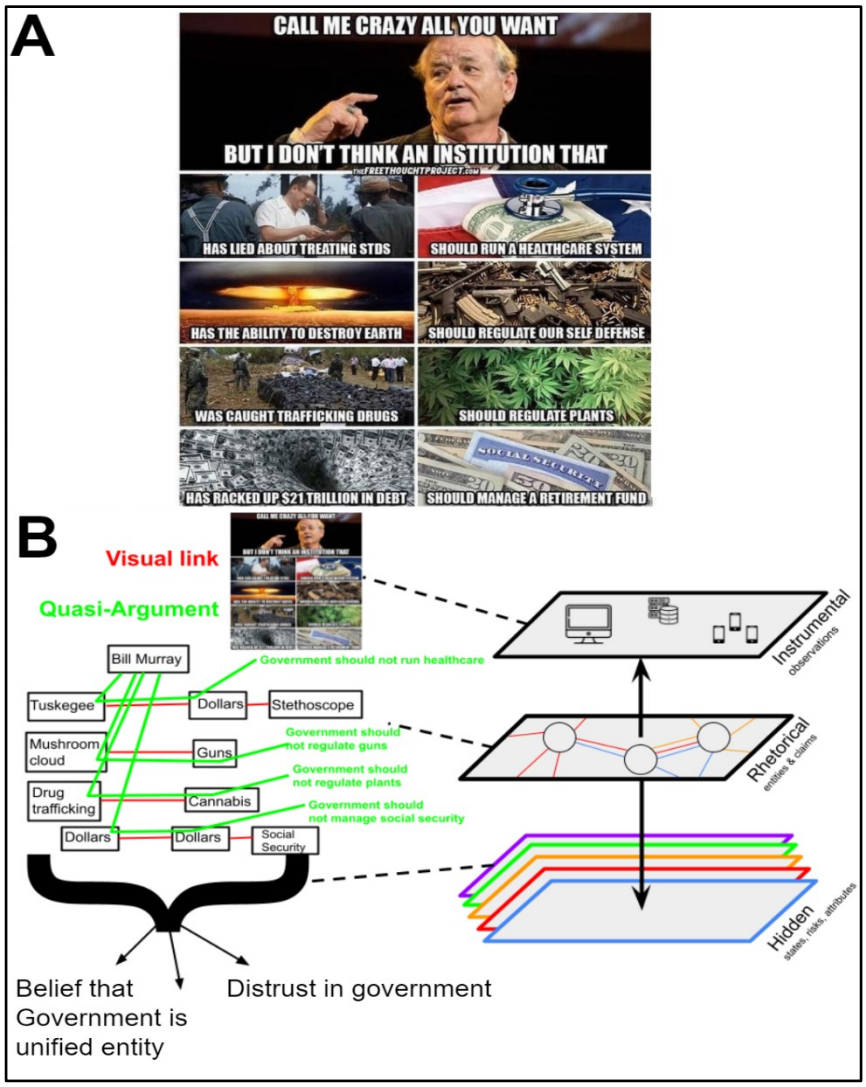

Figure 9. Example of the DRE3 model as applied to an image meme with text. A) a target image meme under analysis. B) Application of DRE3 model, breaking down the meme in terms of the Instrumental tier (what was observed), the Rhetorical tier (entities, warrants, claims), and the Hidden State tier (implications and use-specific inferences).

In this example, the higher-order claim that the United States government cannot be trusted is advanced by submitting lower-order arguments. The text-image pairing in this meme enacts argumentation differently than in Example 1. While the first example illustrates argument by analogy, this example supports its claims with visual evidence and follows an "if-then" pattern.

Phase I. Entity Identification

In the above meme, the following entity categories are rhetorically significant:

Persons: Actor Bill Murray

Scenes: Tuskegee syphilis study, mushroom cloud, drug heist.

Objects: Dollar bills with a stethoscope, stock of guns, marijuana plants, vortex of dollar bills, dollar bills with social security card.

Phase II. Rhetorical Analysis

The visual segmentation of the meme-box is crucial to how the argument is enacted. The visual sequencing relies on the viewer moving from the top to the bottom and from the left to the right. The top centered image features the actor Bill Murray. The text superimposed on this image invites the viewer into a dare with the person sharing the meme. The challenge "Call me crazy all you want" invokes the trope of the conspiracy theorist, a label typically branded on those who accuse the government of large-scale wrongdoing. The rest of the meme-box is set up to enact that challenge and rebut the conspiracy theorist label. Bill Murray, known for his antics that speak truth to power, functions as a symbol of interpellation for the conspiracy-minded, who are not taken seriously by the mainstream but are convinced of the truth to which they have awoken.

The lower order arguments are presented in claim-evidence pairs, each contained in smaller boxes in the left-hand column of the meme. Four claims about government malevolence are substantiated with images meant to provide evidence.

The first claim accuses the U.S. government of lying about medical treatments of STDs. The image over which the textual claim is superimposed features African Americans, a visual sign meant to invoke the Tuskegee syphilis study that abused black American bodies in a deceptive government intervention. The image in fact is an iconic historical photograph of the study. But, even in the absence of audience knowledge about the provenance of

the photograph, knowledge about the Tuskegee study itself is enough to decode the image as representing that particular instance of government dishonesty and failure.

The second claim accuses the government of the ability to destroy the planet and is substantiated with the paired image of a mushroom cloud that invokes the Hiroshima atomic bomb disaster.

The third claim accuses the government of trafficking in drugs. The textual claim is superimposed on an image meant to invoke the plane crash that exposed alleged CIA involvement in drug trafficking in Panama.

The fourth box in the left-hand column claims that the U.S. government has $21 trillion in debt. Here the paired image simply shows a giant vortex of dollar bills illustrating the metaphor of "money down the drain". The preceding images which pull from historical archives construct the credibility of the meme, leading the viewer to implicitly assume the facticity of the final allegation, even though the fourth argument departs from the claim-visual evidence pattern established by the previous three.

The visual segmentation and sequencing in the meme optimizes the constrained space of the meme-box to deliver a relatively complex argument with multiple claims and pieces of evidence. Each text-image pairing on the left works in conjunction with the text-image pairing on the right to both verbally and visually enact the if-then argument pattern. The boxes on the left provide evidence for the claims on the right. For example, the government's dishonesty in the Tuskegee study is presented as evidence for the claim that a nationalized health care system cannot be trusted because of the ways in which it might abuse unsuspecting citizens. Likewise, its willingness to bring the planet to the brink of destruction by deploying nuclear weapons is provided as evidence that the government should not be allowed to regulate gun ownership. The strategic use of the meme-box to bound the argument is especially stark in this sequence. While evidence of the government's disregard for human life can be leveraged to support curtailing the government's military power, the corresponding claim instead attacks gun regulation, implying that citizens need to be prepared to defend themselves against an untrustworthy government.

However, the implication that guns are powerless in the face of nuclear destruction, which would undermine the meme argument, is suppressed by the visual alignment of evidence and claim side-by-side. This visual formatting contained within the meme box constrains the possibility of additional lines of reasoning even more powerfully than a similar argument made through other forms, such as orally in a speech or verbally in a news article. The visual demarcation of the meme box has the powerful potential to restrict reasoning to the elements displayed within the box. Because of how distinctly recognizable the meme-box has become and how unique it is in appearance compared to other visual modes of public discourse, the meme-box is able to separate itself from the rest of the landscape of public argumentation and create both discrete instances of argument unique to its own content and structure, as well as to interact within the ecosystem of related memetic arguments.

Phase III. Hidden State Identification

The four boxes on the left in alignment with each of their counterparts on the right together advance the higher-order claims that the U.S. government is dangerous, unethical, and inept and its interventions should be substantially curtailed. This claim reifies the hidden-state sentiment of distrust in the government. It is important to note, also, how the argumentation enacted by the meme relies on some but not extensive contextual knowledge in the viewer. The parsimony of the symbols within the meme (restricted to a few words and images) relies on the audience's background knowledge and ability to supply warrants. For example, audience knowledge about the Tuskegee study and its targeting of African Americans is essential to reading the first image on the left-hand side as evidence for its paired textual claim. However, even minimal recognition of some elements is sufficient for the viewer to then accept the other image text pairings and submit to the lines of reasoning traced by the memetic elements. Likewise, the meme relies on an interpellated audience to supply the necessary assumptions (warrants) to complete the arguments. For example, the leap from the government's moral failing in the Hiroshima bombing does not automatically lead to an argument against gun

> regulations, unless the viewer is already concerned about the erosion of Second Amendment rights and is thus primed to read the atomic bomb image as evidence that the government does not have its citizens' best interests at heart and would therefore regulate gun ownership to reduce the threat of self-defense from its citizens.

The two examples elaborated above show the kinds of information about memetic claims and hidden states that can be inferred with a rhetorical approach. In the following section we integrate the insights from rhetoric and ecology to outline some considerations for the design of online discourse monitoring systems.

V. Toward a High-Throughput Rhetorical Analysis (Meme SCADA)

The example applications of the DRE3 model in the prior section show the kinds of information about hidden underlying states inferable with a rhetorical approach, that are impossible using syntax-driven analysis such as keyword extraction or entity recognition alone. Digital discourse moves at a very fast pace. Rapid changes in digital discourse (e.g., during an unfolding political event) are likely the times when monitoring and analysis are most needed. Unfortunately, the DRE3 model, as applied above, is low-throughput. This problem is not unsolvable. The field of ecology offers a hopeful precedent, because it emerged from low-throughput observation of natural history, and later increased in scope and rigor through the application of quantitative frameworks and large-scale monitoring networks. We propose that rhetorical ecosystem analysis is capable of making a similar transition to a higher through-put research phase, in the case of some digital artifacts.

The value of developing capabilities for cataloging, indexing, searching, mapping, monitoring, and modeling digital discourse is also not limited to facilitating research. Just as better ecological understanding and monitoring has enabled forecasts, such as those related to algal blooms, disease, wildfires, and the potential risks of construction or development [97], better understanding and monitoring of digital discourse could forecast outbreaks of violence, acceptance of government initiatives, the spread of ideology, and the potential risks involved in narrative influence [98]. A wide variety of disciplines undoubtedly have interest in tools for modeling, mapping, and monitoring digital discourse, such as public relations, public health

policy, and military information support operations (MISO) [98]. Many high reliability organizations, or organizations which must maintain low-failure rates or risk cascading failure [50], have expressed or demonstrated a need for tools which perform these functions [99–103]. While recent crisis events have drawn particular interest to the potential application of these functions in monitoring and modeling digital discourse about public health and political extremism, there has been a long-standing need for these functions in areas which are entirely apolitical, such as of multimodal content regarding interpretations of emergency situations like forest fires, floods, and earthquakes [104].

Transitioning from low-throughput to high-throughput, and from theory and research to forecasting and decision-making support, will only be accomplished by considering the related requirements of the outputs, of the processes and methods which lead to them, and of the tools and infrastructure which enable them. Here we explore and frame these requirements, consider methodology, and propose the structure of a monitoring system best categorized as a type of SCADA (Supervisory Control and Data Acquisition) system for digital discourse which incorporates the DRE3 model and modern computational techniques [105]. Addressing the use-case specific requirements of the many domains which might have interest in monitoring tools has been considered elsewhere [81]. Instead, the focus here will be on the requirements for more general sensemaking about public narratives generated by image memes.

Narrative Intelligence

The general requirements for sensemaking common to all intelligent systems are the abilities to capture relevant data from the environment (sense), fit the data to expectations or adapt those expectations to fit the data (model), and use the expectations to consider or frame choices (policy) as a basis for informing action [87]. Various frameworks exist to convert these general requirements into formal processes and specific requirements for systems which facilitate sensemaking. These frameworks are often built for activities which require special consideration beyond the fundamental sense-model-policy framework, such as in militaries [106–108], teams [107–109], intimate relationships [110], machines and AI [111,112], and businesses [113]. Of the many sensemaking frameworks available, intelligence production may be the most appropriate for sensemaking related to digital discourse.

Intelligence production is an organizational sensemaking process which is intended to produce deliverables to inform policy that achieves or

maintains the interests of an organization [114,115]. Formal intelligence production processes are particularly helpful for organizations that are large enough to make the natural emergence of synthetic intelligence or macrocognition unlikely or illusory, and for organizations which are interacting with systems of interest that are sufficiently complex to prevent existing synthetic intelligence from being able to manage available sense data appropriately [109,114,116–118]. The process of intelligence production was originally semi-formalized by the Roman military [118] and has been iteratively developed throughout history in response to situations where conditions complicating macrocognition arose or became exacerbated [114,119–123].

Intelligence production is a helpful way to frame the requirements of sensemaking in digital domains given that intelligence production was formalized to face similar challenges, such as voluminous collections across myriad surfaces, multimodal data [124,125], deception and intentional disruption of data collections (counterintelligence) [126], and difficulty of detecting, monitoring, and interpreting counterpublic membership and activity [50,127–129]. Since intelligence production is usually performed by high reliability organizations [50] and faces the aforementioned challenges, it has been iteratively developed over time to maintain reliability and cope with imperfect data and uncertainty. While various specifications exist for particular use-cases, such as in business and commercial intelligence [113], generally intelligence production is modeled using 5 distinct stages: 1) planning and direction (requirements setting), 2) collection, 3) processing and evaluation, 4) production and analysis, and 5) dissemination [113,125,130,131]. These 5 stages provide opportunities for separations of concern between categories of function and process, as well as between personnel and access to information [131,132] to limit the possibility of "having either the facts or the conclusions warped by the inevitable and even proper prejudices" of those involved [133]. However, it should be noted that the steps formalized in the intelligence production model are not necessarily implemented in discrete phases, and that even where separate steps are intended, they still occur in parallel with blurs between processes [134,135].

Ecological and rhetorical metaphors and methodologies may offer unique and valuable approaches to monitoring and analyzing digital discourse, but no metaphor is a perfect mapping [136]. Here we apply the intelligence production framework to facilitate practical considerations for "mapping the gap" between ecology- and rhetoric-inspired methodology and the needs of a meme analysis pipeline at each stage.

Planning and Direction

The first step of the intelligence production cycle is planning and requirements setting. This stage entails considering what kinds of intelligence products are needed and in what time frame, and translating these needs into technical and personnel requirements, scope, and expectations for the following steps [130–132]. In the case of a meme analysis pipeline, we suggest that the relevant products be broken into 5 broad categories:

- **Data Sets.** While raw datasets do not constitute a formal intelligence product, the data collected and used for projections and other features are nonetheless a product which should be made available both internally and externally, similar to the provision of Twitter's streaming API (application programming interface) and "Firehose" [137,138]. These releases are essential for 3 primary reasons. First, the analysis pipeline should never be considered entirely complete; data used and produced by various features should be available for both quality testing and use in the development of new features. Second, datasets of content with semantic annotations could be invaluable for the development and training of AI. Finally, the capability to release data used allows for reproducibility and transparency in the case that outputs are considered partisan or questionable.

- **Research Intelligence.** Research intelligence refers to information that may provide context or support for other intelligence products or help in further analysis or sensemaking, such as wikis, or "fact books" which might provide details about content and communities of interest in the context of digital discourse [114,139], field guides for providing education on common patterns and processes [98], exploratory search features for analysts and researchers, and research products such as academic articles or white papers.

- **Estimative Intelligence.** Estimative intelligence refers to information regarding uncertain phenomena, such as the likelihood of an object impacting a particular hidden state, though some definitions place a larger emphasis on projection

[140–143]. In the monitoring of digital discourse, helpful estimative intelligence might include metrics and projections regarding the state, rate of change, and impact, of beliefs, communities, patterns of activity, or content, informed by methodologies from ecology and rhetoric.

- **Warning intelligence.** Warning intelligence refers to information about anomalous phenomena or rapid or unexpected changes to system state [139,144,145]. In the monitoring of digital discourse, useful examples of warning intelligence would include the detection of anomalous activity, the emergence of what may be coordinated, aggressive, and strategic activity associated with untracked or tracked objects or communities, notifications about other organized activity such as the censorship of content on a platform, or the presence of harassment, threats, or explicitly illegal activity.

- **Actionable Intelligence**. Actionable intelligence suffers from a lack of consistent usage or a consistent definition, but generally refers to information which needs to be addressed urgently and informs or enables actions that might be or need to be taken [146]. In the monitoring of digital discourse, actionable intelligence would help inform interventions such as the removal of content, inform design of content or messaging based on current trends, and guide sensemaking by providing new routes to consider when presented with ambiguity or structurally complex information.

Collection

The second step is broadly referred to as "collection". This term is sometimes used to refer to the entirety of the intelligence production cycle [133,147]. However, in the context of the production cycle and its processes, it refers to the conversion of requirements set during planning and direction into tangible targeting, selection, and instrumentation choices in order to collect data [125,130,148]. At this stage, the focus is on the collection of "raw intelligence", or unanalyzed information, in accordance with requirements—as such, it is sometimes referred

to as collation [132]. In the past, organization of raw intelligence was fairly disorganized [118–120,134,149]. But with the increase in volume, and the need to collect multimodal data from myriad surfaces, came a need for specialization not just in analysis but in the collection of raw intelligence as well, resulting in various formal categories of tradecraft, or types of intelligence collection and annotation methodologies [130,150].

There are a series of ethical and practical challenges to the development of collection requirements and procedure for image memes in the interest of developing an image meme analysis pipeline. A root problem, worth addressing first, is that even at the cutting edge of machine learning applications in analyzing memes, there are serious limitations imposed by the lack of existing annotated collections to use as training data [23]. Thus, the use of AI at this time for automated collections would likely be inappropriate given that even the ability to differentiate between an "image meme" and "just an image" is a difficult, semantic challenge—let alone the ability to analyze it. However, given the rate of change, complexity, and volume of image memes, collection would place too high a burden on researchers, experts, and analysts. Crowd-sourcing may therefore be the best avenue of approach. While crowd-sourcing approaches have come under criticism, recent successes indicate that more complex tasks may now be ready to be outsourced to crowds [95]. Choices in incentivization mechanisms and user experience design would need to be considered in depth elsewhere, but there is a rich history of crowd-sourcing data in ecology which could be of use in framing collection requirements. For example, millions of entries for bird sightings are generated by citizen bird watchers each month [151] and data from bird sighting submissions can be used by analysts for real-time monitoring of animal activity as well as for forecasting phenomena such as outbreaks of West Nile virus [152]. The frameworks used for crowd-sourcing in ecology may allow for a direct transfer to other domains, such as those which provide data management principles [153] and offer methods for improving information quality or "Crowd IQ" [154].

Among the approaches developed in ecology and ecology-adjacent fields from learning-by-doing in crowd-sourcing, three stand out as both valuable and immediately applicable. First, based on crowd-sourced classification of plants and birds, quality of collections can be greatly improved simply by improving the quality and scope of the class structures (schema)

and data standards the crowd will interact with [154]. Second, the study of crowd-sourcing fish classifications and remote-sensing in hydro-ecology has shown that quality can be improved over time by segmenting users by expertise and using these segmentations to provide different levels of responsibility [155,156]. Third, work on crowd-sourcing biomedical annotations has revealed that expert contributions can be used to train and tune user contributions, particularly to detect anomalies and unexpected deviations from patterns. Similarly, user contributions can be used to train and tune automated systems and be assisted and guided by them in performing contribution tasks (see figure 10) [95]. These approaches could be directly applied to "field" collections of image memes. Given that collections are occurring online, most relevant information, such as where the object was collected, the object's file type, and reaction or "impact" data if it was collected from social media, could be automatically fit to pre-existing data standards with no need for experts involved in collections before being placed in a buffer for classification. The collected objects could then be used to train AI to determine what and what does not constitute a meme.

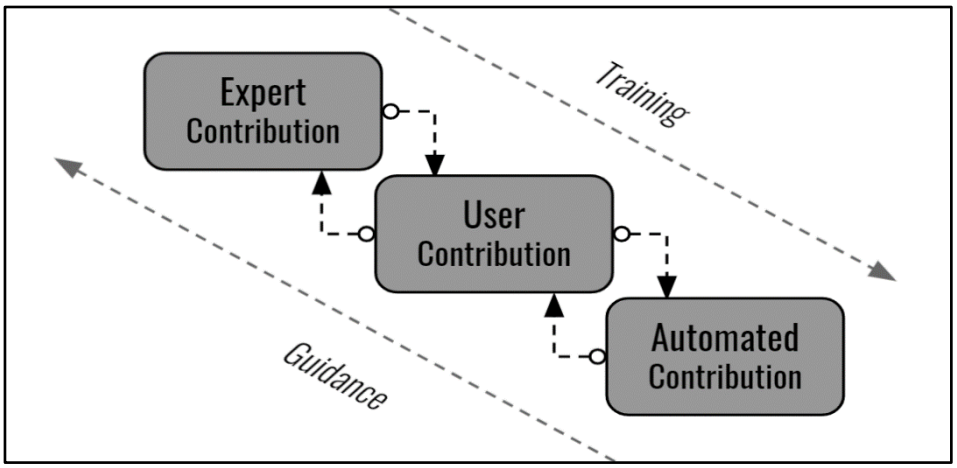

Figure 10. The flow of benefits offered between types of user contributions. Contributions by user segments with higher levels of competency in a task can be used as training data for those of a lower competency, while contributions from segments with lower levels of competency can be used to help provide guidance to those of a higher competency (e.g., suggested classifications).

While it might be reasonably assumed that data about the user who posted the collected object should be automatically parsed and collected as well, this may not be necessary. As noted elsewhere in this article, memes, particularly political memes, are often presented without attribution. Further, user data may need to be bypassed because creating or sharing political or even

quasi-political memes or other content, especially within counter-publics where meme-activity is rich and of interest to researchers, is increasingly being accompanied by the expectation of potential consequences from peers [157], employers [158,159], and institutions [160,161], as well as by potential punitive consequences from media-sharing platforms [162–165] and governments [166,167]. The DRE3 model's focus on claims in memes informed by a rhetorical approach, and on relationships, placement, and change of that content informed by an ecological approach, as opposed to a focus on the identity of the poster, prevents misattribution or association inferred by posting history (e.g. a CDC official sharing an anti-vaccination meme for educational purposes), reduces the potential for harm by "outing" or "doxxing" internet users, especially in countries with higher potential for consequences for sharing political content, and reduces the potential for critical misuse of the analysis pipeline. For the purposes of understanding movement of memes specifically, the channel over which the meme travels is sufficient. If the collector of the meme in context with a particular platform constitutes a channel, then this channel can be considered a location—leaving no reason to deanonymize the collector and making the generation of an "identity" within the pipeline an opt-in exercise.

Processing and Evaluation

The third step of the cycle is often referred to as processing and evaluation and refers to a pre-analysis stage in which data is cleaned, refined [148], and filtered [130] and the reliability and credibility of sources of the information are considered [132,134,168]. The raw intelligence assembled in the collection phase is now altered or reassembled for usability, "coded data is decrypted, foreign languages [are] translated, and photographic material [is] interpreted" [148]. The importance of processing and filtering cannot be overlooked. Without comparable measures, accessible reference information, or compression into usable formats, much of the data could essentially become meaningless [169]. When this processing is done in concert with proper scope and orientation introduced in the planning and direction phase, it also reduces the potential for endless abstraction by making the means and intentions of the process clear [87,170].

It is at this stage in an image meme analysis pipeline that experts would be needed to begin classifying objects and improving

information quality as the pipeline begins to move beyond syntax and metadata toward semantic annotations. Even with the use of crowd-sourced and automated collections, the load would still be far too great for experts and trained analysts to handle alone. This being the case, the same framework of training, guidance, and segmentation between the kinds of contributors described in the prior section would offer continued utility (see figure 10). Automated systems would be given responsibilities such as detecting quantitative features that are correlated with virality and longevity of the image meme, which can then be used to direct the attention of both experts and average users [23]. These systems would make use of data from the contributions of human users to train for more complex tasks. Expert users would have the primary responsibility of developing and detecting claim and argument patterns and applying these labels to content, which could then be used to train average users or even AI to do the same.

Claim identification presents the largest challenge to crowdsourcing the DRE3 model due to the subjectivity of the extraction whether it comes from rhetorical experts or average users. Image memes, as discussed in prior sections, tend to have an ambiguity which offers the poster plausible deniability about the assertion of claims. Therefore, simple automation of feature recognition cannot be relied on for extracting claims from images. However, this challenge may instead be seen as an opportunity. There are many viable methods for extracting and aggregating arguments from text [171–173], allowing for the substance of these common arguments in various phrasings to be aggregated and clustered. The remaining disparity between interpretations would not, and should not, be considered noise—but instead valuable data for producing metrics related to the subjectivity and complexity of the content and of diverse perspectives interpreting it. Average users would share responsibility for claim extraction, though their primary responsibility would be the extraction of relevant entities from the content.

Once experts have provided sufficient labeling of rhetorical pattern and structure, average users could be slowly trained. Segments of those users may even eventually be trusted with contributing rhetorical or other expert classifications, though the provision of greater responsibilities would likely require new tools or frameworks for managing trust in crowd-sourcing systems. Automated features however, would likely need to stay

in a guidance role regarding most semantic analysis of image memes. Semantics on the internet are prone to rapid change and often require contextual knowledge. For example, triple brackets around an organization or person's name is now often considered an antisemitic symbol marking Jewish background or influence. But obviously, not all uses of triple brackets indicate this—and worse, prior to this association, the same triple brackets were used to indicate a "cyberhug". This does not mean that automated features would be useless. For example, the ability to note that some typographical feature may mean something to specific audiences and to direct a user's attention to that symbol is a valuable guidance feature.

Production and Analysis

The fourth stage of the cycle is referred to as production and analysis, wherein experts begin to produce the intelligence products requested, given the collected, processed, and evaluated information available and relevant to them [148]. At this stage in a meme analysis pipeline, data and content cataloged throughout the collection and processing stages can now be structured into data sets for developing, improving, and replicating automated features at all stages in the pipeline and for more specific exploratory analysis by experts. More importantly, it is also at this stage in the meme-analysis pipeline that rhetorical and ecological framing and techniques begin to have their most valuable contributions.

- **Research Intelligence.** The content labels, entity extractions, and identified claims informed by rhetoric now have a role in enabling semantics-driven exploratory search. The bottom-up detection of patterns and topological motifs allow analysts to view single pieces of content as a part of memetic clusters, not just of other pieces of content, but of entities, claims, and subclaims expressed in that content, and of the hidden states that may be signaled by them. With the metrics and features which accompany the objects labeled within these memetic clusters, the analyst is able to monitor a semantic field, or rhetorical ecosystem, as described in previous sections, before analysis has even been performed. The data is now available to enable methods of analysis from ecology discussed elsewhere in this

document. In addition, the content, patterns, and aforementioned ecological motifs can now be structured into coherent and navigable wikis, field guides, and fact books, modeled after the large, robust identification systems and guides found in ecology—helping improve methods and standards at all stages of the pipeline and increasing the likelihood of novel genres or features being detected.

- **Estimative Intelligence.** The use of ecological frameworks and methods for identifying and communicating state features of content and claims, and considering the relationships between entities, memes, and claims, as discussed previously, could be of great value. The ability to classify and quantify state features implies the ability to consider potential for impact and spread, as well as the ability to measure rate. The provision of data regarding these changes to content and claims and related rates of changes may allow analysts to not only communicate current state, but also project future state of both claims and associated hidden states. This information can be leveraged in order to generate reports regarding underlying ecosystem hidden state features and their potential for change.

- **Warning Intelligence.** The ability to classify and quantify state features, and project future states, further implies the ability to use those projections in the production of warning intelligence or general alerts. First, with the presence of patterns of spread, rhetorical structure, and state changes, comes the ability to detect breaks from expected patterns, or anomaly signaling. These anomalies can be prioritized and reviewed in ex post analysis to reveal and catalog new patterns, allowing for indications of phenomena which urgently require attention, such as swarm-behavior in political happenings, communications, harassment, censorship events, or organized activity. In addition, the ability to simply index content paired with the ability to classify and quantify state features means an ability to tag or "track" content.

Ecology already has robust methods for the tagging of animals, some of which are used to enable early warning and risk alert systems. Similar methods could help inform the translation of changes to state into relevant notifications and warnings [174].

- **Actionable Intelligence.** State features and context provided by hidden state analysis could generate intelligence products to improve decision-making around digital discourse in a number of ways. First, design and timing of content could be informed by the hidden states behind the claims dominating the environments they are intended to be deployed in. Second, if certain activities presented in warning intelligence require action, state features and hidden states can inform interventions. Finally, organizations whose decisions are meant to be informed by the interests of their constituencies can learn, through the tracking of claims, what those interests are, to increase the relevance of, and avoid negative externalities in, content deployments.

Dissemination

The final step of the cycle is the dissemination of intelligence products to stakeholders and decision-makers [102,104,113,119] and integration of those products into existing knowledge-bases for future use [96,119]. The various categories of individuals who would receive these intelligence products are often broadly referred to as “consumers" or “users” [104]. These intelligence products are traditionally written or oral reports intended to be periodically disseminated [148]. However, an insight which may be gleaned from ecological and ecology-adjacent forecasting is that when threats tend to be fast-moving or ongoing, and cannot be solved, only managed, intelligence needs to be consistently available, updated in real-time, and automatically disseminated and tailored based on expected need or upon request [59,175]. While the release of both periodical and non-periodical publications, newsletters, and briefings would be of value, they could not be relied on as the only method of dissemination to stakeholders.

> In addition to these static disseminations, intelligence products would have to be tailored and presented in several ways. First and foremost, would be automated and other on-demand reports, that could be made available when requested, on particular claims, clusters, or other queryable objects. The ability to have dissemination via notification would be significant as well, given that warning intelligence is, by its nature, emergent and non-periodic, and is therefore in need of a channel over which it can be provided to those to whom it would be most relevant. Further, who may need this warning intelligence can change greatly with context. For example, warning intelligence regarding purported foreign influence of memetic content would only become relevant to some users of pipeline outputs upon their viewing of that content. Thus, intelligence would also have to be made available upon encounter. On-encounter dissemination could also be useful in terms of actionable intelligence, to help facilitate interventions, or, in terms of estimative intelligence and research intelligence, to allow analysts to use the content in front of them to direct the exploratory search of the existing corpus in developing new intelligence products, or to allow contributors during the processing and evaluation phase to better understand how to perform classification. Finally, given the rate of change in digital discourse, the ability to watch intelligence update in real time becomes essential. This type of real-time analysis of large volumes of digital discourse would be useful for a range of individuals, for example, public health officials observing the dynamics of public sentiment and impact of government messaging [81].

Toward a Meme SCADA

With these requirements in mind, there is one approach in particular which presents the affordances and flexibility necessary to handle all of the challenges posed by the production cycle discussed above: the use of dashboard-based SCADA (Supervisory, Control, and Data Acquisition) systems. SCADAs are used to supervise state, acquire data from remote sensors, and control operations in real time [176]. While SCADA systems were traditionally intended for use in industrial operations, approaches from this area of research and application have recently gained traction in ecology [177,178]. Framing image meme analysis pipeline as part of a SCADA infrastructure is potentially the most practical approach for two primary reasons. First, SCADA infrastructure is built with real-time

use in mind and designed to facilitate the production of dashboard-like presentations of multimodal data and hidden states which are often difficult to communicate. Second, SCADA infrastructure design methodologies assume the need to collect and aggregate data from myriad sensors, and help inform information fusion protocols needed to generate forecasts, estimates, and current state features in real-time. In the case of the meme-analysis pipeline, supervisory and data acquisition features would be most prominent, though control features might be expressed in the form of prioritizations for users performing classifications and collections (such as during political happenings or swarm-behavior events), and in the form of explicit direction of automated collections and classifications. Here we present the rough blueprint of a meme analysis pipeline built in the style of an ecological or industrial SCADA system, from the requirements and outputs discussed within the previous section (see Figures 11 and 12).

Figure 11 shows the process by which artifacts (image memes) are collected, processed, analyzed, and disseminated. It begins with automated and manual collections of artifacts being given standardized annotations related to the location, structure (data type), and impact of the item. Next, these yet-to-be-processed artifacts are placed into a buffer; experts, average users, and automated features select artifacts from this buffer to identify their (i) statistically or quantitatively derived attributes and classifications, (ii) featured entities, (iii) claims, and rhetorical structure. The artifacts are annotated with these classifications using rhetorical and format annotation standards before being placed into an indexed and queryable catalog. Automated features and experts can draw from this catalog to perform analyses offered through a dashboard system for dissemination and monitoring. In addition, developers could use the catalog for training and test data in the development of new automated features. Finally, experts can make requests through the dashboard for prioritizations on manual collections and could direct the prioritization of automated collections (e.g., on certain kinds of content or from specific communities). Figure 12 shows the various forms of analysis and products which should be made available both through the dashboard and otherwise.

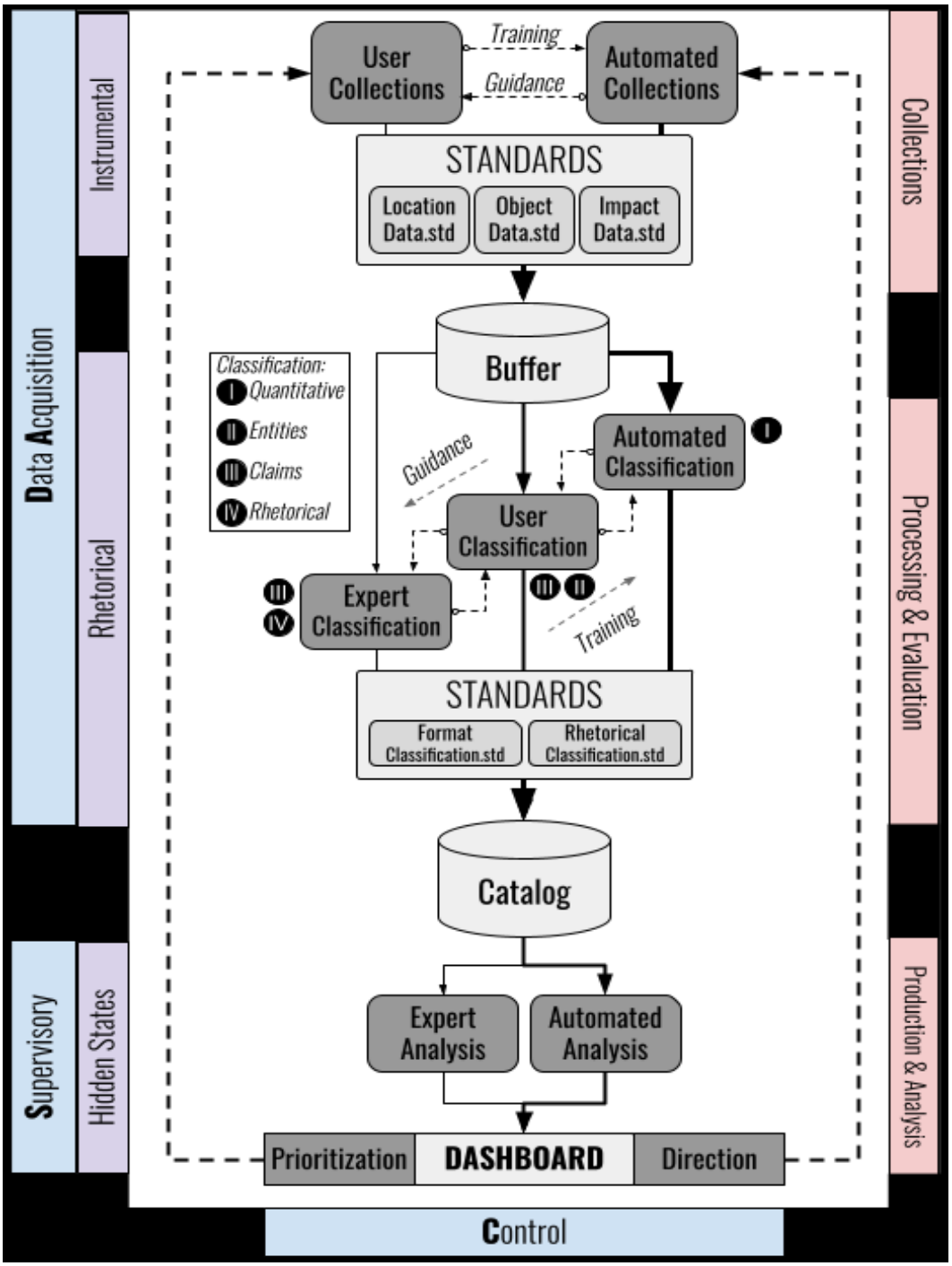

Figure 11. A rough blueprint of a meme-analysis pipeline. Color is used to indicate areas of the pipeline related to specific aspects of SCADA systems (blue), DRE3 analysis layers (purple), and intelligence analysis stages (red). The blueprint shows the various steps of content collection, processing, and analysis leading to the management of final intelligence products within a dashboard.

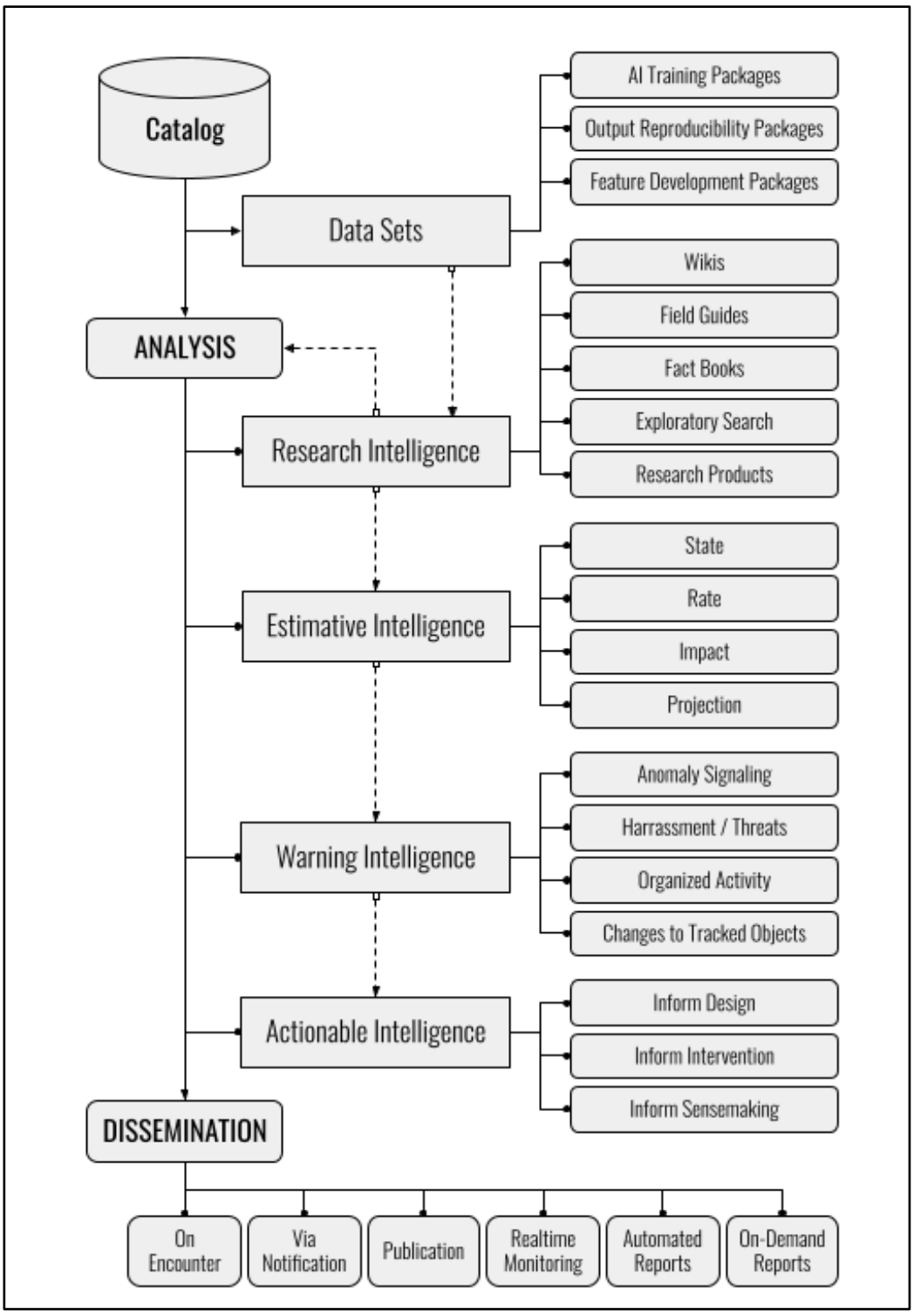

Figure 12. A map of desired outputs from a meme-analysis pipeline.

VI. Discussion

In this paper, we have reviewed the relevance of rhetorical and ecological approaches for analyzing multimedia digital discourse, such as shareable image memes. While rhetorical analysis captures the nuanced relationships between artifacts and audiences, ecological analysis captures the complex relationships among organisms and their niche. Others have explored similarities between the fields of ecology and rhetoric [37,179]. We have elaborated this connection through three key themes from modern ecology: the multilevel systems perspective, antifragility, and ecosystem services. These key themes integrated into the Digital Rhetorical Ecosystem three-tier (DRE3) model, providing a framework for incorporating rhetoric into computational pipelines for analyzing digital discourse, with ecological toolkits and frameworks as intermediaries. In addition to the transfer of concepts used in ecology into the digital discourse space and specific implications for SCADA design, here we conclude by exploring some broader implications.

We go so far as to hypothesize that a disruption or correction of narratives forged through memetic circulation needs to adopt the memetic form itself, sometimes known as a counter-meme [180]. We advocate re-deploying the memetic form to interrupt the credibility of a specific meme argument by illustrating why the claim advanced by the original meme does not rest soundly on the evidence or the warrants (assumptions) signaled explicitly or implicitly within the meme. Current efforts to fact-check memes address memes with a different genre of rebuttal discourse (e.g., the Facebook fact-check box that often links to news articles of official credibility). Digital audiences that have become vulnerable to the influence of memetic argument have also grown a staunch resistance to this particular form of fact-checking. Therefore, we argue that any attempt to neutralize memetically constructed narratives needs to understand the rhetorical power encoded within the memetic form and to use that form strategically to restructure public discourse. We urge, however, that counter-memetic efforts acknowledge the conditions of cognitive complexity endemic to digital knowledge environments and avoid the pitfalls of easy fact/fiction dichotomy for issues that are murky, complex, or ambiguous. Counter-memetic strategy should expose how memes mistakenly create narratives of certainty in the face of situational ambiguity and complexity. That is, counter memes should avoid making new issue-based arguments themselves, and instead reveal the argument weaknesses in memes deployed to advance public argument. Simply put, memes can be used to

demonstrate the argument weaknesses of memes. The repeated circulation of rebuttal memes to demonstrate the inferiority of memetic argument has potential to eventually decelerate reliance on the memetic form in public discourse. In addition, asking users to identify claims embedded within image memes during the stage of data processing and evaluation (Figure 11), could induce a more critical or meta-cognitive engagement with the memetic content and its deficits.

Rhetorical analysis has traditionally focused on single cases. Advances in computational technology provide the possibility of scaling up rhetorical analysis, for at least certain kinds of artifacts, such as image memes. Such high-throughput automated possibilities are evident in AI software such as Project Debater [181] and SwarmCheck [182] which can make sense of voluminous amounts of argument data using argumentation principles. The integration of rhetorical analysis with ecosystem tracking into a SCADA can enrich the field of rhetorical study by growing data-driven rhetorical theory. In 1969, Chaim Perelman and Lucy Olbrechts Tyteca published the influential New Rhetoric—a comprehensive compendium of argument strategies that relied not on formal logic but on everyday rhetorical practices [183]. Their catalog was built upon meticulous collection and analysis of real specimens of persuasion. Likewise, with the building of the proposed SCADA, we have the possibility of identifying and cataloging argument patterns across large amounts of image meme data, in a partially-automated fashion. The incidental value to argumentation theory of tracking the emergence, interaction, proliferation, and demise of image memes through discursive ecosystems is significant. We can determine whether argument patterns in image memes replicate documented argument patterns or assemble new ones. We can assess whether the unique genre of the image meme privileges certain argument patterns over others. An over-reliance on certain argument patterns (like argument by exposing hypocrisy [17]) may signal epistemic trends that are being exploited in the digital public sphere because they make minimal attention demands. When audiences are conditioned to argue in certain ways, their receptivity to other argument patterns that demand more central processing may diminish. We may observe at scale, with the intelligence that emerges from the SCADA, that one significant answer to the epistemic crisis we are currently battling is to understand the problem not just through a content framework (e.g., the fake news-real news dichotomy) but rather to problematize the medium, in this case the rhetorical form of the image meme, as one of the primary drivers of the crisis.

Another way to address the crisis is by examining ethical frameworks for managing a resource commons. In ecological philosophy, the "land ethic" [184] captures a sense of duty and responsibility towards ecosystem interactions. In the eponymous book, Aldo Leopold contrasted the land ethic with alternative frameworks that might be used to guide decisions around resource use, such as economic valuation, pragmatic use, and libertarian or egalitarian ideology. The land ethic serves as a conceptual nexus that integrates actors with different interests, and bridges world knowledge traditions. The application of a land ethic to online spaces might help ground otherwise-abstract digital communities and give a framework for service through deep time to these spaces. The ecological land ethic begins from a scientific foundation, then introduces insights from psychology and philosophy to characterize the nature of proper human-ecosystem relationships. In the case of a digital commons ethic, the system is physically grounded in the software and hardware that are the enabling architecture of the online platform. Framing an empirical (computational) basis as a starting point for studying online discourse could allow a "rhetorical commons" ethic to emerge, as driven and structured by psychological and ethical preferences.

Approaches to collective governance of ecological and resource commons have also integrated the economic insights of Elinor Ostrom and others [185]. As with these ecological commons, digital governance and economic systems could be designed with specified functions, performance metrics, and a stated collective purpose [186]. This model of "digital commons as public good" has already been applied to online communities [187,188]. Connecting the notion of "rhetorical commons" to the economic game theoretic setting of the "tragedy of the commons" helps connect the behavior of users, to outcomes at the level of the commons [189].

Conclusions and Recommendations

Can an ecological framework layered on rhetorical analysis help bridge the world of meaning and the capacities of computational pipelines? The ongoing and changing nature of the epistemic crisis requires new technological approaches towards scaling the modeling and understanding of our rhetorical commons. Here we expanded on previous appeals to rhetorical ecology and observations of the fundamental similarities between these fields [37], to posit the foundation for a type of system which might be able to infer, model, and intervene in multimedia digital discourse. With such a system, it could be possible to move beyond syntactic and user-driven understandings of digital discourse, to better observe and codify

cycles and patterns within it, and to make progress towards ecologically-framed platform policies which can be more clearly informed by social preferences and values.

Recommendations:

- Review best practices in improving information quality of crowdsourced subject-matter tagging in physical, digital, and rhetorical ecosystem contexts.
- Review and synthesize research on argument mining methodologies using crowdsourced annotations.
- Research the implementation and limitations of applications and web extensions for providing lenses (e.g., enriched augmented views of an object) on content displayed on various electronic devices.
- Curate a list of qualitative and quantitative patterns in the rhetorical structure and use of image memes.
- Consider users a part of an information commons rather than simply affected by an information system in future work on misinformation dynamics.
- Ensure that the identity, privacy, and preferences of users are protected in rhetorical cataloging schemes.

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