RESOLVE
NETWORK

Violent Extremist & REMVE Online Ecosystems:

Ecological Characteristics for Future Research & Conceptualization

Jade Hutchinson, Julian Droogan,

Lise Waldek, & Brian Ballsun-Stanton

ACKNOWLEDGEMENTS

https://doi.org/10.37805/remve2022.5

CONTENTS

INTRODUCTION

The term "ecosystem" and a wider set of related ecological concepts have increasingly been adapted for use in discussions of terrorist and violent extremist networks and activities, using, for example "evolution", "ecology", and "adaptation" to describe both online and offline spaces as well as the violent extremist dynamics that occur within them. For example, ecological approaches in terrorism studies have been employed in the past to understand the development of acts of political violence from a combination of disparate factors;[1] as a framework to classify a hierarchy of causal systems and to examine the co-creative process of terrorists with their environment;[2] and, more recently, to understand how extremist communities and terrorist groups interacted with and were influenced by social media and technology.[3] In the online context, specifically, ecological language has been utilized to connote a bewildering sense of complexity and dynamism in interactions, activities, and connections.[4]

The study of online cross-platform violent extremist ecosystems has notably increased in recent years. Following the successful adoption of social media by the Islamic State (IS),[5] quickly emulated by racially and ethnically motivated violent extremists (REMVE) such as the Christchurch attacker, major technological companies increased their efforts at content regulation and the deplatforming of extremists.[6] One effect was to further decentralized already distributed online REMVE communities across multiple platforms and to incentivize them to use these many platforms in increasingly strategic ways.[7] The subsequent growth in studies drawing on ecological concepts to explore online dynamics has provided the opportunity for a systematic review of how scholars and practitioners use ecology and ecological characteristics, and the benefits and limitation these afford. There is utility in creating a shared vocabulary and frames of reference for researchers and practitioners concerned with online violent extremism. A shared vocabulary of ecological terms and processes will help provide a conceptual map used to aid in the understanding and prevention of online violent extremism.

---

1   See, for example: Stephane J. Baele, Lewys Brace, and Travis G. Coan, "Uncovering the Far-Right Online Ecosystem: An Analytical Framework and Research Agenda," *Studies in Conflict & Terrorism* (2020): 1–21. https://doi.org/10.1080/1057610X.2020.1862895; D. V. Segre and J. H. Adler, "The Ecology of Terrorism," *Survival* 15, no. 4 (1973): 178–83, https://doi.org/10.1080/00396337308441412.

2   See, for example: Gerard Sevan, "A Proposed Cosmology of Identity in The Sociotechnical Ecosystem of Homeland Security," *Homeland Security Affairs (blog)*, December 1, 2017, https://www.hsaj.org/articles/14400; Noémie Bouhana, *The Moral Ecology of Extremism: A Systemic Perspective* (London: Commission for Countering Extremism, 2019).

3   See, for example: N. F. Johnson, et al. "New Online Ecology of Adversarial Aggregates: ISIS and Beyond," *Science* 352, no. 6292 (2016): 1459–63, https://doi.org/10.1126/science.aaf0675; Stuart Macdonald, Daniel Grinnell, Anina Kinzel, and Nuria Lorenzo-Dus, "Daesh, Twitter and the Social Media Ecosystem: A Study of Outlinks Contained in Tweets Mentioning Rumiyah," *The RUSI Journal* 164, no. 4 (2019) 60–72, https://doi.org/10.1080/03071847.2019.1644775;.

4   There is little consistency in the application of the term ecosystem in REMVE studies, reducing the potential utility it offers as a tool of investigation.

5   Clifford and Powell, *Encrypted Extremism*.

6   Maura Conway, "Why Deplatforming the Extreme Right Is a Lot More Challenging than Deplatforming IS," *GNET (blog)*, January 15, 2021, https://gnet-research.org/2021/01/15/why-deplatforming-the-extreme-right-is-a-lot-more-challenging-than-deplatforming-is/.

7   See, for example: Manuela Caiani, "Radical Right Cross-National Links and International Cooperation," in *The Oxford Handbook of the Radical Right*, ed. Jens Rydgren (Oxford University Press, 2018), 394–411, https://doi.org/10.1093/oxfordhb/9780190274559.013.20; Jade Hutchinson, "Far-Right Terrorism: The Christchurch Attack and Potential Implications on the Asia Pacific Landscape," *Counter Terrorist Trends and Analyses* 11, no. 6 (2019): 19–28).

Despite this increasing focus on violent extremist ecosystems in the online sphere, it is unclear the extent to which ecological terms in literature on extremism—and particularly literature focused on the online space—are empirically validated or even consistently used. Indeed, there remain fundamental gaps in understanding and defining what we mean when we discuss the ecology of violent extremism and online violent extremist ecosystems. These gaps have notable implications for defining what an online ecosystem actually is—including its characteristics, impact, scope, and reach—and identifying appropriate policy responses to address them.   This is of particular importance in the context of the growing volume of studies looking at REMVE communities online and across multiple platforms.

Based on findings from a structured literature review examining the use of terms "ecosystem" and "ecology" in terrorism and violent extremism studies and related disciplines, this research brief presents a list of ten ecological characteristics for further consideration by those working in research, policy, and practice focused on online violent extremist ecosystems. Brief examples are provided of how these characteristics might be conceptualized in research into REMVE online ecosystems, given the increased attention REMVE online ecosystems have garnered in recent years.

This review of the literature indicates that the concepts and terms "ecosystem" and "ecology" have potential, if limited, analytical utility for policymakers and academics, beyond their descriptive and currently largely metaphorical use in the literature. Despite the clear limitations which accompany the translation of natural science terminology into terrorism and violent extremism studies, certain characteristics of ecosystems may present specific analytical perspectives useful to those seeking to address or study terrorism and violent extremism online. For instance, although digital environments are not true ecological systems in the biological sense, delineating and defining conceptual components of an ecosystem may provide a shared conception when used to describe how extremist violence emerges from online environments, or when used to interpret these descriptions in a policy and practice setting. Descriptive definitions and the proposed advantages and limitations of using characteristics related to ecosystems are addressed in the following sections.

ECOSYSTEMS: FROM BIOLOGICAL STUDIES TO THE SOCIAL SCIENCES & TERRORISM STUDIES

The term ecosystem was originally coined in the field of ecology, the branch of the biological sciences investigating how organisms relate to one another and to their surroundings. In biology, ecosystem is used to describe how organisms and their environment interact together as a holistic community. Scientists break the term down into component processes that are understood to structure how ecosystems work. For instance, processes of "evolution" and "self-organization" are factors essential to biological ecosystems, and these can be examined to better understand, model, or map how an ecosystem operates as whole. An ecosystem is understood through the interaction of these process to form a larger system that is highly dynamic and complex.

Defining "Ecosystems" and "Ecology"

The terms "ecosystem" and "ecology", used in their original context, denote the relationships between communities of organisms and their surrounding environment. Therefore, in this literature review, we borrow from the original biological lexicon to summarize findings from the research in a consistent manner. Ecology, therefore, is a classification system that encompasses both existing and emergent networks of human and non-human things. An ecosystem is one aspect of a larger ecology: itself containing a hierarchy of systems comprising networks of human and non-human things. Therefore, an ecological approach to understanding violent extremists is the examination of users, their sociotechnical networks within a hierarchy of systems, their user experiences within these networks, and how these systems develop from internal and external pressures.

Outside of the natural sciences, the term ecosystem has come to refer more broadly to any complex and interconnected system or network, i.e., a "social ecosystem". In this sense, ecosystem is used in a popular and simplified fashion. In the context of the internet and social media, for example, the terms ecosystem and ecology most often refer to the interactions of organisms (people) within technological surroundings (digital structures such as social media platforms), and how these elements influence one another to create a complex and dynamic whole.

Importantly, and in contrast to the natural sciences, the social sciences do not generally use ecological concepts in an analytical fashion. Instead, ecosystem becomes a way of describing any complex system consisting of many parts, rather than a theoretical framework for analyzing and understanding this complex whole and the interaction of its parts in any rigorous manner, or in a way that could provide testable hypotheses for empirical research.

While this does not negate the utility of the term or use of metaphor in social sciences or in terrorism studies, it does pose questions around how and when it is used, whether it is defined in a similar manner, and whether it can be better operationalized to further our understanding of online violent extremist inputs, interactions, and development.

To scope out how "ecosystem" as it relates to violent extremist populations and movements has been utilized, and areas for further exploration, the term, and those associated with it, was tracked across three distinctive bodies of academic scholarship: terrorism studies, including online violent extremism studies; media and communications; and, in a more limited fashion, ecology and the natural sciences. The aim was to understand foundational issues related to online violent extremist ecosystems, including:

- When and where this concept first appeared in the academic literature;

- Why the concept was adopted;

- Whether it was transmitted from another discipline such as media studies;

- The nature and limits of how this concept has been used to understand both offline and online extremists; and;

- Points of departure from which online violent extremist ecosystems can be examined in a rigorous, analytical, and empirical manner.

The literature was drawn from across a range of disciplines including terrorism studies, media and communications studies, computing, and the natural sciences. Further information regarding the literature review strategy and methods is presented in Appendix One, and a complete set of all sources is presented in Appendix Two. Based on this review, this brief presents ten promising characteristics for further exploration, definition, and nuance in the study of violent extremist online ecosystems.

CONCEPTUALIZING ONLINE VIOLENT EXTREMIST ECOSYSTEMS: 10 CHARACTERISTICS FOR CONSIDERATION & DEFINITIONAL CLARITY

While there are limits to adopting biological models from the natural sciences to understand the complexities of human social and technological systems, ten characteristics as identified in the literature may offer further insights into how online ecosystems work and are fashioned, and what this means for the populations who form a component of their whole. Any application of these concepts to online violent extremism studies does not depend on online ecosystems perfectly mimicking biological systems—which they do not. The internet is structured by human design and agency, not impersonal natural laws. However, online technology has become so vast and complex as to ostensibly resemble a product of evolution and mimic processes of biology. The vast number of discrete human actions and decisions that collectively contribute to digital media platforms can be considered a biological system in themselves.

Therefore, these ecosystem characteristics do provide useful conceptual points of departure and definitional clarification for academics and policy makers concerned with online violent extremist communi-

ties, allowing them to begin to examine how these complex environments might operate, the forces that shape them, and opportunities for further study in a practical way to reach desired outcomes. Accordingly, this publication focuses on clarifying the descriptive definitions of the ten characteristics and highlighting their limitations as a basis for further study, validation, and conceptual analysis. It does this in four ways, providing a basis to create shared vocabulary, apply different lenses to understanding violent extremism online, and adopt and adapt methods from other fields to better analyze and assess the phenomenon:

First, by breaking the concept of ecosystem down into discrete characteristics that are conceivably open to measurement, clarifying these characteristics can provide analytical rigor to future studies of online violent extremist populations. Rather than using ecosystem as a useful descriptive indicator for complexity, a consideration of the ten characteristics provides a starting place for applying an ecological approach in an analytical manner to better reveal how violent extremist populations operate online.

Second, further clarification of each of these characteristics could inform the development of a model for exploring multiway processes that shape violent extremist movements online. Rather than simply considering what people do online, or how the online architecture shapes people, concepts such as adaptation, evolution, and non-linear behavior (as discussed below) may allow researchers to clarify the processes in which online social movements and social media architectures are to some degree co-created. This ability to explore violent extremist movements, or even acts of online violence, as interactions between people and their digital environments may provide insight into how to apply more targeted intervention strategies.

Third, the characteristics identified provide a proposed shared vocabulary for researchers and practitioners operating in the online violent extremist space. The study of online violent extremist movements is continuously changing in step with the dramatic pace and nature of events that have occurred in this space over the last decade. Indeed, global challenges such as the wave of Islamic State using social media and the rapid emergence and growth of REMVE online, have meant that the field has by necessity been largely reactive to fast-paced events, even crises. As a relatively new field of study, however, a shared vocabulary may help provide a conceptual map of the landscape to aid proactive approaches to understand and prevent online violent extremism. This series of clarifications around definitional clarity and their operational potential represent a review of current thinking and starting place for further thinking and research that could be developed into a common analytical structure and/or language.

Fourth, a more analytical exploration of online ecosystems may provide opportunities to better understand the origins and formation of violent extremist populations, as well as how they adapt to change. Ecosystem ecology focuses on a set of systems that are inherently dynamic. It is therefore focused—at base—on change, even if this change may lead to self-organizing systems and new homeostasis. By applying concepts taken from the biological sciences to online systems, researchers may be better able to ascertain how online violent extremist populations change and adapt to disruptions in their environments. Again, it is important to stress that it is highly unlikely that concepts taken from the natural world will be perfectly suited to studies of socio-technical systems, and that there is a dan-

ger of adopting a naturalistic fallacy. Instead, testing characteristics such those detailed below in the online space will contribute to a common analytical structure and/or language for mapping and modeling changes in that space.

With these possible benefits in mind, Figure 1 illustrates ten characteristics identified within the literature review as component processes that contribute to the formation of a holistic ecosystem. It should be noted that the ten characteristics identified and delineated below are not a definitive list of all characteristics that are considered to contribute to ecosystems in the natural sciences. Instead, we have selected ten that were most prevalently cited in the terrorism and media and communications literature relating to online systems. In the following section, each of the ten characteristics is defined, described in more detail, and considered in relation to its potential utility. Each section also includes a text box explaining how each term has been utilized in related fields—computer sciences, media studies, and communication studies. While these characteristics can be applied to all forms of violent extremism online, given the heightened interest and greater attention to online REMVE ecosystems over the past few years, each section also includes a brief analysis of the relevance of these characteristics for research, policy, and practice in this space.

Four of these ten characteristics (network, dynamism, classification, and complexity) can be considered to be foundational, and are highlighted to a greater extent as they serve as a necessary foundation for the later, more complex characteristics listed (adaptation, self-organization, evolution, swarm intelligence, non-linear behavior, and emergence). Further explanation of each characteristic, its use in terrorism or violent extremism literature, and potential areas for further validation are detailed in the subsections below.

Figure 1. 10 Characteristics of Online Violent Extremist Ecosystems for Further Study
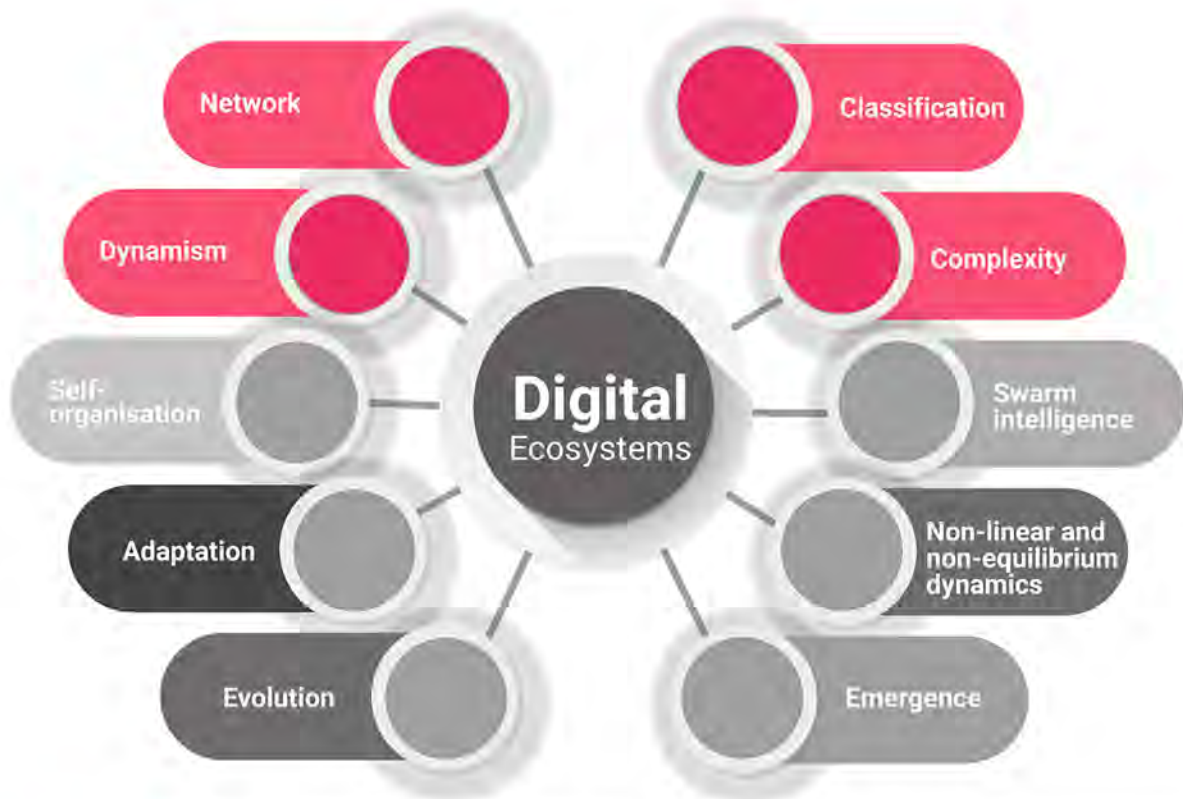
• **Network:** Interconnective characteristics that define the structure of interacting and connected phenomena, including but not limited to agents, environments, relationships, and entities.

• **Dynamism:** State of continuous change and disturbance necessitating adaptive behaviors and resilience to survive.

• **Classification:** Mechanism for identifying and categorizing elements within an ecosystem and relationships between them.

• **Complexity:** Divergent, interactive, and at times unknown variables functioning within an ecosystem.

• **Self-organisation:** Self-formed functionality or organization towards an ordered stability.

• **Adaptation:** Short term changes or variables that increase an element's suitability to their environment and chances of survival.

• **Evolution:** Accumulated changes and adaptations that inform the mutual development of organisms and environments over time.

• **Swarm intelligence:** Phenomena wherein a group acts in synchronization without pre-planning,

• **Non-linear and non-equilibrium dynamics:** Scenarios in which outputs are not directly proportional to inputs.

• **Emergence:** Properties that arise because of the interaction between components of a system that would not otherwise emerge on their own.

1 Networks
Interconnectivity and Stability

A network, at its simplest, refers to a series of interconnected things, including but not limited to agents, environments, relationships, and entities. In ecological terms, it refers to visible and invisible component parts, relationships, and interactions that together generate an ecosystem. Mapping networks within an ecosystem enables researchers to understand the ways and degrees to which agents and environments are related, as well as the nature of their relationship.

Social media platforms consist of networks made up of users, links, and actions. Users may use multiple social media platforms, creating a yet greater network-of-networks, often using hyperlinks to bridge these. Figure 2 illustrates the concept of "network" using six social media platforms, Facebook, Gab, Reddit, Twitter, 8chan/8kun, and 4chan. The illustration emphasizes the platforms' interconnection and interaction in the online environment both in terms of communications seen and sent between users inside a given platform and use across multiple platforms.

Figure 2: Networks
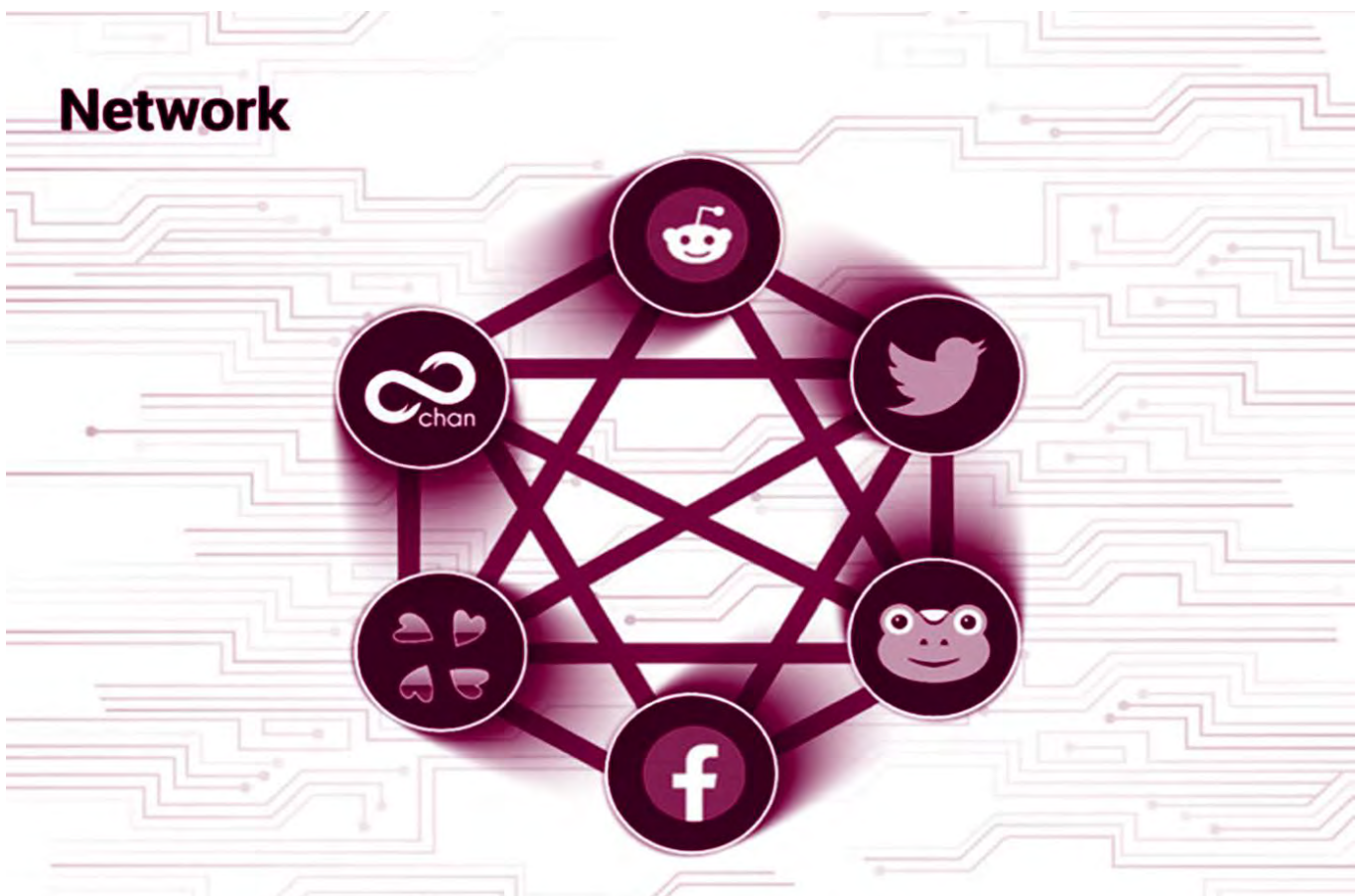
Terrorism and online extremism scholarship tend to utilize the term "network" as a framing mechanism to understand the interactive nature of a set of component parts. For example, network can be used to frame the power relationships operating between members of extremist communities, criminal networks, or terrorist groups. Research into online violent extremism has highlighted the interconnected, interactive, fleeting, and dispersed characteristics of extremist networks operating within social media environments.[8] Networks have also been used to examine the flow of extremist discourse and ideology through a digital media ecosystem.[9]

> ## "Networks" in Other Fields[10]
>
> In the media, communications, and computer science literature, the term "multi-actor" or "multi-agent" network is used to characterize the complex, non-linear nature of a digital media ecosystem as users' social interactions are facilitated by multiple platforms. These multi-actor systems are made up of users' participation, interaction, and content on multiple platforms.

While network analysis has been part of the academic toolkit for some time (for example through social network analysis in terrorism studies or actor-network theory in media and communication studies), applying ecological network analysis to online violent extremist studies offers novel opportunities.[11] By moving the focus away from a platform-specific approach to characterizing a network as patterns of activity across platforms and over time, researchers can apply "stable" or "unstable" judgements to violent extremist communications.[12] In modelling populations of users across multiple platforms, research-

---

8   For example: Baele, Brace, and Coan, "Uncovering the Far-Right Online Ecosystem."

9   Baele, Brace, and Coan, "Uncovering the Far-Right Online Ecosystem"; Conway, Khawaja, Lakhani, and Reffin, "A Snapshot of the Syrian Jihadi Online Ecology"; Conway, Khawaja, Lakhani, Reffin, Robertson, and Weir, "Disrupting Daesh"; Johnson, et al., "Hidden Resilience and Adaptive Dynamics of the Global Online Hate Ecology"; Marcus Felson, *The Ecosystem for Organized Crime* (Helsinki: The European Institute for Crime Prevention and Control, 2006), http://old.heuni.fi/material/attachments/heuni/papers/6Ktmwqur9/HEUNI_papers_26.pdf; Department of Security Studies and Criminology, *Mapping Networks and Narratives of Online Right-Wing Extremists in New South Wales (Version 1.0.1)* (Sydney: Macquarie University), http://doi.org/10.5281/zenodo.4071472.

10   Information drawn from: Joseph B. Bayer, Penny Triệu, and Nicole B. Ellison, "Social Media Elements, Ecologies, and Effects," *Annual Review of Psychology* 71, no. 1 (2020): 471–97, https://doi.org/10.1146/annurev-psych-010419-050944; Merali, "Complexity and Information Systems"; Masaharu Tsujimoto, Yuya Kajikawa, Junichi Tomita, and Yoichi Matsumoto, "A Review of the Ecosystem Concept—Towards Coherent Ecosystem Design," *Technological Forecasting and Social Change* 136 (2018): 49–58, https://doi.org/10.1016/j.techfore.2017.06.032; Gerard Briscoe, "Digital Ecosystems" (PhD diss., Imperial College London, 2009), http://arxiv.org/abs/0909.3423; Gerard Briscoe, "Complex Adaptive Digital EcoSystems," in *MEDES '10: Proceedings of the International Conference on Management of Emergent Digital EcoSystems* (New York: Association for Computing Machinery, 2010), 39–46, https://doi.org/10.1145/1936254.1936262.

11   Bruno Latour, "Reassembling the Social: An Introduction to Actor Network Theory" (Oxford: Oxford University Press, 2005); Borum, "Radicalization into Violent Extremism I."

12   In computer science literature, networks are considered "stable" if the ecosystem has converged to an equilibrium distribution and if the system exhibits bounded behaviours, and "unstable" if not. For example, a user community is stable when it is self-sustaining and there

ers can develop an understanding of the drivers and patterns in particular online violent extremist networks, such as those associated with REMVE networks, with consequences for efforts to address them.

When discussing networks in this context, it is important to note that how we think about information systems has shifted from a "classical view" (characterized by hierarchy and top-down design) to a "network-in-use" system (characterized by bottom-up, decentralized, and therefore complex design and dynamics that complicate efforts to predict the network's future state).[13]

Socially situated information technologies like social media are more like network-in-use systems; where information is circulated in an informal and unbounded manner, and where administrators wield less control over how information is shared, how it evolves, or its social impact. While efforts to understand how these networks operate and what factors contribute to their stability may be possible, explanatory research as to how these networks will evolve and adapt in the broader ecosystem is significantly more difficult.

2 Dynamism
Agility and Continued Change

Dynamism is the ability to remain agile, resilient, and adaptive in response to disturbances. It is understood to be an important characteristic in the sustainability of a biological ecosystem, along with the concepts of self-organization, scalability, and sustainability.[14] Aided by dynamism, digital ecosystems survive and reproduce under constantly changing conditions and challenges. For instance, digital ecosystems evolve in relationship to a rapidly changing technological foundation and residing companies are therefore "forced to innovate in shorter cycles to remain competitive."[15]

---

are enough active users to experience positive social effects (e.g., exposure to novel content or affirmation of social group) to incentive users to continue using a set of platforms in a consistent way. A platform can be considered unstable when it has been colonized by spambots or offers little engaging content to keep consistent user activity. See the section in Annex Three on Networks for further citations and reading.

13 Classic information systems are characterized by a top-down design and a persistent hierarchy of organization embodied in a fixed set of relationships, where modularization is predicated on clearly defined boundaries and interfaces. In contrast, network-in-use systems are characterized by emergent, "bottom-up" dynamics and challenges, where complex connectivity and evolving information content within the network make it near impossible to predict the future state of the network. What is more, because certain networked structures and behaviors are rarely distinguished between a classic "top-down" paradigm and emergent "bottom-up" network dynamics, it can be difficult to clearly differentiate the two perspectives when applied. See, for example: Gohar Feroz Khan, "Social Media-Based Systems: An Emerging Area of Information Systems Research and Practice," *Scientometrics* 95 (2013): 159–80, https://doi.org/10.1007/s11192-012-0831-5.

14 Merali, "Complexity and Information Systems"; Briscoe, "Digital Ecosystems"; Briscoe, "Complex Adaptive Digital EcoSystems"; Wenbin Li, Youakim Badr, and Frédérique Biennier, "Digital Ecosystems: Challenges and Prospects," in *MEDES '12: Proceedings of the International Conference on Management of Emergent Digital EcoSystems* (New York: Association for Computing Machinery, 2012), https://doi.org/10.1145/2457276.2457297.

15 Franziska Götz, Christian Hamann, Christoph Buck, Severin Oesterle, Torsten Eymann, and Reinhard Meckl, *Dynamic Capabilities as the Key Approach to Investigate Digital Ecosystems* (Potsdam: 15th International Conference on Wirtschaftsinformatik, 2020), https://doi.org/10.30844/wi_2020_m5-goetz.

Figure 3, for example, illustrates the concept of "dynamism" using six social media platforms. The illustration emphasizes the platform and resident communities' ability to remain agile and resilient against disturbances. While the "network" diagram (Figure 2) illustrates data-and-user flows between platforms, dynamism (Figure 3) illustrates how content on one platform can drive engagement and activity on other platforms. Dynamism is expressed in many ways, one example being the increased use of bots to automatically repost a person's Twitter content on Gab, enabling the user to sidestep potential disruption on Twitter.

Figure 3: Dynamism

While considerations of dynamism have been limited in online terrorism studies, the concept is occasionally used to characterize how terrorists behave when online and how online extremist communities remain agile and resilient against disturbances.[16] For example, one study examined how dynamism enabled the so-called Islamic State to survive through self-organized and resilient online groupings.[17] Col-

---

16   Johnson, et al., "New Online Ecology of Adversarial Aggregates"; Baele, Brace, and Coan, "From 'Incel' to 'Saint'"; Baele, Brace, and Coan, "Uncovering the Far-Right Online Ecosystem."

17   Johnson, et al.,"New Online Ecology of Adversarial Aggregates."

lecting data that reflects users' dynamic experiences of multiple networks and the factors that enable dynamism within them poses significant difficulties—and the systematic examination of multi-network data sets across time remains in its early stages in terrorism and violent extremism studies. In part, this reflects the complexity of multi-platform data collection and the ethical constraints of undertaking this type of online social science research.

Our own experience in data collection on online REMVE ecosystems from 2019-2022 across multiple platforms has demonstrated the difficulties in gathering data appropriate to understand ecological dynamism in an online environment at scale.[18] Even researchers focusing on Twitter data at scale (millions of tweets) would find it very hard to understand it through the characteristic of dynamism because Twitter doesn't supply crucial data: impressions (views) and the ability to understand where a given tweet is shown to each specific user in Twitter's algorithmic timeline. In addition, researchers do not usually have access to the browsing history of individuals. Thus, we cannot model how user attention moves across platforms over time (e.g., following hyperlinks, leaving a comment on a different platform, and sharing a link).

Despite these difficulties, however, understanding dynamism and its sources in online violent extremist ecosystems remains important. Enablers of dynamism that provides violent extremists with the opportunity to adapt and take advantage of those enablers could be the subject of further study, with implications for our understanding of how to address them. For example, in studies of dynamism in REMVE online ecosystems, researchers may focus on how bots are used to automatically repost content hosted on mainstream social media platforms to platforms with less stringent regulations, such as Gab, to avoid disruption.

"Dynamism" in Other Fields[19]

The concept of dynamism has been extensively used by media, communication, and computer science scholars to describe complex systems. For instance, the term has been used to outline strategies capable of monitoring and managing multiple component processes simultaneously, like the time dependence of variables in a system. In computational systems, it relates to the profile of digital entities that are necessary for the system's sustainability but that constantly change over time.

---

18   See Brian Ballsun-Stanton, Lise Waldek, and Julian Droogan, *Mapping Networks and Narratives of Online Right-Wing Extremists in New South Wales* (NSW Department of Communities and Justice, 2020), https://zenodo.org/record/4005051.

19   Merali, "Complexity and Information Systems"; Briscoe, "Digital Ecosystems"; Briscoe, "Complex Adaptive Digital EcoSystems"; Li, Badr, and Biennier, "Digital Ecosystems."

3 Classification
Addressing Complexity Through Categorization

Classification is fundamental to understanding ecosystems in the natural sciences. In this context, it refers to a hierarchical system of categories and relationships among organisms, entities, and the environment. Figure 4 illustrates the concept of "classification" using six social media platforms, using platform moderation and echo chamber as classification categories. The illustration offers an example of how a classification framework reduces complexity and helps to establish structure, relationship, and ontology. User behaviors and the expected affordances of platforms may be classified into general groups which depend on a discreet set of platform's services, rather than the platform as a whole.

In the terrorism and extremism literature concerned with online ecosystems, the concept of classification has largely been used as a metaphor to identify socio-cultural and political factors that are considered contributing variables to terrorism.[20] There are also examples of scholars using ecosystem thinking and classification systems to identify trends in ideology and practice within the digital environment.[21] These studies are limited in number, with few studies using an ecosystem classification in online terrorism studies in any analytical manner.[22]

> ### "Classification" in Other Fields[23]
>
> Media and communications literature utilize classification systems to identify networked actors, social and technological environments, and to characterize the various drivers that compose digital, socio-technical, and media ecosystems. In computer science, the conceptualization of ecosystems as a classification system affords the opportunity to search for solutions to automated technical systems by emulating biological designs and processes.

---

20   Crenshaw, "The Causes of Terrorism"; Miller, "Eco-Epidemiology as Anti-Terrorism."
21   Baele, Brace, and Coan, "Uncovering the Far-Right Online Ecosystem"; Conway, et al., "A Snapshot of the Syrian Jihadi Online Ecology."
22   With few exceptions, such as: Baele, Brace, and Coan, "Uncovering the Far-Right Online Ecosystem."
23   Michael G. Jacobides, Carmelo Cennamo, and Annabelle Gawer, "Towards a Theory of Ecosystems," *Strategic Management Journal* 39, no. 8 (2018): 2255–76, https://doi.org/10.1002/smj.2904; Matthew M. Mars and Judith L. Bronstein, "The Promise of the Organizational Ecosystem Metaphor: An Argument for Biological Rigor," *Journal of Management Inquiry* 27, no. 4 (2018): 382–91, https://doi.org/10.1177/1056492617706546; Briscoe, "Digital Ecosystems"; Li, Badr, and Biennier, "Digital Ecosystems."

Ecosystem thinking allows greater scope to reflect on what types of classification thinking we adopt and why, and its utility when answering specific research questions across platforms. A complex environment such as an online ecosystem, comprised of multiple networks and characteristics, can be potentially classified in numerous ways—for instance by users, content type, interaction and so on. For example, the diagram presented in Figure 4 shows the classification of two spectrums—"strength of violent extremist echo chamber" and "level of platform moderation"—across a series of far-right extrem-ist social media accounts, providing a basis for cross-platform comparison.

Figure 4: Classification
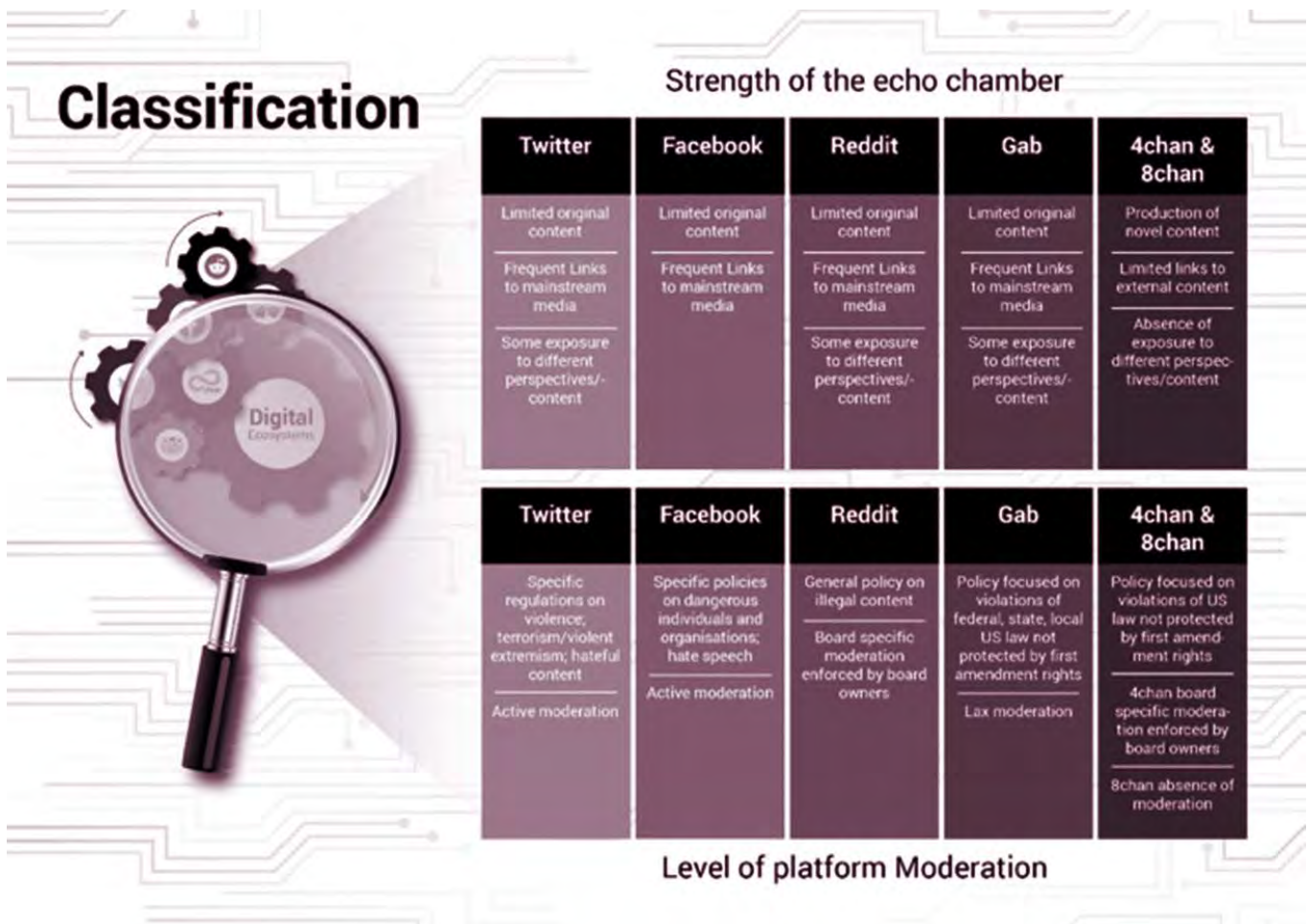
Classification systems are longstanding tools used in social science research. An ecological use of classification gives researchers the means to manage complexity while sorting networked and emergent components into manageable, analyzable parts within a specific field or on the same topic. For instance, when applied to digital environments supportive of REMVE extremist content and communities, an ecological approach seeks to build consistent schemes of classification designed to account for a technological foundation, that in its pace of evolution defies existing systems of classification. However, classification schemes related to REMVE content would need to be agreed on and applied consistently, as different classification systems are designed to meet different needs. For example, classifications related to the level of platform moderation may not be useful for efforts to understand and address questions associated with the stability of a particular network or popularity of specific content. For research informing policy and practice aimed at addressing online violent extremist ecosystems, classification structures should be tailored accordingly. For research informing policy and practice on online REMVE ecosystems, for example, it is particularly important to develop and delineate definitional classification structures based on levels of violence in online rhetoric and content. Such classification structures can help delineate between far right versus REMVE content, particularly in exploratory research, with important implications for policy responses.
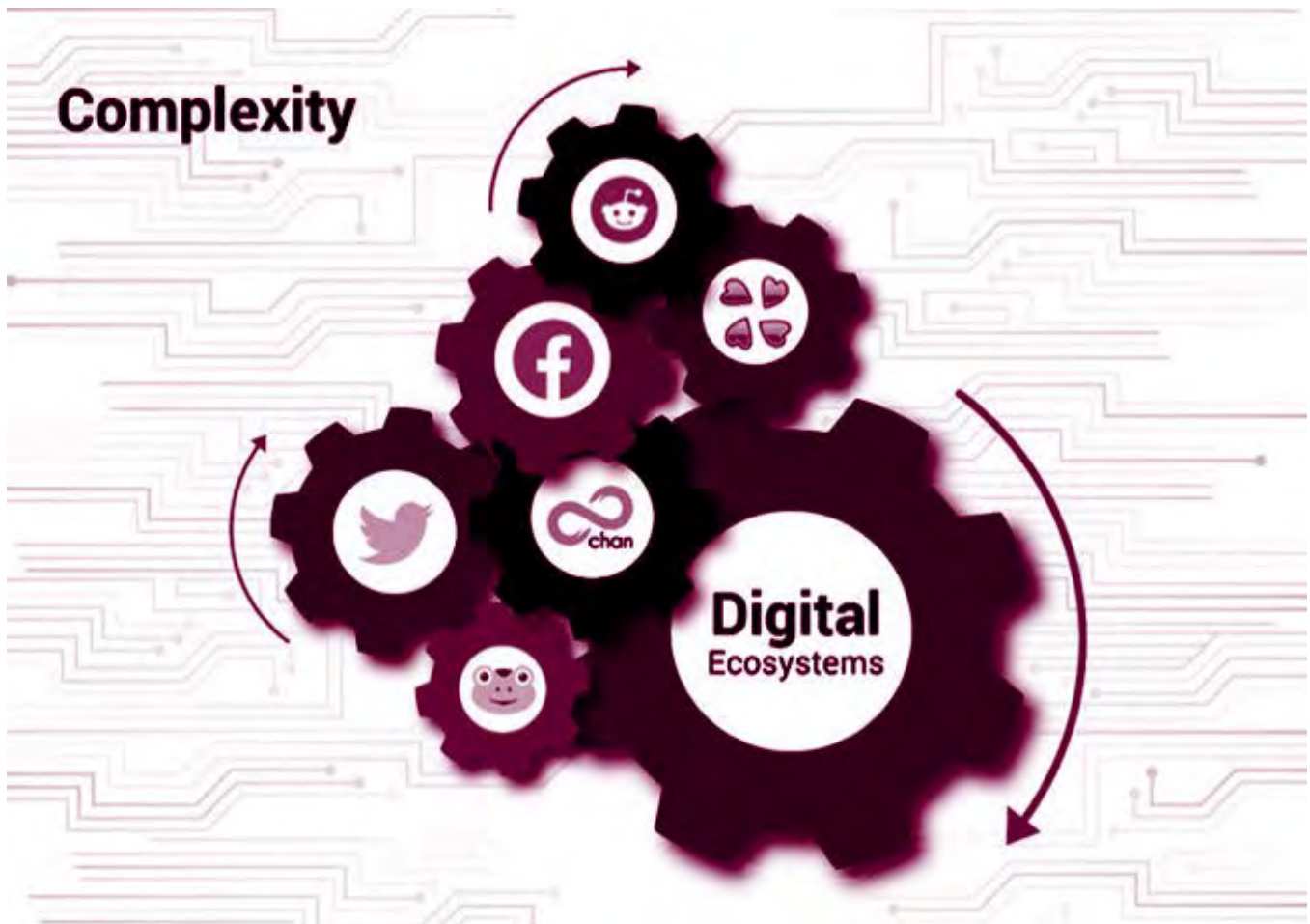
4 Complexity
Non-linearity, Heterogeneity, & Continued Evolution

Complexity emerges from the self-organizing and heterogeneous networks of interacting and evolving actors. Theories of complexity originate from within the natural sciences where the term is used to understand the non-equilibrium mechanics and non-linear dynamics of systems, networks, and ecosystems (discussed below in further detail).[24] Complexity is a challenging phenomenon to study, particularly in research endeavors that observe static samples taken from a subsection of a broader digital ecosystem. For instance, the information derived from a subset of tweets may be illustrative of a certain population on Twitter, but their examination can not necessarily account for other factors or dynamics that may be influencing or have influenced them.

Figure 5 illustrates the concept of "complexity" using six social media platforms. The illustration emphasizes the platforms' interactive, dynamic, and heterogeneous qualities. Policy, advertising, media-mentions, funding models, and downtime on one platform may change user behaviors on other platforms in unexpected fashion.

---

24   Andrew P. Vayda and Bonnie J. McCay, "New Directions in Ecology and Ecological Anthropology," *Annual Review of Anthropology* 4, no. 1 (1975): 293–306, https://doi.org/10.1146/annurev.an.04.100175.001453; Jeremy Walker and Melinda Cooper, "Genealogies of Resilience: From Systems Ecology to the Political Economy of Crisis Adaptation," *Security Dialogue* 42, no.2 (2011): 143–60, https://doi.org/10.1177/0967010611399616.

Figure 5: Complexity

Currently, the concept of complexity as it relates to online ecosystems features only rarely in the terror-ism and online extremism literature—for instance, featuring as a descriptor of social and cognitive psy-chological systems or as an emergent quality of information or socio-technical systems.[25] For instance, Bronfenbrenner's ecological theory and psychological models have been used to better understand the emergent sociocognitive conditions that favor terrorism.[26] However, a complex system exhibits "emer-gent" behavior (discussed further below); meaning that it is not possible to predict all the eventual states of a system from first principles. This means that, like network-in-use systems (discussed above), a com-plex system can end up doing, performing, or being something completely unexpected from the point at which it was initially observed.

---

25   Segre and Adler, "The Ecology of Terrorism"; Locicero and Sinclair, "Terrorism and Terrorist Leaders"; Max Taylor, "Criminogenic Qualities of the Internet," *Dynamics of Asymmetric Conflict* 8, (2015): 97–106, https://doi.org/10.1080/17467586.2015.1065082; Maura Conway, "Routing the Extreme Right," *The RUSI Journal* 165, no. 1 (2020): 108–13, https://doi.org/10.1080/03071847.2020.1727157; Maura Conway, "Determining the Role of the Internet in Right-Wing Extremism and Terrorism: Six Suggestions for Progressing Research," Pre-sentation, The Avert Network: Online Series, 2020.

26   Locicero and Sinclair, "Terrorism and Terrorist Leaders."

For online communities made up of human subjects, complexity stems not only from a difficult-to-observe initial state, but also from the pressures of social organization. One example of complexity-making adaptations is REMVE participants learning to confuse their language through "irony" or "shitposting" and allowing their serious statements to be defended through a "just trolling you" defense. Not only is it difficult to determine true meanings and intent, but it is even more difficult to predict multiple audiences' reactions to this "trolling."

In this case, complexity comes about because of the interactions between REMVE users and the con-straints of platform policy and moderation, leading to a process of adaptation (see further discussion of "adaptation" below). Where initially REMVE language may have been more explicitly violent and thus easily identifiable, the interactions between actors and moderation policies spurs adaptations that make the online landscape more complex, and in the case of "shitposting", this makes the identification of REMVE content more difficult. Hence, complexity is a product of interaction. Understanding complex systems, such as REMVE online actions and networks, entails understanding and identifying those char-acteristics that make them complex, including adaptation, emergence, evolution, and the other charac-teristics discussed in this brief.

Opportunities exist to apply systems theory concepts of complexity to socio-technical systems involv-ing online violent extremist populations.[27] Such studies could provide insights into the rapidly changing nature of internet technology and how violent extremist networks adapt to socio-technical changes, perhaps through a comparative lens to identify the impact of complex dynamics and processes as noted above. As discussed in Figure 5, complexity-focused studies could also explore whether disruptions to platforms because of violent extremist activities or non-related reasons impact violent extremist use and long-term adoption of other platforms in an unexpected fashion. This may be of particular impor-tance in understanding the factors that influence REMVE activities online. For example, how do platform moderation changes or platform disruptions function to increase or decrease the complexity of REMVE activities online? Do they result in further dispersion of REMVE activities across other platforms, or spur adaptations in the types of material spread?

Given the difficulties complexity poses to identifying, crafting, and measuring the effectiveness of efforts aimed at addressing violent extremism online, greater attention to comparative research and classifi-cation systems to better understand and delineate components operating within complex online inter-actions may be useful in better clarifying which specific policies and programs are likely to be useful or ineffective and where.

---

27   Taylor, "Criminogenic Qualities of the Internet."

> **"Complexity" in Other Fields[28]**
>
> In media, communications, and computer science literature, complexity is used both as a descriptor of networked media and as a quality of information systems. For instance, complexity is used to describe the changing state and emergent properties of multi-actor populations operating under dynamic selection pressures occurring in digital ecosystems. At times, evolutionary theory, in particular the concept of succession which describes the process by which a biological community evolves over time, has been applied in the literature to investigate the emergence of complexity. For instance, as a digital ecosystem develops over time the multi-actor populations nested within subsystem networks become increasingly more complex.[29]

5 Adaptation

Adaptation has three distinct but interrelated meanings in evolutionary biology. Under pressure from natural selection, adaptation is the dynamic evolutionary process that enables an organism to fit their environment. In the context of a population of organisms, adaptation is a state reached during the same process of natural selection. It is also the physical representation of an adaptive trait that manifests in response to selective pressures presented by an environment. Indeed, evolution, as discussed below, can be simplistically understood as a long-term process influenced by adaptation and natural selection.[30]

In the terrorism and online extremism literature, adaptation has been used to describe how interconnected clusters of agents transfer from one online domain to another, while still fulfilling similar technological and functional outcomes in an ecosystem. In a single case, the term has been used to understand how online networks of extremists thrive globally in self-organized and interconnected clusters that form a resilient network-of-networks across platforms, countries, and languages.[31] Because adaptation is concerned with the manifestation of traits made to endure experienced selective pressures, adaptive traits

---

28   Merali, "Complexity and Information Systems"; Briscoe, "Digital Ecosystems"; Briscoe, "Complex Adaptive Digital EcoSystems"; Dominici, "Of Security and Liberty, of Control and Cooperation"; Lance Strate, "Studying Media AS Media: McLuhan and the Media Ecology Approach," *MediaTropes EJournal* 1 (2018): 127–42; Androniki Christopoulou, *The Information Disorder Ecosystem: A Study on the Role of Social Media, the Initiatives to Tackle Disinformation and a Systematic Literature Review of False Information Taxonomies* (Greece: School of Science and Technology at the International Hellenic University), https://repository.ihu.edu.gr//xmlui/handle/11544/29381; Bayer, "Social Media Elements, Ecologies, and Effects."

29   Vayda, "New Directions in Ecology and Ecological Anthropology"; Walker, "Genealogies of Resilience."

30   Stephen Jay Gould, *Ever Since Darwin: Reflections in Natural History* (London: W. W. Norton & Company, 1979); Richard Dawkins, *The Extended Phenotype: The Long Reach of the Gene* (*Revised edition*) (New York: Oxford University Press, 1999); Richard Dawkins, *The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design (1st edition)* (W. W. Norton & Company, 2015); Richard Dawkins, *The Selfish Gene (4th edition)* (Oxford: Oxford University Press, 2016).

31   Johnson, "New Online Ecology of Adversarial Aggregates"; Johnson, "Hidden Resilience and Adaptive Dynamics of the Global Online Hate Ecology."

are an important characteristic of online violent extremist ecosystems for further study. Not all adaptations are successful and those that are can be combined with other behaviors, iterations, and interactions within or between violent extremist communities. An example of adaptation within an online extremist population is the strategic appropriation and use of innocuous hashtags by QAnon followers to covertly spread their messaging while subverting pressures imposed by platform moderation. This has been seen, for example, in the use of the #savethechildren hashtag to spread propaganda suggesting government elites are engaged in forms of ritual child abuse.

"Adaptation" in Other Fields[32]

In the media, communications, and computer science literature, adaptation is consistently used to refer to the resilience, reflexivity, and innovative behavior exhibited by aspects of digital infrastructure and software, media technology, and their human users. It features regularly in the characterization of digital ecosystems, assuming that the digital ecosystem under study is designed to develop scalable solutions to complex dynamic problems. Adaptation is also often partnered with properties like self-organization, scalability, and sustainability as core characteristics of digital ecosystems.[33]

Understanding how violent extremist activities adapt in the face of environmental conditions imposed by company policies and how their platforms manage to these adaptations among violent extremist actors, is essential in efforts to craft online environments capable of addressing violent extremism. For example, as noted in the complexity section, interactions between REMVE activities and environmental conditions (including platform moderation policies) may result in adaptations that introduce further complexity in the system. Understanding where and why those adaptations (including migration to new platforms, cloaking violent extremist content in irony, etc.) emerge is key to understanding and identifying the persistence and impact of REMVE activities online and in informing future policy and platform moderation responses cognizant of further potential adaptations. Other forms of adaptation and how they refer

32   Jaime Bogardy, *Remanufacturing Ourselves in the Face of Trauma: A Media Ecology Perspective on Post-9/11 Culture* (ProQuest Dissertations Publishing, 2010), http://search.proquest.com/docview/756358131/?pq-origsite=primo; Kevin Kelly, *What Technology Wants* (London: Penguin Books, 2011); Mohammad Yousuf, "Niches in the Networlked Media Ecosystem: Functionalities, Gratifications, and a Typology of Online News and Informational Media" (PhD diss., University of Oklahoma, 2016); Briscoe, "Digital Ecosystems"; Briscoe, "Complex Adaptive Digital EcoSystems"; Gerard Briscoe and Philippe De Wilde, "Computing of Applied Digital Ecosystems," in *MEDES '09: Proceedings of the International Conference on Management of Emergent Digital EcoSystems* (New York: Association for Computing Machinery, 2009), 28–35, https://doi.org/10.1145/1643823.1643830; Li, Badr, and Biennier, "Digital Ecosystems"; John Krogstie, "Modeling of Digital Ecosystems: Challenges and Opportunities," in *Collaborative Networks in the Internet of Services*, eds. Luis M. Camarinha-Matos, Lai Xu, and Hamideh Afsarmanesh (Berlin, Heidelberg: Springer, 2012), 137–45, https://doi.org/10.1007/978-3-642-32775-9_14.

33   Bogardy, "Remanufacturing Ourselves in the Face of Trauma"; Kelly, *What Technology Wants*; Yousuf, "Niches in the Networlked Media Ecosystem"; Briscoe, "Digital Ecosystems"; Briscoe, "Complex Adaptive Digital EcoSystems"; Briscoe and De Wilde, "Computing of Applied Digital Ecosystems"; Li, Badr, and Biennier, "Digital Ecosystems"; Krogstie, "Modeling of Digital Ecosystems."

to and might be used to further understand online violent extremist communities are discussed below under self-organization, evolution, and swarm intelligence.

6 Self-Organization

Self-organization describes a non-designed system that self-emerges to achieve a level of stability. Self-organization, from an ecological perspective, is non-directed growth, while online communities are, at least in part, directed by human agency and choice, as well as by the algorithmic architecture employed—but not generally made publicly available—by social media companies.[34] Despite this, self-organization may still be a useful ecological lens for framing group formation and organization. It provides a reminder that online groups can originate their own objectives without prior prompting, can generate spontaneous internal lines of communication and control, and find new reasons for existing.

There are limited references to self-organization within the terrorism and online extremism literature reviewed. Studies that do use the term focus on networked clusters of human or synthetic users inhabiting a digital ecosystem, for example networks of pro-IS pages connected to particular Facebook pages.[35] For instance, Johnson (et al.) described the development of narratives among "self-organized online aggregates" who supported the so-called Islamic State on Facebook.[36] These self-organized aggregates organically proliferated preceding the onset of real-world campaigns and adopt novel adaptive mechanisms to enhance their survival on the platform.[37]

Self-organization could be used in the online REMVE space to better identify how online groups respond to disruptions to maintain dynamic online transnational networks in the face of increased online scrutiny.[38] Self-organization emphasizes the multiple layers of an ecosystem and the structuring of the various agents, environments, information, and drivers within and between these layers. The adoption of self-organization may help to identify key processes that impact closely related drivers critical to an online violent extremist ecosystem, and how different networks split off from or spawn others. An example are the many wellness-oriented online communities that became vectors for REMVE sentiment and propaganda during the COVID-19 pandemic and associated public health orders. In this case, self-organization occurred through the rapid spread and adoption of conspiratorial narratives linking ideas of health and wellbeing with anti-vaccine, anti-lockdown, and ultimately anti-government sentiment. This created new and seemingly spontaneous networks between wellness and REMVE-aligned social media accounts.

---

34   Briscoe, "Digital Ecosystems."

35   Johnson, et al., "New Online Ecology of Adversarial Aggregates."

36   Ibid.

37   Ibid.

38   Ashley. Mattheis, *Atomwaffen Division and its Affiliates on Telegram: Variations, Practices, and Inter-connections* (Washington, D.C.: RESOLVE Network, 2022), https://doi.org/10.37805/remve2022.1.

> ## "Self-Organization" in Other Fields[39]
>
> Self-organization is a prominent concept in the media and communications literature investigating and understanding the functionality of digital ecosystems. For instance, digital ecosystems are characterized as self-organizing multi-actor environments, where individual agents are proactive and responsive during interactions between agents and the broader system that shapes the global behavior of agents. Self-organization in this body of literature is often partnered with evolutionary theory when applied to digital ecosystems. Like biological systems, self-organizing digital ecosystems are relatively free, scalable architectures that are constrained enough to automatically generate solutions to solve complex, dynamic problems.[40]

7 Evolution

In the biological sciences, evolution refers to selective processes that are guided by natural laws and principles. These processes operate between organisms and their environments to govern their mutual development over time.[41] An important point of distinction between evolution and adaptation as discussed earlier is worth revisiting. Adaptation feeds into evolution, but refers to adjustments or traits enabling survival in new environments or given a change in a current environment. Evolution, on the other hand, refers to generational developments resulting from beneficial adaptations.

Terrorism studies have largely adopted "evolution" as a descriptor or metaphor to denote the history and development of terrorist groups, or the development and possible future use of technology by violent extremist actors. More rarely, evolution has been used as a descriptor to explain the development of socio-technical systems, including digital media spaces that are specific to online extremism.[42]

There are wider implications for how evolution could be used to explain change over time in response to pressure within studies of online violent extremist populations. For example, an evolutionary-ecological approach provides a framework for assessing the influences between agents and their environments over time. These influences flow in both directions—i.e., from users to platform architecture and vice-

---

39 Harold Boley and Elizabeth Chang, "Digital Ecosystems: Principles and Semantics," in *2007 Inaugural IEEE-IES Digital Eco-Systems and Technologies Conference* (2007 Inaugural IEEE-IES Digital EcoSystems and Technologies Conference, 2007), 398–403, https://doi.org/10.1109/DEST.2007.372005.

40 Briscoe, "Digital Ecosystems."

41 Gould, *Ever Since Darwin*; Dawkins, *The Extended Phenotype*; Dawkins, *The Blind Watchmaker*; Dawkins, *The Selfish Gene*.

42 Bryan Vila, "A General Paradigm for Understanding Criminal Behavior: Extending Evolutionary Ecological Theory*," *Criminology* 32, no. 3 (1994): 311–60, https://doi.org/10.1111/j.1745-9125.1994.tb01157.x; Boyd, "Ecology of Terrorism"; Boyd, "Modeling Terrorist Attacks"; Baele, Brace, and Coan, "Uncovering the Far-Right Online Ecosystem"; Veilleux-Lepage, *How Terror Evolves*.

versa. An evolutionary approach to recording these influences could lead to a better understanding of specific processes between people and online architectures, and therefore a more accurate categorization of their relationship to one another. For instance, their relationship may be mutualistic; where both actors or entities receive a mutual benefit from their interaction; or it may be symbiotic; where the relationship is interdependent but does not assume either actor or entity benefits from their engagement.

Evolution can also be used metaphorically to discuss how selection pressures in online environments can change violent extremist online activities, tactics, and presence over time. For instance, forms of moderation, changes in platform features, and social pressures against group topics all can be construed as selection pressures with an impact on violent extremist's ability to survive and thrive in online environments. Individuals and groups can grow and thrive on a platform so long as they exhibit traits that the platform values through engagement and amplification. How violent extremists adapt to these pressures and the cumulative traits they develop over time that make them more resilient are important areas of study for policy, practice, and platform moderation efforts. For instance, outlinking habits are an adaptation to bypass deplatforming selection pressures, but also a tactic that has been passed down over time to boost survivability.

One example is the use of peer-to-peer platforms such as Telegram to promote conspiratorial anti-COVID lockdown protests across dispersed geographies. This adaptive use of social media, however, did not emerge out of a REMVE milieu, but was instead taken from earlier global protest and activist movements. In this case, REMVEs adopted new internet behaviors that had already emerged from within the wider digital environment.

"Evolution" in Other Fields[43]

In the media and communications literature evolution features as a simple descriptor or metaphor to understand the history of specific media technologies such as mass media or digital media. This use is closer to the non-scientific origins of the term in which "evolution" denoted the idea of the process of giving rise to a thing or a sense development. Less often, the term has been expanded in media and communications scholarship to provide a theoretical framework to understand the selective process by which a digital media ecosystem develops.

---

43 Francisco-Javier García-Marco, "Libraries in the Digital Ecology: Reflections and Trends," *The Electronic Library* 29, no. 1 (2011): 105–20. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1108/02640471111111460; Carlos A. Scolari, "Media Ecology: Exploring the Metaphor to Expand the Theory," *Communication Theory* 22, no. 2 (2012): 204–25, https://doi.org/10.1111/j.1468-2885.2012.01404.x; Casey Man Kong Lum, "Introduction: The Intellectual Roots of Media Ecology," *New Jersey Journal of Communication* 8, no. 1 (2000): 1–7, https://doi.org/10.1080/15456870009367375; Kelly, *What Technology Wants*.

The dynamism and sustainability of online violent extremist networks over time becomes a function of deplatforming and co-development with emergent phenomena when framed as an adaptive behavioral trait. Indeed, there is much that may be learned through studying the "inheritance" of different tactics from violent extremists generation-to-generation and group-to-group in online environments to better adapt platform moderation policies and environments. Processes that could be tracked include how different types of violent extremists engage in formal or informal learning behaviors with one another, or how REMVE online activities mimic, engage with, and adopt the behaviors of non-REMVE groups to develop insight into trends and future adaptations and ongoing evolution. Doing so would also provide policymakers and practitioners with information that could potentially be adapted for more proactive policy responses.

8 Swarm Intelligence

Swarm intelligence is the group flocking behavior that coordinates a school of fish, herd of deer, or flock of birds into a singular collective movement. All members of the group act in synchronization without pre-planning, a command-and-control system, or conscious intentionality. The group is seen to exhibit a collective intelligence, despite the lack of any unifying or singular mind.

In the terrorism and online extremism literature, swarm intelligence features in a limited number of descriptions of how online extremist communities evolve in response to disruption efforts, specifically in how they find new ways to distribute content (i.e., to "swarmcast"). An example is how the Islamic State was able to continuously distribute news and propaganda from the battlefront through an ever-changing distributed network of internet sites that relied on the decisions made by many actors in unison, and that mimicked—but was not—a coordinated or directed strategy.[44] In cases like this, a swarmcasting technique does not necessarily rely on the collective unplanned movement of multiple individuals, but instead on the collective and unplanned human decision making of multiple thinking agents.

Although swarm intelligence may be difficult to measure, it can be highly useful when applied to the interactions between online populations and their digital environments.[45] Use of this concept may provide a flexible, dynamic, and interactive model for how large, distributed populations conduct spontaneous problem-solving within an online ecosystem.[46] For example, studies analyzing distributed, global patterns of activity within online extremist communities may reveal trends in collective behavior specific to problem solving, but occurring without explicit direction from others. This could include how populations spontaneously come up with new ways to deceive platform administrators, or processes of mass adaptation in response to disturbances such as deplatforming, changes to algorithms, or the advent of new technologies. One example is the mass use of shared schematic or symbolic account profile pictures by extremists as a way of deceiving online moderators while telegraphing shared in-group belonging and status.

---

44   Nico Prucha Fisher and Emily Winterbotham, *Mapping the Jihadist Information Ecosystem: Towards the Next Generation of Disruption Capability* (London: RUSI, 2020), https://rusi.org/sites/default/files/20190716_grntt_paper_06.pdf, 6.

45   Ibid.

46   Boley and Chang, "Digital Ecosystems."

Swarm intelligence could also be used to better understand how online violent extremist populations respond to selection pressures within dynamic digital networks, with particular utility for understanding collective, but uncoordinated, REMVE population responses in light of increased attention to REMVE content.

Understanding swarm intelligence in such behaviors can help identify and discern the extent to which coordinated behaviors and actions are actually at play, and what that means in terms of the extent of cohesion and structure of a violent online ecosystem or movement. This is of particular importance for policymakers and practitioners seeking to disrupt or address violent extremist activities, including REMVE activities, online, with implications for policy effectiveness and impact in light of potential swarm intelligence or coordinated efforts to sidestep policy responses.

"Swarm Intelligence" in Other Fields[47]

Swarm intelligence is used in artificial intelligence theory and application to refer to collective behaviors resulting from the interactions of individuals with each other and their artificial or biological environments. The concept is highly useful when applied to the interactions between online populations and their digital environments but features rarely in descriptions of the collective behavior of agents interacting with each other and with their technological environment in media and communication studies.

9 Non-linear Behavior

Non-linear behavior denotes a set of processes that describe complexity and dynamism within an environment. These include non-equilibrium and non-linear dynamics, which are used to describe the nature of a digital ecosystem featuring shifting boundaries, new network formations, emerging domains, and volatile multi-actor networks.[48]

Theories of non-linear behavior aim to calculate and reveal patterns and structures underlying the complexity of the system so to better harness and predict it. For example, rapid state transitions potentially allow the system to adapt to sudden environmental changes with minimal loss of functionality. An example would be the ability for loose networks of online actors distributing REMVE propaganda to evade content moderation through constantly shifting their use of language and imagery to below automated

---

47   Ibid.

48   Bernardo Huberman, *The Laws of the Web: Patterns in the Ecology of Information* (Cambridge: MIT Press, 2001); Briscoe, "Digital Ecosystems."

moderation thresholds. This is taken to be a feature of sustainability.[49] These loose networks adapt to content moderation, producing content that will evade those policies. However, this process of adaptation is not necessarily linear in nature, as some adaptations may stay while others play an outsized role in activities over time. Hence, processes of adaptation underly complexity and adopting a non-linear framework to examine them may help in anticipating future processes of online change and evolution that defy linearity to better inform policy and practice in real time.

"Non-Linear Behavior" in Other Fields

In the media, communications, and computer science literature, non-linear behavior has been suggested to provide an opportunity for the scalable organization and evolution of complex hierarchical solutions in digital ecosystems.

Non-equilibrium dynamics feature very rarely in the online extremism and terrorism literature.[50] However, there is significant potential for this sort of dynamic analysis in terrorism studies using testable game theory simulations and modelling behavior to test how REMVE populations respond to changes to their online ecosystems, such as platform architecture or moderation. While this theoretical basis is not ecological in nature, discussion of agents, payoffs, and dynamic systems is a productive intersection between philosophical modelers and terrorism researchers.[51]

Adopting a non-equilibrium and non-linear lens in studying online violent extremist ecosystems could also aid in addressing some of the issues caused by complexity in predicting future network formation and ecosystem evolution. For example, presupposing linearity in behaviors, without acknowledging or demonstrating the non-linearity of behaviors, where found, can result in misguided efforts to address and predict violent extremist dynamics online. A consideration of non-linear behavior reminds us that research or solutions that presume linearity in online actions are not equipped to deal with non-linear behaviors that may define an online violent extremist ecosystem and violent extremist responses to policy decisions.

---

49   Huberman, *The Laws of the Web*; Briscoe, "Digital Ecosystems"; Johnson, et al., "Hidden Resilience and Adaptive Dynamics of the Global Online Hate Ecology."

50   Johnson, et al., "New Online Ecology of Adversarial Aggregates"; Johnson, et al., "Hidden Resilience and Adaptive Dynamics of the Global Online Hate Ecology."

51   Firdaus Udwadia, George Leitmann, and Luca Lambertini, "A Dynamical Model of Terrorism," *Discrete Dynamics in Nature and Society* (2006), https://doi.org/10.1155/DDNS/2006/85653; Czesław Mesjasz, "Complex Systems Studies and Terrorism," in *Conflict and Complexity: Countering Terrorism, Insurgency, Ethnic and Regional Violence*, eds. Philip Vos Fellman, Yaneer Bar-Yam, and Ali A. Minai (Springer, 2015), 35–71, https://doi.org/10.1007/978-1-4939-1705-1_2; Euel Elliott and L. Douglas Kiel, "A Complex Systems Approach for Developing Public Policy Toward Terrorism: An Agent-based Approach," *Chaos, Solitons & Fractals* 20, no. 1 (2004): 63–68, https://doi.org/10.1016/S0960-0779(03)00428-4; Chukwudi Okoye, O. C. Collins, and Godwin Christopher Ezike Mbah, "Mathematical Approach to the Analysis of Terrorism Dynamics," *Security Journal* 33, no. 3 (2020): 427–38, http://dx.doi.org/10.1057/s41284-020-00235-5.

10 Emergence

Emergence describes new properties that arise because of the interaction between components of a biological system, and that would not otherwise have arisen on their own. They are characterized by increasing complexity and in turn drive increasing complexity.[52] The internet is a complex and decentralized network that exhibits many emergent features, including the generation of online subcultures that collectively ascribe value to common online spaces or individuals and create shared textual and visual languages. These "emergent" behaviors are not predictable or "by design," but exist purely as a function of user behaviors as they interact with disparate systems.

In terrorism and violent extremism studies, the concept of emergence has not yet been applied in relation to online communities inhabiting digital ecosystems. Instead, emergence is primarily concerned with the environmental conditions that are conducive to terroristic behaviors. For example, it is implied that emergent properties, born of the interaction between online affordances such as "anonymization" and "individuation", are in part responsible for certain social and psychological problems related to online violent extremism and terrorism.[53]

The concept of emergence has significant applicability to the study of online violent extremist groups. This is because online extremist groups (like many online subcultures) appear to be emergent phenomenon, the product of interactions among various and distinct actors, cultures, online systems, and technological structures. At an analytical level, emergent properties are essential to connecting layers of an online digital ecosystem because macro-level systems are seen as an emergent realization of micro-level dynamics, or, more simply, larger ecosystems are the product of multiple smaller level interactions and outcomes within them. To identify how emergent properties are produced requires an in-depth descriptive understanding or classification of the various layers, drivers, and relations that uniquely characterize an online ecosystem.

---

52 Gould, *Ever Since Darwin*; Lauren E. Elrick, "The Ecosystem Concept: A Holistic Approach to Privacy Protection," *International Review of Law, Computers & Technology* 35, no. 1 (2021): 24–45, https://doi.org/10.1080/13600869.2020.1784564.

53 Mina Al-Lami, Andrew Hoskins, and Ben O'Loughlin, "Mobilisation and Violence in the New Media Ecology: The Dua Khalil Aswad and Camilia Shehata Cases," *Critical Studies on Terrorism* 5, no. 2 (2012): 237–56, https://doi.org/10.1080/17539153.2012.692509; Veilleux-Lepage, *How Terror Evolves*; Andrew Silke, ed., *Terrorists, Victims and Society: Psychological Perspectives on Terrorism and Its Consequences* (1st edition) (Hoboken: Wiley, 2003), 19; Claude Barbre, "Reviewed Work: The Fundamenalist Mindst: Psychological Perspectives on Religion, Violence, and History, by Charles B. Strozier, David M. Terman, James W. Jones, Katharine A. Boyd, and Martin E. Marty," *Journal of Religion and Health* 50, no. 3 (2011): 521–26, https://www.jstor.org/stable/41349810.

> ## "Emergence" in Other Fields[54]
>
> In media and communication studies this is understood to be a process by which multiple networks consisting of media, persons, technology, and economics, expand and give rise to new entities such as the "network economy" and "network society". The concept of emergence in technological systems is, at times, partnered with evolutionary concepts like coadaptation and co-evolution[55]

The emergence of new patterns of behavior and ideologies within an online violent extremist community should be differentiated from the processes by which they first occurred. Violent extremist groups commonly appropriate already emergent phenomena online. The use and cooption of memes and shared languages that first emerged outside of extremist subcultures (i.e., "Pepe the Frog" or "Redpilling") by REMVEs online is an example of this appropriation of emergent phenomena. Understanding how already emergent properties impact or are adopted by violent extremist and REMVE subcultures adds important nuance for policy and practice. Recognizing this means acknowledging that violent extremism does not occur in a vacuum online, but instead is the product of multiple interactions within a broader online environment.

More broadly, it is likely that online extremist, violent extremist, and REMVE communities themselves could be usefully examined as emergent phenomena in and of themselves. It appears intuitively the case that whole online social movements such as the Incel and QAnon phenomenon emerge from the complex interactions of people within online networks as they seek to explain their world, justify ambitions, and engage in social activities. These interactions are inseparable from the digital environment that hosts and organizes them.

Yet the inherently complex and dynamic nature of this process, as well as the opaqueness surrounding exactly how social media platforms create their digital environments through algorithmic code, makes the empirical mapping or testing of something like emergence challenging. Understanding these algorithms and how they contribute to emergent phenomena that impact or drive violent extremism online is necessary to determining how best to address it.

---

54 Jacobides, Cennamo, and Gawer, "Towards a Theory of Ecosystems"; Mars and Bronstein, "The Promise of the Organizational Ecosystem Metaphor"; Briscoe, "Digital Ecosystems"; Li, Badr, and Biennier, "Digital Ecosystems."

55 Dominici, "Of Security and Liberty, of Control and Cooperation"; Jacobides, Cennamo, and Gawer, "Towards a Theory of Ecosystems"; Mars and Bronstein, "The Promise of the Organizational Ecosystem Metaphor"; Briscoe, "Digital Ecosystems"; Li, Badr, and Biennier, "Digital Ecosystems."

DISCUSSION AND LIMITATIONS

After discussing each of the ten characteristics individually, we now briefly consider them collectively in discussing some of the considerations and limitations associated with them for studies of violent extremism and REMVE online.

The first, and most important, consideration is the limits of pushing biological concepts and processes into the online domain. As we have seen above, in many cases naturalistic processes such as evolution or swarm intelligence, simply do not translate into human social life any more than as approximate metaphors for complex social processes. This is because biological processes associated with ecosystems rely on non-directed and impersonal naturalistic laws, while the behavior of human groups online—including violent extremist groups—are dependent on the choices of many individuals operating under cultural conditions and constraints. As much as an ecological metaphor to describe human groups inhabiting online environments is attractive and potentially useful, it is important to not lose sight of this very real difference.

Another consideration is the limits of exploring each characteristic in isolation. Although empirical studies are necessary to test and explore each characteristic online, it is unlikely that any of these characteristics operate independently from others. While ecosystems can be usefully broken down into component parts, it is in the interaction between components that will ultimately give the concept its applicability when examining the digital domain. As discussed above, any conceptual understanding of complex processes such as swarm intelligence or emergence would probably depend on the prior classification of networks that are themselves dynamic. The feasibility of multi-characteristic studies on online violent extremist communities, however, remains a challenge for future studies. Understanding, both conceptually and definitionally, each of these characteristics is the first step in embarking on studies to examine how they interact with one another (even if they manifest in different ways) to produce similar, distinct, expected, and unexpected outcomes.

It should also be noted, and as illustrated by the discussion of characteristics above, that some characteristics emerge out of the interaction and pre-existing operation of others. Processes such as evolution, adaptation, swarm intelligence, and non-linear behavior all rely on feedback processes between interacting systems. For example, as moderation protocols change, on various platforms, violent extremists and REMVEs adopt strategies of migration, talking around topics, linking to outside sources, and adjusting jargon. These seemingly spontaneous, self-generated, and uncoordinated adaptations in-turn drive further complexity and the evolution of online movements. These processes occur in conjunction with the selection pressures felt by the communities in question and the changing network effects offered by competing systems.

A third consideration is that these ten characteristics, if indeed found to be operating within a violent extremist online ecosystem, would not do so in isolation of other wider processes, both online and offline. Online ecosystems are not bounded entities cut-off from larger economic, political, and socio-cul-

tural forces within which digital media operates. Computational architecture may well interact with violent extremist users in ways that mimic biological ecosystems, however, users will also be impacted by economic considerations (how the platform is monetized), socio-cultural processes (the social dynamics inherent to any online community), and the impact of government legislation and interventions (platform moderation and possible preventing and countering violent extremism initiatives). Thus, it should be remembered that not only are online ecosystems imperfectly bounded from one another, but that the online domain operates in conjunction with the offline, adding yet another—indeed perhaps the greatest—level of complexity to the system.

CONCLUSION

This overview of characteristics of violent extremist ecosystems online, as derived from a broad review of the literature, has provided insights into the applicability of ecology and ecosystem to the online activities of violent extremists. It hopes to contribute to further debates and empirical studies into online violent extremist and REMVE activities in three ways:

1 Through providing a shared vocabulary that can be adopted, and debated, by researchers and policymakers, including specific examples of how key terms might be applied to online REMVE activities;

2 Through offering some new and different lenses through which to see and understand violent extremism online, for instance as a process of adaptations to a changing online environment that lead to complex and non-linear outcomes;

3 By providing a starting point for the incorporation of new methodologies to examine these processes i.e., game theory modelling for non-linear systems.

A review of sources from the fields of terrorism studies, media and communications, and ecology demonstrates that ecosystem and related ecological concepts are highly elastic terms used to describe complex online systems made up of networks of human and technological forces, including networks characterized by violent extremism. Despite the efforts made here to clarify the conceptual components which partially compose an "online extremist ecosystem", more empirical validation is necessary in terrorism studies and counter terrorism practice regarding how the term "ecosystem" can be used in ways that go beyond being a useful indicator for complexity, and that incorporate insights gained from natural and social sciences.

There is an opportunity for terrorism researchers to better theorize the nature of online violent extremist ecosystems, and the discrete processes that operate within these online communities, as well as for prac-

tioners and policymakers to better understand and conceptualize them when making determinations on policy and practice. Successful terrorist attacks such as the 2019 Christchurch mass-shootings gained global impact because of the ability of the perpetrator to harness and exploit the technological and cultural affordances present in a web of digital culture, social networking technology, online communities, and networks. Similarly, the growth and spread of online extremist milieus and associated movements such as the far-right "chan cultures" emerge from a dynamic mass of human and technological interactions. Indeed, the rapid growth of political extremism over recent years could usefully be described as an emergent phenomenon dependent on highly complex online and offline ecosystems made up of humans and technological systems.

The natural sciences offer a conceptual vocabulary to begin examining the component processes that collectively make up online ecosystems and allow them to operate. While remaining aware of the very real differences between the natural and human sciences and in no way attempting to merely superimpose natural processes onto online systems, this review has suggested ten characteristics for consideration and further definitional clarity in research, policy, and practice moving forward: network, dynamism, classification, complexity, adaptation, self-organization, evolution, swarm intelligence, non-linear behavior, and emergence.

While limitations to utilizing these characteristics exist, there remains an opportunity to utilize them as starting points for creating more sophisticated analytical frameworks to better understand how online violent extremist populations operate across networks, how they adapt to online and offline events, and how these ecosystems of hate impact the larger population. This is equally important for counter terrorism and countering violent extremism practitioners, who may benefit from a more nuanced conceptual understanding of how online violent ecosystems operate, and that may provide opportunities to better understand, manage, and disrupt these networks.

APPENDIX ONE: REVIEW METHOD | THE WAVE STRUCTURE

To capture a wide array of diverse material, this literature review used a wave-like strategy to structure the collection and organization of sources. This first involved identifying an index of seven databases: University Libraries; Taylor & Francis Online; Annual Reviews; The Year's Work in Critical and Cultural Theory; Pub-MED; Cochrane Library; and Google Scholar.

Following this, a set of relevant search terms were identified and compiled and then run across the seven databases. Each database was searched manually online. A sample of the search terms used are:

- Terrorism/ violent extremism + ecology;

- Terrorism/ violent extremism + ecosystems;

- Terrorism/ violent extremism + ecology + social media;

- Terrorism/ violent extremism + ecosystem + social media.

The First Wave

The first search resulted in the identification of 67 key primary sources including journal articles, books, book chapters, and professional reports. Following the sampling procedure, the first wave of terrorism publications was thematically analyzed against eight review questions:

1. Does this publication provide an account of a digital ecology and/or ecosystem?

2. What concepts and/or characteristics compose a digital ecology and/or ecosystem?

3. What does a digital ecology and/or ecosystem consist of?

4. What predictive and/or descriptive statements are made in discussions of a digital ecology and/or ecosystem?

5. What conceptual frameworks are used to understand a digital ecology and/or ecosystem?

6. What methods and measurements are used to analyze a digital ecology and/or ecosystem?

7. In discussions specific to the concept of a digital ecology and/or ecosystem, what publications does the present study reference?

8. Are there any additional findings in the present study that are applicable to overall project?

The Second Wave

From the first wave of the literature review, a list of secondary references was generated in response to question seven. These were categorized as "second-wave terrorism" and resulted in 121 additional new sources for review. Drawn from the first wave of terrorism sources, this second wave of terrorism publications was then categorized and analyzed in reference to the same eight review questions.

The Third Wave

The third list of references followed the methodology set out above. However, to cater for the emergent diversity of literature transcending the terrorism studies field, each reference was now coded based on the predominant discipline or field in which it was published. Once each reference was coded by discipline this third wave of publications was divided into two reference lists: 1. "first-wave media, communications, and computer sciences" (45 sources in total); and 2. "first-wave natural sciences" (30 sources in total). These 75 sources were then read and analyzed for their conceptual relevance to the concept of digital ecology and/or ecosystems.

Answers to the original seven review questions were then cross-referenced across all three waves of the literature review. In total, 267 sources were reviewed across a series of disciplines including terrorism studies, computing, media and communications, international relations and politics, and the natural sciences.

An illustrative overview of the three waves of the literature review is recorded on the next page, including the earliest and latest relevant publications identified from each.

Table 1. The three waves of the literature review

1 The First Wave

The first wave of terrorism literature primarily contained sources drawn from terrorism, political violence, and online extremism publications books, journals, and professional reports. It included 67 sources in total.

Earliest Publication:

Segre, D. V., and J. H. Adler. 1973. "The Ecology of Terrorism." Survival 15 (4): 178–83. https://doi.org/10.1080/00396337308441412.

Latest Publication:

Conway, Maura. 2021. "Why Deplatforming the Extreme Right Is a Lot More Challenging than Deplatforming IS." GNET (blog). January 15, 2021. https://gnet-research.org/2021/01/15/why-deplatforming-the-extreme-right-is-a-lot-more-challenging-than-deplatforming-is/.

2 The Second Wave

The second wave of literature was composed of a variety of socio-biology, media and communication studies, computer sciences, business and entrepreneurial studies, economics, law, terrorism studies, and online extremism. It included 121 sources in total.

Earliest Publication:

Park, Robert Ezra. 1936. "Human Ecology." American Journal of Sociology 42 (1): 1–15. https://doi.org/10.1086/217327.

Latest Publication:

Kleinberg, Bennett, Isabelle van der Vegt, and Paul Gill. 2020. "The Temporal Evolution of a Far-Right Fo-rum." Journal of Computational Social Science, February, 1–23. https://doi.org/10.1007/s42001-020-00064-x.

3 The Third Wave

The third wave of literature represented a wide diversity of literature broadly contained with media, communications media, communications, computer sciences, and natural sciences publications. It included 75 sources in total.

Media, Communications, and Computer Sciences

Earliest Publication:

Hendry, Paolo Dini and Mary Darking and Neil Rathbone and Miguel Vidal and Pablo Hernández and Pierfranco Ferronato and Gerard Briscoe and Stan. 2005. "The Digital Ecosystems Research Vision: 2010 and Beyond." https://ictlogy.net/bibliography/reports/projects.php?idp=4216&lang=es.

Latest Publication:

Elrick, Lauren E. 2021. "The Ecosystem Concept: A Holistic Approach to Privacy Protection." International Review of Law, Computers & Technology 35 (1): 24–45. https://doi.org/10.1080/13600869.2020.1784564.

Natural Sciences

Earliest Publication:

Odum, Eurgene P. 1968. "Energy Flow in Ecosystems: A Historical Review." American Zoologist 8 (1): 11–18. https://doi.org/10.1093/icb/8.1.11.

Latest Publication:

Fath, Brian D, and Sven Erik Jørgensen. 2019. Encyclopedia of Ecology. http://www.sciencedirect.com/science/referenceworks/9780444641304.

APPENDIX TWO: REVIEWED SOURCES | LISTED BY WAVE

The First Wave (69 Readings)

Abd Razak, M.A., Ramli, M.A., Jamaludin, M.A., 2020. The potential of food terrorism towards halal ecosystem. Food Res. 4, 1–11. https://doi.org/10.26656/fr.2017.4(S1).S19

Ad Ariely, G., 2014. Adaptive Responses to Cyberterrorism, in: Chen, T.M., Jarvis, L., Macdonald, S. (Eds.), Cyberterrorism: Understanding, Assessment, and Response. Springer, New York, NY, pp. 175–195. https://doi.org/10.1007/978-1-4939-0962-9_10

Akhtar, S., 2017. The tripod of terrorism. International Forum of Psychoanalysis 26, 139–159. https://doi.org/10.1080/0803706X.2017.1338356

Al-Lami, M., Hoskins, A., O'Loughlin, B., 2012. Mobilisation and violence in the new media ecology: the Dua Khalil Aswad and Camilia Shehata cases. Critical Studies on Terrorism 5, 237–256. https://doi.org/10.1080/17539153.2012.692509

Asal, V.H., Ackerman, G.A., Rethemeyer, R.K., 2012. Connections Can Be Toxic: Terrorist Organizational Factors and the Pursuit of CBRN Weapons. Studies in Conflict & Terrorism 35, 229–254. https://doi.org/10.1080/1057610X.2012.648156

Atran, S., 2021. Psychology of Transnational Terrorism and Extreme Political Conflict. Annu. Rev. Psychol. 72, 471–501. https://doi.org/10.1146/annurev-psych-010419-050800

Baele, S.J., Brace, L., Coan, T.G., 2020. Uncovering the Far-Right Online Ecosystem: An Analytical Framework and Research Agenda. Studies in Conflict & Terrorism 0, 1–21. https://doi.org/10.1080/1057610X.2020.1862895

Baele, S.J., Brace, L., Coan, T.G., 2019. From "Incel" to "Saint": Analyzing the violent worldview behind the 2018 Toronto attack. Terrorism and Political Violence 0, 1–25. https://doi.org/10.1080/09546553.2019.1638256

Bellutta, D., Chen, Y., Gartenstein-Ross, D., Pulice, C., Subasic, A., Subrahmanian, V.S., 2020. Understanding Shifting Triadic Relationships in the Al-Qaeda/ISIS Faction Ecosystem. IEEE Transactions on Computational Social Systems 7, 1423–1434. https://doi.org/10.1109/TCSS.2020.3022586

Borum, R., 2011. Radicalization into Violent Extremism II: A Review of Conceptual Models and Empirical Research. Journal of Strategic Security 4. https://doi.org/<p>http://dx.doi.org/10.5038/1944-0472.4.4.2</p>

Boxer, P., Huesmann, L.R., Dubow, E.F., Landau, S.F., Gvirsman, S.D., Shikaki, K., Ginges, J., 2013. Exposure to Violence Across the Social Ecosystem and the Development of Aggression: A Test of Ecological Theory in the Israeli–Palestinian Conflict. Child Development 84, 163–177. https://doi.org/10.1111/j.1467-8624.2012.01848.x

Boyd, K.A., 2016. Modeling Terrorist Attacks: Assessing Statistical Models to Evaluate Domestic and Ideo-logically International Attacks. Studies in Conflict & Terrorism 39, 712–748. https://doi.org/10.1080/1057610X.2016.1141003

Boyd, K.A., 2014. Ecology of Terrorism: Cross-National Comparison of Terrorist Attacks (Doctor of Philoso-phy). City University of New York, Graduate Center, City University of New York.

Bratich, J., Banet-Weiser, S., 2019. From Pick-Up Artists to Incels: Con(fidence) Games, Networked Misogy-ny, and the Failure of Neoliberalism. International Journal of Communication 13, 25.

Broadhead, S., 2018. The contemporary cybercrime ecosystem: A multi-disciplinary overview of the state of affairs and developments. Computer Law & Security Review 34, 1180–1196. https://doi.org/10.1016/j.clsr.2018.08.005

Brown, S.D., Hoskins, A., 2010. Terrorism in the new memory ecology: Mediating and remembering the 2005 London Bombings. Behavioral Sciences of Terrorism and Political Aggression 2, 87–107. https://doi.org/10.1080/19434471003597399

Cardeli, E., Bloom, M., Gillespie, S., Zayed, T., Ellis, B.H., 2019. Exploring the Social-Ecological Factors that Mobilize Children into Violence. Terrorism and Political Violence 0, 1–23. https://doi.org/10.1080/09546553.2019.1701444

Christopoulou, A., 2019. The Information disorder Ecosystem: A study on the role of Social Media, the Initia-tives to tackle disinformation and a Systematic Literature Review of False Information Taxonomies. School of Science and Technology at theInternational Hellenic University, Greece.

Clarke, M.C., 2004. Terrorism, Engineering and the Environment: Their Interrelationships. Terrorism and Po-litical Violence 16, 294–304. https://doi.org/10.1080/09546550490483431

Conway, M., 2021. Why Deplatforming the Extreme Right is a Lot More Challenging than Deplatforming IS. GNET. URL https://gnet-research.org/2021/01/15/why-deplatforming-the-extreme-right-is-a-lot-more-challenging-than-deplatforming-is/ (accessed 2.2.21).

Conway, M., 2020. Routing the Extreme Right. The RUSI Journal 165, 108–113. https://doi.org/10.1080/03071847.2020.1727157

Conway, M., Khawaja, M., Lakhani, S., Reffin, J., 2021. A Snapshot of the Syrian Jihadi Online Ecology: Differential Disruption, Community Strength, and Pre-ferred Other Platforms. Studies in Conflict & Terror-ism 0, 1–17. https://doi.org/10.1080/1057610X.2020.1866736

Conway, M., Khawaja, M., Lakhani, S., Reffin, J., Robertson, A., Weir, D., 2019. Disrupting Daesh: Measur-ing Takedown of Online Terrorist Material and Its Impacts. Studies in Conflict & Terrorism 42, 141–160. https://doi.org/10.1080/1057610X.2018.1513984

Dean, Geoff, Peter Bell, and Zarina Vakhitova. 2016. "Right-Wing Extremism in Australia: The Rise of the New Radical Right: Journal of Policing, Intelligence and Counter Terrorism: Vol 11, No 2." Journal of Po-licing, Intelligence and Counter Terrorism 11 (2): 121–42.

Department of Security Studies and Criminology. 2020. "Mapping Networks and Narratives of Online Right-Wing Extremists in New South Wales." (Version 1.0.1). Sydney: Macquarie University. http://doi.org/10.5281/zenodo.4071472

Doering, S., Davies, G., 2019. The Contextual Nature of Right-Wing Terrorism across Nations. Terrorism and Political Violence 0, 1–23. https://doi.org/10.1080/09546553.2019.1598390

Dominici, P., 2017. Of Security and Liberty, of Control and Cooperation. Terrorism and the New Ecosystem of Communication. Italian Sociological Review 7, 201–220.

Editorial responsibilities arising from personalization algorithms, 2017. The ORBIT Journal 1, 1–12. https://doi.org/10.29297/orbit.v1i1.26

Ernst, Nicole, Sven Engesser, Florin Büchel, Sina Blassnig, and Frank Esser. 2017. "Extreme Parties and Pop-ulism: An Analysis of Facebook and Twitter across Six Countries." Information, Communication & Socie-ty 20 (9): 1347–64. https://doi.org/10.1080/1369118X.2017.1329333.

Felson, M., 2006. The Ecosystem for Organized Crime 20.

Freilich, J.D., Chermak, S.M., Gruenewald, J., 2015. The future of terrorism research: a review essay. Interna-tional Journal of Comparative and Applied Criminal Justice 39, 353–369. https://doi.org/10.1080/01924036.2014.922321

Gartenstein-Ross, D., Blackman, M., 2019. Fluidity of the Fringes: Prior Extremist Involvement as a Radicali-zation Pathway. Studies in Conflict & Terrorism 0, 1–24. https://doi.org/10.1080/1057610X.2018.1531545

Gill, P., Horgan, J., Corner, E., 2019. The Rational Foraging Terrorist: Analysing the Distances Travelled to Commit Terrorist Violence. Terrorism and Political Violence 31, 929–942. https://doi.org/10.1080/09546553.2017.1297707

Ging, Debbie. 2019. "Alphas, Betas, and Incels: Theorizing the Masculinities of the Manosphere." Men and Masculinities 22 (4): 638–57. https://doi.org/10.1177/1097184X17706401.

Gordon, A., 2010. Can terrorism become a scientific discipline? A diagnostic study. Critical Studies on Terror-ism 3, 437–458. https://doi.org/10.1080/17539153.2010.521644

Hadzic, M., Chang, E., n.d. Use of Anti-Terrorist Digital Ecosystem in the Fight Against Terrorism 7.

Hamid, N., 2020. The Ecology of Extremists' Communications: Messaging Effectiveness, Social Environ-ments and Individual Attributes. The RUSI Journal 165, 54–63. https://doi.org/10.1080/03071847.2020.1731248

Hamilton, L., 1978. Ecology of Terrorism: A Historical and Statistical Study. (Ph.D.). University of Colorado at Boulder, United States -- Colorado.

Innes, M., Roberts, C., Preece, A., Rogers, D., 2018. Ten "Rs" of Social Reaction: Using Social Media to Analyze the "Post-Event" Impacts of the Murder of Lee Rigby. Terrorism and Political Violence 30, 454–474. https://doi.org/10.1080/09546553.2016.1180289

Johns, A., 2017. Flagging White Nationalism 'After Cronulla': From the Beach to the Net. Journal of Intercul-tural Studies 38, 349–364. https://doi.org/10.1080/07256868.2017.1314259

Johnson, N.F., Zheng, M., Vorobyeva, Y., Gabriel, A., Qi, H., Velasquez, N., Manrique, P., Johnson, D., Restrepo, E., Song, C., Wuchty, S., 2016. New online ecology of adversarial aggregates: ISIS and beyond. Science 352, 1459–1463. https://doi.org/10.1126/science.aaf0675

Kamprad, A., Liem, M., 2021. Terror and the Legitimation of Violence: A Cross-National Analysis on the Relationship between Terrorism and Homicide Rates. Terrorism and Political Violence 33, 96–118. https://doi.org/10.1080/09546553.2018.1523150

Kluch, S.P., Vaux, A., 2017. Culture and Terrorism: The Role of Cultural Factors in Worldwide Terrorism (1970–2013). Terrorism and Political Violence 29, 323–341. https://doi.org/10.1080/09546553.2015.1038523

LaFree, G., Bersani, B.E., 2014. County-Level Correlates of Terrorist Attacks in the United States Correlates of Terrorist Attacks in the United States: Research Article. Criminology & Pub. Pol'y 13, 455–482.

Linera Rivera, R.E., 2016. Social representation of threat in extended media ecology: Sochi 2014 olympics, jihadist deeds, and online propaganda (Ph.D.). Field-ing Graduate University, United States -- California.

Locicero, A., Sinclair, S.J., 2008. Terrorism and Terrorist Leaders: Insights from Developmental and Ecologi-cal Psychology. Studies in Conflict & Terrorism 31, 227–250. https://doi.org/10.1080/10576100701879638

Mattoni, A., 2017. A situated understanding of digital technologies in social movements. Media ecology and media practice approaches. Social Movement Studies 16, 494–505. https://doi.org/10.1080/14742837.2017.1311250

McTeigue, N., 2016. Reclaiming Australia? The digital formations of the Australian anti-Islamic nationalist movement. Macquarie University, Sydney, Australia.

Wilner, Michael. 2013. Prosor to UN: Counter-terrorism must address "ecosystem of extremism." The Jerusa-lem post.

Miller, R.E., 2006. Eco-Epidemiology as Anti-Terrorism. International Quarterly of Community Health Educa-tion 26, 307–317.

Morrison, J.F., 2020. Talking Stagnation: Thematic Analysis of Terrorism Experts' Perception of the Health of Terrorism Research. Terrorism and Political Violence 0, 1–21. https://doi.org/10.1080/09546553.2020.1804879

Nacos, B.L., 2011. Radicalisation and media: connectivity and terrorism in the new media ecology, by Akil N. Awan, Andrew Hoskins and Ben O'Loughlin. Critical Studies on Terrorism 4, 473–476. https://doi.org/10.1080/17539153.2011.634705

Nossiter, A., 2016. An open europe is a vulnerable one; Belgium a "favourable ecosystem" for terrorism. The National Post.

Ochara, N.M., Odhiambo, N.A., Kadyamatimba, A., 2020. The Digitalised Terrorism Ecology: A Systems Perspective. AJIC 1–19. https://doi.org/10.23962/10539/29196

Onat, I., 2019. An analysis of spatial correlates of terrorism using risk terrain modeling. Terrorism and Political Violence 31, 277–298. https://doi.org/10.1080/09546553.2016.1215309

Osuri, G., 2019. #Kashmir 2016: Notes toward a media ecology of an occupied zone. South Asian Popular Culture 17, 111–131. https://doi.org/10.1080/14746689.2019.1612554

Parvez, M.S., 2020. Understanding Digital Media and the Lifecycles of Bangladeshi Violent Extremists. Uni-versity of Sydney, Australia.

Phillips, P.J., Pohl, G., 2020. Terrorism, lightning and falling furniture. Behavioral Sciences of Terrorism and Political Aggression 12, 140–156. https://doi.org/10.1080/19434472.2019.1595697

Robinson, P., 2009. Editor's introduction: communicating terrorism. Critical Studies on Terrorism 2, 1–5. https://doi.org/10.1080/17539150902752416

Rossmo, D.K., Harries, K., 2011. The Geospatial Structure of Terrorist Cells. Justice Quarterly 28, 221–248. https://doi.org/10.1080/07418820903426197

Sadik, S., Ahmed, M., Sikos, L.F., Islam, A.K.M.N., 2020. Toward a Sustainable Cybersecurity Ecosystem. Computers 9, 74. https://doi.org/10.3390/computers9030074

Schwarz, E., 2018. Flesh and steel: antithetical figures in the war on terrorism. Critical Studies on Terrorism 11, 394–413. https://doi.org/10.1080/17539153.2018.1456737

Segre, D.V., Adler, J.H., 1973. The ecology of terrorism. Survival 15, 178–183. https://doi.org/10.1080/00396337308441412

Sevan, Gerard. 2017. "A Proposed Cosmology of Identity in The Sociotechnical Ecosystem of Homeland Secu-rity." Homeland Security Affairs (blog). December 1, 2017. https://www.hsaj.org/articles/14400.

Shomron-Atar, E.N., 2018. Psychoanalysis Against Fascism: Fascism, Terrorism, and the Fascist and Terrorist Within. Psychoanalytic Perspectives 15, 48–63. https://doi.org/10.1080/1551806X.2018.1396129

Siyech, M.S., 2019. Arms Smuggling in India: Exploring Links between Crime and Terrorism. Studies in Conflict & Terrorism 0, 1–18. https://doi.org/10.1080/1057610X.2019.1678875

Spilerman, S., Stecklov, G., 2009. Societal Responses to Terrorist Attacks. Annu. Rev. Sociol. 35, 167–189. https://doi.org/10.1146/annurev-soc-070308-120001

Starbird, K., 2017. Examining the Alternative Media Ecosystem Through the Production of Alternative Narra-tives of Mass Shooting Events on Twitter. ICWSM 11.

Taylor, M., Horgan, J., 2006. A Conceptual Framework for Addressing Psychological Process in the Develop-ment of the Terrorist. Terrorism and Political Vio-lence 18, 585–601. https://doi.org/10.1080/09546550600897413

Walker, M.K., 2015. Akil N. Awan, Andrew Hoskins, and Ben O'Loughlin. Radicalisation and Media: Con-nectivity and Terrorism in the New Media Ecology. Terrorism and Political Violence 27, 379–380. https://doi.org/10.1080/09546553.2015.1006102

Weimann, G., 2015. Terrorism in Cyberspace: The Next Generation, 1st edition. ed. Columbia University Press, Washington, D.C. : New York : Columbia Univer-sity Press.

The Second Wave (122 Readings)

Abbasi, I., Khatwani, M., 2014. An Overview of the Political Theories of Terrorism. IOSR Journal of Humani-ties and Social Science 19, 103–107. https://doi.org/10.9790/0837-1985103107

Allcott, H., Gentzkow, M., 2017. Social Media and Fake News in the 2016 Election. Journal of Economic Perspectives 31, 211–236. https://doi.org/10.1257/jep.31.2.211

Anker, P., 2001. Imperial ecology: environmental order in the British Empire, 1895-1945. Harvard University Press, Cambridge, Mass.

Archetti, C., 2012. Understanding Terrorism in the Age of Global Media: A Communication Approach. Pal-grave Macmillan UK, London, UNITED KINGDOM.

Audi, R. (Ed.), 2015. What is Systems Theory?, in: The Cambridge Dictionary of Philosophy. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9781139057509

Autio, E., Nambisan, S., Thomas, L.D.W., Wright, M., 2018. Digital affordances, spatial affordances, and the genesis of entrepreneurial ecosystems. Strategic Entrepreneurship Journal 12, 72–95. https://doi.org/10.1002/sej.1266

Awan, A.N., Hoskins, A., O'Loughlin, B., 2012. Radicalisation and media: connectivity and terrorism in the new media ecology, 1. issued in paperback. ed. Routledge, London.

Baele, S.J., Brace, L., Coan, T.G., 2019. From "Incel" to "Saint": Analyzing the violent worldview behind the 2018 Toronto attack. Terrorism and Political Violence 0, 1–25. https://doi.org/10.1080/09546553.2019.1638256

Barbre, Claude. 2011. Review of Review of The Fundamentalist Mindset: Psychological Perspectives on Reli-gion, Violence, and History, by Charles B. Strozier, David M. Terman, James W. Jones, Katharine A. Boyd, and Martin E. Marty. Journal of Religion and Health 50 (3): 521–26.

Bastos, M., Raimundo, R., Travitzki, R., 2013. Gatekeeping Twitter: Message diffusion in political hashtags. Media, Culture & Society 35, 260–270. https://doi.org/10.1177/0163443712467594

Benson, D.C., 2014. Why the Internet Is Not Increasing Terrorism. Security Studies 23, 293–328. https://doi.org/10.1080/09636412.2014.905353

Blaker, L., 2015. The Islamic State's Use of Online Social Media. MCA 1. https://doi.org/10.5038/2378-0789.1.1.1004

Blew, R., 1996. On the Definition of Ecosystem. Bulletin of the Ecological Society of America 77, 171–173.

Boley, H., Chang, E., 2007. Digital Ecosystems: Principles and Semantics, in: 2007 Inaugural IEEE-IES Digi-tal EcoSystems and Technologies Conference. Presented at the 2007 Inaugural IEEE-IES Digi-tal EcoSystems and Technologies Conference, pp. 398–403. https://doi.org/10.1109/DEST.2007.372005

Boots, B.N., Getis, A., 1988. Point Pattern Analysis. SAGE Publications.

Bouhana, N., 2019. The Moral Ecology of Extremism: A Systemic Perspective.

Bowker, G.C., 1999. Sorting things out: classification and its consequences, Inside technology. MIT Press, Cambridge, Mass.

Boxer, P., Huesmann, L.R., Dubow, E.F., Landau, S.F., Gvirsman, S.D., Shikaki, K., Ginges, J., 2013. Ex-posure to Violence Across the Social Ecosystem and the Development of Aggression: A Test of Ecological Theory in the Israeli–Palestinian Conflict. Child Development 84, 163–177. https://doi.org/10.1111/j.1467-8624.2012.01848.x

Brantingham, P.J., Brantingham, P.L., 1991. Environmental Criminology. Waveland Press.

Breslau, D., 1990. The Scientific Appropriation of Social Research: Robert Park's Human Ecology and Ameri-can Sociology. Theory and Society 19, 417–446.

Bronfenbrenner, U. (Ed.), 2005. Making Human Beings Human: Bioecological Perspectives on Human Devel-opment, 1st edition. ed. SAGE Publications, Inc, Thousand Oaks.

Bronfenbrenner, U., 1989. Ecological Systems Theory.

Bronfenbrenner, U., 1979. The ecology of human development: experiments by nature and design. Harvard University Press, Cambridge, Mass.

Burtch, G., Carnahan, S., Greenwood, B.N., 2018. Can You Gig It? An Empirical Examination of the Gig Economy and Entrepreneurial Activity. Management Science 64, 5497–5520. https://doi.org/10.1287/mnsc.2017.2916

Carugati, A., Fernández, W., Mola, L., Rossignoli, C., 2018. My choice, your problem? Mandating IT use in large organisational networks. Information Systems Journal 28, 6–47. https://doi.org/10.1111/isj.12120

Chadwick, A., 2011. The Political Information Cycle in a Hybrid News System: The British Prime Minister and the "Bullygate" Affair. The international journal of press/politics 16, 3–29. https://doi.org/10.1177/1940161210384730

Clark, C.J., Everson-Rose, S.A., Suglia, S.F., Btoush, R., Alonso, A., Haj-Yahia, M.M., 2010. Association between exposure to political violence and inti-mate-partner violence in the occupied Palestinian territory: a cross-sectional study. The Lancet 375, 310–316. https://doi.org/10.1016/S0140-6736(09)61827-4

Clifford, B., Powell, H., n.d. Encrypted Extremism: Inside the English-Speaking Islamic State Ecosystem on Telegram, Program on Extremism. The George Washington University, Washington DC: United States.

Cohen, L.E., Machalek, R., 1988. A General Theory of Expropriative Crime: An Evolutionary Ecological Ap-proach. American Journal of Sociology 94, 465–501. https://doi.org/10.1086/229027

Conway, M., Khawaja, M., Lakhani, S., Reffin, J., Robertson, A., Weir, D., 2019a. Disrupting Daesh: Meas-uring Takedown of Online Terrorist Material and Its Impacts. Studies in Conflict & Terrorism 42, 141–160. https://doi.org/10.1080/1057610X.2018.1513984

Conway, M., Scrivens, R., Macnair, L., 2019b. Right-Wing Extremists' Persistent Online Presence: History and Contemporary Trends. International Centre for Counter-Terrorism - The Hague. https://doi.org/10.19165/2019.3.12

Crenshaw, M., 1981. The Causes of Terrorism. Comparative Politics 13, 379. https://doi.org/10.2307/421717

Crockett, M.J., 2017. Moral outrage in the digital age. Nature Human Behaviour 1, 769–771. https://doi.org/10.1038/s41562-017-0213-3

Cu, E.M., Schermerhorn, A.C., Merrilees, C.E., Goeke-Morey, M.C., Shirlow, P., Cairns, E., 2010. Political violence and child adjustment in Northern Ireland: Testing pathways in a social–ecological model including single-and two-parent families. Developmental Psychology 46, 827–841. https://doi.org/10.1037/a0019668

Cummings, E.M., Goeke-Morey, M.C., Merrilees, C.E., Taylor, L.K., Peter Shirlow, 2014. A Social–Ecological, Process-Oriented Perspective on Political Violence and Child Development. Child Development Perspectives 8, 82–89. https://doi.org/10.1111/cdep.12067

Cummings, E.M., Merrilees, C.E., Schermerhorn, A.C., Goeke-Morey, M.C., Shirlow, P., Cairns, E., 2010a. Testing a social ecological model for relations between political violence and child adjustment in Northern Ireland. Development and psychopathology 22, 405–418. http://dx.doi.org.ezproxy.uow.edu.au/10.1017/S0954579410000143

Cummings, E.M., Schermerhorn, A.C., Merrilees, C.E., Goeke-Morey, M.C., Shirlow, P., Cairns, E., 2010b. Political violence and child adjustment in Northern Ireland: Testing pathways in a social–ecological model including single-and two-parent families. Developmental Psychology 46, 827–841. https://doi.org/10.1037/a0019668

Dawson, L., 2017. Sketch of a Social Ecology Model for Explaining Homegrown Terrorist Radicalisation. ICCT Research Papers. https://doi.org/10.19165/2017.1.01

Dubow, E.F., Huesmann, L.R., Boxer, P., 2009. A Social-Cognitive-Ecological Framework for Understanding the Impact of Exposure to Persistent Ethnic–Political Violence on Children's Psychosocial Adjustment. Clin Child Fam Psychol Rev 12, 113–126. https://doi.org/10.1007/s10567-009-0050-7

Earl, J., Garrett, R.K., 2017. The new information frontier: toward a more nuanced view of social movement communication. Social Movement Studies 16, 479–493. https://doi.org/10.1080/14742837.2016.1192028

ecosystem, n.d. . The Free Dictionary.

EU Internet Referral Unit, 2016. Year One Report: Highlights. Europol.

Eurich, A. (Ed.), 1970. The reformed English curriculum, in: High School 1980; the Shape of the Future in American Secondary Education. New York: Pitman, United States, pp. 160–68.

Facebook, 2017. Facebook, Microsoft, Twitter and YouTube Announce Formation of the Global Internet Fo-rum to Counter Terrorism. About Facebook. URL http://web.archive.org/web/20210607100028/https://about.fb.com/news/2017/06/global-internet-forum-to-counter-terrorism/ (accessed 4.10.21).

Finin, T., Joshi, A., Kolari, P., Java, A., Kale, A., Karandikar, A., 2008. The Information Ecology of Social Media and Online Communities. AI Magazine 29, 77–92. http://dx.doi.org.ezproxy.uow.edu.au/10.1609/aimag.v29i3.2158

Fisher, N.P., Winterbotham, E., 2020. Mapping the Jihadist Information Ecosystem: Towards the Next Genera-tion of Disruption Capability (No. 6), Global Research Network on Terrorism and Technology. RUSI, Lon-don.

Fourie, I., 2002. The Laws of the Web: Patterns in the Ecology of Information. The Electronic Library 20, 245. http://dx.doi.org.ezproxy.uow.edu.au/10.1108/el.2002.20.3.245.3

Fuller, M., 2007. Media Ecologies: Materialist Energies in Art and Technoculture, 1st edition. ed. A Leonardo Book, Cambridge, Massachusetts London, England.

García-Marco, F.-J., 2011. Libraries in the digital ecology: reflections and trends. The Electronic Library 29, 105–120. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1108/02640471111111460

Gatrell, A.C., Bailey, T.C., Diggle, P.J., Rowlingson, B.S., 1996. Spatial Point Pattern Analysis and Its Ap-plication in Geographical Epidemiology. Transactions of the Institute of British Geographers 21, 256–274. https://doi.org/10.2307/622936

Gibson, J.J., 1979. The ecological approach to visual perception. Houghton Mifflin, Boston.

Gillespie, M., Osseiran, S., Cheesman, M., 2018. Syrian Refugees and the Digital Passage to Europe: Smartphone Infrastructures and Affordances. Social Media + Society 4, 2056305118764440. https://doi.org/10.1177/2056305118764440

Ging, D., 2019. Alphas, Betas, and Incels: Theorizing the Masculinities of the Manosphere. Men and Mascu-linities 22, 638–657. https://doi.org/10.1177/1097184X17706401

Guattari, F., 2000. The three ecologies, Athlone contemporary European thinkers. Athlone Press, London.

Hamid, N., 2020. The Ecology of Extremists' Communications: Messaging Effectiveness, Social Environ-ments and Individual Attributes. The RUSI Journal 165, 54–63. https://doi.org/10.1080/03071847.2020.1731248

Hasen, R.L., 2017. Cheap Speech and What It Has Done (to American Democracy) (SSRN Scholarly Paper No. ID 3017598). Social Science Research Network, Rochester, NY.

Hesseling, R.B.P., 1992. Using Data on Offender Mobility in Ecological Research. Journal of Quantitative Criminology 8, 95–112.

Hofstede, G.H., 2001. Culture's consequences: comparing values, behaviors, institutions, and organizations across nations, 2nd ed. ed. Sage Publications, Thou-sand Oaks, Calif.

Huberman, B., 2001. The laws of the Web: patterns in the ecology of information. MIT Press, Cambridge, Mass.

Islas, O., 2015. La ecología de los medios: metadisciplina compleja y sistémica. Palabra Clave 18.

Jewkes, Y., Yar, M., Denning, D. (Eds.), 2011. Terror's web: How the internet is transforming terrorism, in: Handbook of Internet Crime. Willan Publishing, Uff-culme, UNITED STATES.

Johnson, N.F., Leahy, R., Restrepo, N.J., Velasquez, N., Zheng, M., Manrique, P., Devkota, P., Wuchty, S., 2019. Hidden resilience and adaptive dynamics of the global online hate ecology. Nature 573, 261-2,265A-265D. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1038/s41586-019-1494-7

Johnson, N.F., Zheng, M., Vorobyeva, Y., Gabriel, A., Qi, H., Velasquez, N., Manrique, P., Johnson, D., Restrepo, E., Song, C., Wuchty, S., 2016. New online ecology of adversarial aggregates: ISIS and beyond. Science 352, 1459–1463. https://doi.org/10.1126/science.aaf0675

Kegley, C.W. (Ed.), 1990. International Terrorism: Characteristics, Causes, Controls. Palgrave Macmillan, New York, NY.

Kelly, K., 2011. What technology wants, A Penguin Book Technology, Science. Penguin books, New York Toronto London.

Kleinberg, B., Vegt, I. van der, Gill, P., 2020. The temporal evolution of a far-right forum. J Comput Soc Sc 1–23. https://doi.org/10.1007/s42001-020-00064-x

Koene, A., Perez, V., Webb, H., Patel, M., Ceppi, S., Jirotka, M., McAuley, D., 2017. Editorial responsibili-ties arising from personalization algorithms. The ORBIT Journal 1, 1–12. https://doi.org/10.29297/orbit.v1i1.26

LaFree, G., Bersani, B.E., 2014. County-Level Correlates of Terrorist Attacks in the United States. Criminolo-gy & Public Policy 13, 455–481. https://doi.org/10.1111/1745-9133.12092

Landau, S.F., Pfeffermann, D., 1988. A Time Series Analysis of Violent Crime and Its Relation to Prolonged States of Warfare: The Israeli Case*. Criminology 26, 489–504. https://doi.org/10.1111/j.1745-9125.1988.tb00852.x

Latour, B., 2005. Reassembling the social: an introduction to actor-network-theory, fulcrum.org. Oxford Uni-versity Press.

Law, J., 1992. Notes on the theory of the actor-network: Ordering, strategy, and heterogeneity. Systems Prac-tice 5, 379–393. https://doi.org/10.1007/BF01059830

Leventhal, T., Brooks-Gunn, J., 2000. The neighborhoods they live in: The effects of neighborhood residence on child and adolescent outcomes. Psychological Bulletin 126, 309–337. https://doi.org/10.1037/0033-2909.126.2.309

Li, W., Badr, Y., Biennier, F., 2012. Digital ecosystems: challenges and prospects, in: Proceedings of the In-ternational Conference on Management of Emergent Digital EcoSystems, MEDES '12. Association for Computing Machinery, New York, NY, USA, pp. 117–122. https://doi.org/10.1145/2457276.2457297

Lum, C.M.K., 2000. Introduction: The intellectual roots of media ecology. New Jersey Journal of Communica-tion 8, 1–7. https://doi.org/10.1080/15456870009367375

Lyon, D., 2001. Surveillance Society. McGraw-Hill Education, Maidenhead, UNITED KINGDOM.

Macdonald, S., Grinnell, D., Kinzel, A., Lorenzo-Dus, N., 2019. Daesh, Twitter and the Social Media Ecosys-tem. The RUSI Journal 164, 60–72. https://doi.org/10.1080/03071847.2019.1644775

McCauley, C., Moskalenko, S., 2008. Mechanisms of Political Radicalization: Pathways Toward Terrorism. Terrorism and Political Violence 20, 415–433. https://doi.org/10.1080/09546550802073367

McCauley, C.R., Moskalenko, S., 2011. Friction: how radicalization happens to them and us. Oxford Univer-sity Press, Oxford; New York.

McLuhan, M., 2001. Understanding Media. Taylor & Francis Group, Florence, USA, UNITED KINGDOM.

Merali, Y., 2006. Complexity and Information Systems: The Emergent Domain. Journal of Information Tech-nology 21, 216–228. https://doi.org/10.1057/palgrave.jit.2000081

Mercea, D., Iannelli, L., Loader, B.D., 2016. Protest communication ecologies. Information, Communication & Society 19, 279–289. https://doi.org/10.1080/1369118X.2015.1109701

Miller, J.G., 1978. Living systems. McGraw-Hill, New York.

Mitchell, W.J.T., 2005. There Are No Visual Media. Journal of Visual Culture 4, 257–266. https://doi.org/10.1177/1470412905054673

Moen, P., Elder, G.H., Lüscher, K., Bronfenbrenner, U., 1995. Examining lives in context perspectives on the ecology of human development, 1st ed. ed, APA science volumes. American Psychological Association, Washington, DC.

Moore, J.F., 1996. The death of competition: leadership and strategy in the age of business ecosys-tems. HarperBusiness, New York.

Morozov, E., 2011. The Net Delusion: The Dark Side of Internet Freedom. PublicAffairs, New York, UNITED STATES.

Muganda, N., 2014. Towards a Regional Ontology for E-Participation: An Ecological View 60–72. https://doi.org/10.4018/978-1-4666-5868-4.ch005

Operating Eurovision and EuroRadio, n.d. EBU - "Fake News" and the Information Disorder [WWW Docu-ment]. URL https://www.ebu.ch/news/2018/04/fake-news-and-the-information-disorder (accessed 4.10.21).

Paganini, P., 2018. The Role of Technology in Modern Terrorism [WWW Document]. Infosec Resources. URL https://resources.infosecinstitute.com/topic/the-role-of-technology-in-modern-terrorism/ (accessed 4.10.21).

Papacharissi, Z., 2014. Affective Publics: Sentiment, Technology, and Politics. Oxford University Press. https://doi.org/10.1093/acprof:oso/9780199999736.001.0001

Park, R.E., 1952. Human Communities: The City and Human Ecology. Free Press.

Park, R.E., 1936. Human Ecology. American Journal of Sociology 42, 1–15. https://doi.org/10.1086/217327

Pennington, R., Krona, M. (Eds.), 2019. The Media World of ISIS, Illustrated edition. ed. Indiana University Press, Bloomington.

Per-Olof, W.H., 1985. Everyday Violence in Contemporary Sweden: Situational and Ecological Aspects. Na-tional Council for Crime Prevention, Sweden, Stockholm.

Plantin, J.-C., Lagoze, C., Edwards, P.N., Sandvig, C., 2018. Infrastructure studies meet platform studies in the age of Google and Facebook. New Media & Society 20, 293–310. https://doi.org/10.1177/1461444816661553

Pugliese, J., 2008. Biotypologies of terrorism. Cultural studies review 14, 49–66.

Rainie, H., Wellman, B., 2012. Networked: the new social operating system. MIT Press, Cambridge, Mass.

Ross, S.M., 2009. Postman, Media Ecology, and Education: From Teaching as a Subversive Activity through Amusing Ourselves to Death to Technopoly. Review of Communication 9, 146–156. https://doi.org/10.1080/15358590802326435

Sahani, Shradha. 2018. "Examining the Association Between Social Media and Violent Extremism: A Social Learning Approach." M.A., United States -- Maryland: University of Maryland, College Park. http://search.proquest.com/docview/2278079013/abstract/A4F3A67983DE40A9PQ/1.

School of Computing, (CA441 BPM), 2012. Socio-Technical Systems.

Scolari, C.A., 2012. Media Ecology: Exploring the Metaphor to Expand the Theory. Communication Theory 22, 204–225. https://doi.org/10.1111/j.1468-2885.2012.01404.x

Shapiro, S., 1997. Caught in a web: The implications of ecology for radical symmetry in STS. Social Episte-mology 11, 97–110. https://doi.org/10.1080/02691729708578832

Sharma, S., 2013. Black Twitter? Racial Hashtags, Networks and Contagion. New Formations 46-64,207.

Silke, A. (Ed.), 2003. Terrorists, Victims and Society: Psychological Perspectives on Terrorism and its Conse-quences: 19, 1st edition. ed. Wiley, Chichester, West Sussex, England ; Hoboken, NJ.

Snipes, Bernard, Gerould, 2019. Vold's Theoretical Criminology, 8th edition. ed. Oxford University Press USA, New York.

Sowney, R., 2004. Terrorists, victims and society. Accident and Emergency Nursing 12, 126. https://doi.org/10.1016/j.aaen.2003.09.003

Stark, R., 1987. Deviant Places: A Theory of the Ecology of Crime. Criminology 25, 893–910.

Stokols, D., 1992. Establishing and Maintaining Healthy Environments: Toward a Social Ecology of Health Promotion. American Psychological Association 47, 6–22.

Strozier, C.B., Terman, D.M., Jones, J.W., Boyd, K. (Eds.), 2010. The fundamentalist mindset: psychological perspectives on religion, violence, and history. Oxford University Press, New York.

Susser, E., 2004. Eco-Epidemiology: Thinking Outside the Black Box. Epidemiology 15, 519–520. https://doi.org/10.1097/01.ede.0000135911.42282.b4

Susser, M., Susser, E., 1996. Choosing a future for epidemiology: I. Eras and paradigms. American Journal of Public Health 86, 668–73.

Syrdal, H.A., Briggs, E., 2018. Engagement with Social Media Content: A Qualitative Exploration. Journal of Marketing Theory and Practice 26, 4–22. https://doi.org/10.1080/10696679.2017.1389243

Teigland, R., Holmberg, H., Felländer, A., 2019. The Importance of Trust in a Digital Europe: Reflections on the Sharing Economy and Blockchains, in: Bakardjieva Engelbrekt, A., Bremberg, N., Michalski, A., Oxelheim, L. (Eds.), Trust in the European Union in Challenging Times: Interdisciplinary European Stud-ies. Springer International Publishing, Cham, pp. 181–209. https://doi.org/10.1007/978-3-319-73857-4_9

Treré, E., 2012. Social Movements as Information Ecologies: Exploring the Coevolution of Multiple Internet Technologies for Activism. International Journal of Communication (19328036) 6, 2359–2377.

Tufecki, Z., 2017. Twitter and Tear Gas : The Power and Fragility of Networked Protest. Yale University Press, New Haven.

Tuten, T., Mintu-Wimsatt, A., 2018. Advancing Our Understanding of the Theory and Practice of Social Media Marketing: Introduction to the Special Issue. Journal of Marketing Theory and Practice 26, 1–3. https://doi.org/10.1080/10696679.2018.1393277

Vila, B., 1994. A General Paradigm for Understanding Criminal Behavior: Extending Evolutionary Ecological Theory*. Criminology 32, 311–360. https://doi.org/10.1111/j.1745-9125.1994.tb01157.x

Wardle, C., Derakhshan, H., 2017. Information Disorder: Toward an interdisciplinary framework for research and policymaking. Counter of Europe.

Wikström, P.-O.H., 1985. Everyday violence in contemporary Sweden : situational and ecological aspects.

Winifred, G., 2016. Chapter 10 – Sociotechnical Systems 1Chapter 10 Sociotechnical Systems. - ppt down-load.

Winner, L., 1993. Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philos-ophy of Technology. Science, Technology, & Human Values 18, 362–378.

Zizek, S., 2007. Censorship Today: Violence, or Ecology, a New Opium for the Masses [WWW Docu-ment]. Slavoj Zizek. URL https://www.lacan.com/zizecology1.htm (accessed 4.10.21).

The Third Wave | Media and Communication (46 Readings)

Alvedalen, J., Boschma, R., 2017. A critical review of entrepreneurial ecosystems research: towards a future research agenda. European Planning Studies 25, 887–903. https://doi.org/10.1080/09654313.2017.1299694

Amble, John Curtis. 2012. "Combating Terrorism in the New Media Environment." Studies in Conflict & Terrorism 35 (5): 339–53. https://doi.org/10.1080/1057610X.2012.666819.

Bassett, C., 2011. 17 Digital Media. The Year's Work in Critical and Cultural Theory 19, 367–386. https://doi.org/10.1093/ywcct/mbr017

Bayer, J.B., Triệu, P., Ellison, N.B., 2020. Social Media Elements, Ecologies, and Effects. Annu. Rev. Psy-chol. 71, 471–497. https://doi.org/10.1146/annurev-psych-010419-050944

Bogaczyk, J., 2017. Intersubjective intentionality, moral consciousness, and media ecology. Review of Com-munication 17, 342–356. https://doi.org/10.1080/15358593.2017.1367823

Bogardy, J., 2010. Remanufacturing ourselves in the face of trauma: A media ecology perspective on post-9/11 culture. ProQuest Dissertations Publishing.

Boley, H., Chang, E., 2007. Digital Ecosystems: Principles and Semantics, in: 2007 Inaugural IEEE-IES Digi-tal EcoSystems and Technologies Conference. Pre-sented at the 2007 Inaugural IEEE-IES Digi-tal EcoSystems and Technologies Conference, pp. 398–403. https://doi.org/10.1109/DEST.2007.372005

Bond, L., Craps, S., Vermeulen, P., 2016. Introduction: Memory on the Move, in: Memory Unbound: Tracing the Dynamics of Memory Studies. Berghahn Books, New York.

Bratich, J., 2014. Occupy All the Dispositifs: Memes, Media Ecologies, and Emergent Bodies Politic. Com-munication and Critical/Cultural Studies 11, 64–73. https://doi.org/10.1080/14791420.2013.827351

Briscoe, G., 2010. Complex adaptive digital EcoSystems, in: Proceedings of the International Conference on Management of Emergent Digital EcoSystems, MEDES '10. Association for Computing Machinery, New York, NY, USA, pp. 39–46. https://doi.org/10.1145/1936254.1936262

Briscoe, G., 2009. Digital Ecosystems. arXiv:0909.3423 [cs].

Briscoe, G., De Wilde, P., 2009. Computing of applied digital ecosystems, in: Proceedings of the International Conference on Management of Emergent Digital EcoSystems, MEDES '09. Association for Computing Machinery, New York, NY, USA, pp. 28–35. https://doi.org/10.1145/1643823.1643830

Caldarola, E.G., Picariello, A., Rinaldi, A.M., 2015. An approach to ontology integration for ontology reuse in knowledge based digital ecosystems, in: Pro-ceedings of the 7th International Conference on Management of Computational and Collective IntElligence in Digital EcoSystems, MEDES '15. Association for Compu-ting Machinery, New York, NY, USA, pp. 1–8. https://doi.org/10.1145/2857218.2857219

Chatzakou, D., Soler-Company, J., Tsikrika, T., Wanner, L., Vrochidis, S., Kompatsiaris, I., 2020. User Iden-tity Linkage in Social Media Using Linguistic and Social Interaction Features, in: Identity and Privacy. Pre-sented at the 12th ACM Web Science Conference 2020.

Cunningham, S., 2015. The new screen ecology: a new wave of media globalisation? Communication Research and Practice 1, 275–282. https://doi.org/10.1080/22041451.2015.1079159

Dijck, J. van, 2016. Connective Memory: How Facebook Takes Change of Your Past, in: Bond, L., Craps, S., Vermeulen, P. (Eds.), Memory Unbound: Tracing the Dynamics of Memory Studies. Berghahn Books, New York.

Dini, P., Iqani, M., Mansell, R., 2011. The (Im)possibility of Interdisciplinarity: Lessons from Constructing a Theoretical Framework for Digital Ecosystems. Culture, Theory and Critique 52, 3–27. https://doi.org/10.1080/14735784.2011.621668

Duffy, B.E., Pruchniewska, U., Scolere, L., 2017. Platform-Specific Self-Branding: Imagined Affordances of the Social Media Ecology, in: Proceedings of the 8th International Conference on Social Media & Society, #SMSociety17. Association for Computing Machinery, New York, NY, USA, pp. 1–9. https://doi.org/10.1145/3097286.3097291

Gere, C., 2016. 16 Media. Years Work Crit Cult Theory 24, 343–355. https://doi.org/10.1093/ywcct/mbw016

Häussler, T., 2019. Civil society, the media and the Internet: changing roles and challenging authorities in digi-tal political communication ecologies. Informa-tion, Communication & Society 0, 1–18. https://doi.org/10.1080/1369118X.2019.1697338

Hein, A., Schreieck, M., Riasanow, T., Setzke, D.S., Wiesche, M., Böhm, M., Krcmar, H., 2020. Digital platform ecosystems. Electron Markets 30, 87–98. https://doi.org/10.1007/s12525-019-00377-4

Hendry, P.D. and M.D. and N.R. and M.V. and P.H. and P.F. and G.B. and S., 2005. The Digital Ecosys-tems Research Vision: 2010 and Beyond.

Hu, X., Sastry, N., 2020. What a Tangled Web We Weave: Understanding the Interconnectedness of the Third Party Cookie Ecosystem, in: 12th ACM Con-ference on Web Science. Presented at the WebSci '20: 12th ACM Conference on Web Science, ACM, Southampton United Kingdom, pp. 76–85. https://doi.org/10.1145/3394231.3397897

Johnsrud, B., 2016. Metaphorical Memories of the Medieval Crusades after 9/11, in: Bond, L., Craps, S., Vermeulen, P. (Eds.), Memory Unbound: Tracing the Dynamics of Memory Studies. Berghahn Books, New York.

Jung, J.-Y., 2008. Internet Connectedness and its Social Origins: An Ecological Approach to Postaccess Digital Divides. Communication Studies 59, 322–339. https://doi.org/10.1080/10510970802467387

Krogstie, J., 2012. Modeling of Digital Ecosystems: Challenges and Opportunities, in: Camarinha-Matos, L.M., Xu, L., Afsarmanesh, H. (Eds.), Collaborative Networks in the Internet of Services, IFIP Advances in Information and Communication Technology. Springer, Berlin, Heidelberg, pp. 137–145. https://doi.org/10.1007/978-3-642-32775-9_14

Lagerkvist, A., 2016. Embodiments of Memory: Toward an Existential Approach to the Cutlure of Connectivi-ty, in: Bond, L., Craps, S., Vermeulen, P. (Eds.), Memory Unbound: Tracing the Dynamics of Memory Studies. Berghahn Books, New York.

Laudon, K.C., Traver, C.G., 2008. E-commerce: business, technology, society. Pearson/Prentice Hall, Upper Saddle River, N.J.

Li, W., Badr, Y., Biennier, F., 2012. Digital ecosystems: challenges and prospects, in: Proceedings of the In-ternational Conference on Manage-ment of Emergent Digital EcoSystems, MEDES '12. Association for Computing Machinery, New York, NY, USA, pp. 117–122. https://doi.org/10.1145/2457276.2457297

López Jiménez, D.F., Odriozola Chéné, J., Bernal Suárez, J.D., 2016. Theory of a Human Ecology of Com-munication: empirical evidence of the Internet con-sumption ecosystem in Ecuador. CommSoc 101–123. https://doi.org/10.15581/003.29.1.101-123

Massachs, J., Monti, C., Morales, G.D.F., Bonchi, F., 2020. Roots of Trumpism: Homophily and Social Feedback in Donald Trump Support on Reddit. 12th ACM Conference on Web Science 49–58. https://doi.org/10.1145/3394231.3397894

Mattoni, A., 2017. A situated understanding of digital technologies in social movements. Media ecology and media practice approaches. Social Movement Studies 16, 494–505. https://doi.org/10.1080/14742837.2017.1311250

Monge, P., Lee, S., Fulk, J., Weber, M., Shen, C., Schultz, C., Margolin, D., Gould, J., Frank, L.B., 2011. Research Methods for Studying Evolutionary and Eco-logical Processes in Organizational Communication: Management Communication Quarterly. https://doi.org/10.1177/0893318911399447

Moran, M.B., Frank, L.B., Zhao, N., Gonzalez, C., Thainiyom, P., Murphy, S.T., Ball-Rokeach, S.J., 2016. An Argument for Ecological Research and Intervention in Health Communication. Journal of Health Com-munication 21, 135–138. https://doi.org/10.1080/10810730.2015.1128021

Moscato, V., Picariello, A., Rinaldi, A.M., 2010. A recommendation strategy based on user behavior in digital ecosystems, in: Proceedings of the International Conference on Management of Emergent Digi-tal EcoSystems - MEDES '10. Presented at the the International Conference, ACM Press, Bangkok, Thai-land, p. 25. https://doi.org/10.1145/1936254.1936259

Poell, T., 2014. Social media and the transformation of activist communication: exploring the social media ecology of the 2010 Toronto G20 protests. Infor-mation, Communication & Society 17, 716–731. https://doi.org/10.1080/1369118X.2013.812674

Rieder, B., 2020. Engines of Order: A Mechanology of Algorithmic Techniques. Amsterdam University Press. https://doi.org/10.2307/j.ctv12sdvf1

Scolari, C.A., 2012. Media Ecology: Exploring the Metaphor to Expand the Theory. Communication Theory 22, 204–225. https://doi.org/10.1111/j.1468-2885.2012.01404.x

Steensen, S., Eide, T., 2019. News Flows, Inter-Media Connectivity and Societal Resilience in Times of Cri-sis. Digital Journalism 7, 932–951. https://doi.org/10.1080/21670811.2018.1520607

Stepanova, V., Ukhanova, A., Grigorishchin, A., Yakhyaev, D., 2019. Evaluating Digital Ecosystems in Rus-sia's Regions. ESC / ЭиСП. https://doi.org/10.15838/esc.2019.2.62.4

Štětka, V., Mihelj, S., Tóth, F., 2020. The Impact of News Consumption on Anti-immigration Attitudes and Populist Party Support in a Changing Media Ecol-ogy. Political Communication 0, 1–22. https://doi.org/10.1080/10584609.2020.1820647

Strate, L., 2008. Studying Media AS Media: McLuhan and the Media Ecology Ap-proach. MediaTropes eJournal 1, 127–142.

Swart, J., Peters, C., Broersma, M., 2017. Repositioning news and public connection in everyday life: a user-oriented perspective on inclusiveness, engage-ment, relevance, and constructiveness. Media, Culture & Socie-ty 39, 902–918. https://doi.org/10.1177/0163443716679034

Taneja, H., Wu, A.X., 2019. Web Infrastructures and Online Attention Ecology. International Journal of Com-munication 13, 21.

Tsujimoto, M., Kajikawa, Y., Tomita, J., Matsumoto, Y., 2018. A review of the ecosystem concept — Towards coherent ecosystem design. Technological Fore-casting and Social Change 136, 49–58. https://doi.org/10.1016/j.techfore.2017.06.032

Veilleux-Lepage, Y., 2020. How Terror Evolves: The Emergence and Spread of Terrorist Techniques, 1st edi-tion. ed. Rowman & Littlefield Publishers, Lanham.

Wood, M.A., 2018. 'I just wanna see someone get knocked the fuck out': Spectating affray on Facebook fight pages. Crime, Media, Culture 14, 23–40. https://doi.org/10.1177/1741659016667437

Yousuf, M., 2016. Niches in the Networlked Media Ecosystem: Funcationalities, Gratifications, and a Typolo-gy of Online News and Informational Media.

The Third Wave | Natural Sciences (30 Readings)

Abel, T., Stepp, J.R., 2003. A New Ecosystems Ecology for Anthropology. Conservation Ecology 7.

Anker, P., 2001. Imperial ecology: environmental order in the British Empire, 1895-1945. Harvard University Press, Cambridge, Mass.

Blew, R., 1996. On the Definition of Ecosystem. Bulletin of the Ecological Society of America 77, 171–173.

Blew, R.D., 1996. On the Definition of Ecosystem. Bulletin of the Ecological Society of America 77, 171–173.

Bohorquez, J.C., Gourley, S., Dixon, A.R., Spagat, M., Johnson, N.F., 2009. Common ecology quantifies human insurgency. Nature 462, 911–4. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1038/nature08631

Briscoe, G., Sadedin, S., Paperin, G., 2007. Biology of Applied Digital Ecosystems, in: 2007 Inaugural IEEE-IES Digital EcoSystems and Technologies Conference. Presented at the 2007 Inaugural IEEE-IES Digi-tal EcoSystems and Technologies Conference, IEEE, Cairns, Australia, pp. 458–463. https://doi.org/10.1109/DEST.2007.372015

Cebrian, M., Torres, M.R., Huerta, R., Fowler, J.H., 2013. Violent extremist group ecologies under stress. Scientific Reports 3, 1544. https://doi.org/10.1038/srep01544

Cronk, L., 1991. Human Behavioral Ecology. Annu. Rev. Anthropol. 20, 25–53. https://doi.org/10.1146/annurev.an.20.100191.000325

Daily, G.C., Matson, P.A., 2008. Ecosystem services: from theory to implementation. Proc Natl Acad Sci U S A 105, 9455–9456. https://doi.org/10.1073/pnas.0804960105

Dawkins, R., 2015. The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without De-sign, 1 edition. ed. W. W. Norton & Company.

Dawkins, R., 1999. The Extended Phenotype: The Long Reach of the Gene, Revised edition. ed. Oxford Uni-versity Press, Oxford ; New York.

Dickinson, G., Murphy, K., 2007. Ecosystems. Routledge.

Elrick, L.E., 2021. The ecosystem concept: a holistic approach to privacy protection. International Review of Law, Computers & Technology 35, 24–45. https://doi.org/10.1080/13600869.2020.1784564

Fath, B.D., Jørgensen, S.E., 2019. Encyclopedia of ecology.

Gatrell, A.C., Bailey, T.C., Diggle, P.J., Rowlingson, B.S., 1996. Spatial Point Pattern Analysis and Its Ap-plication in Geographical Epidemiology. Transactions of the Institute of British Geographers 21, 256–274. https://doi.org/10.2307/622936

Gibson, J.J., 1979. The ecological approach to visual perception. Houghton Mifflin, Boston.

Gould, S.J., 1979. Ever Since Darwin: Reflections in Natural History. W. W. Norton & Company, New York London.

Jacobides, M.G., Cennamo, C., Gawer, A., 2018. Towards a theory of ecosystems. Strategic Management Journal 39, 2255–2276. https://doi.org/10.1002/smj.2904

Jax, K., 2007. Can We Define Ecosystems? On the Confusion Between Definition and Description of Ecologi-cal Concepts. Acta Biotheor 55, 341–355. https://doi.org/10.1007/s10441-007-9024-7

Johnson, N.F., Leahy, R., Restrepo, N.J., Velasquez, N., Zheng, M., Manrique, P., Devkota, P., Wuchty, S., 2019. Hidden resilience and adaptive dynamics of the global online hate ecology. Nature 573, 261-2,265A-265D. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1038/s41586-019-1494-7

Jordan, C.F., 1981. Do Ecosystems Exist? The American Naturalist 118, 284–287. https://doi.org/10.1086/283820

Loreau, M., 2010. Linking biodiversity and ecosystems: towards a unifying ecological theory. Philosophical Transactions of the Royal Society B: Biological Sci-ences 365, 49–60. https://doi.org/10.1098/rstb.2009.0155

Mars, M.M., Bronstein, J.L., 2018. The Promise of the Organizational Ecosystem Metaphor: An Argument for Biological Rigor. Journal of Management Inquiry 27, 382–391. https://doi.org/10.1177/1056492617706546

Martínez-Harms, M.J., Balvanera, P., 2012. Methods for mapping ecosystem service supply: a review. Interna-tional Journal of Biodiversity Science, Ecosystem Services & Management 8, 17–25. https://doi.org/10.1080/21513732.2012.663792

Mervis, J., Kaiser, J., 2003. NSF Hopes Congress Will See the Light on NEON. Science 300, 1869–1870. https://doi.org/10.1126/science.300.5627.1869

Miller, R.E., 2006. Eco-Epidemiology as Anti-Terrorism. International Quarterly of Community Health Educa-tion 26, 307–317.

Odum, E.P., 1968. Energy Flow in Ecosystems: A Historical Review. American Zoologist 8, 11–18. https://doi.org/10.1093/icb/8.1.11

Sagarin, R., 2012. Tidepools and terrorism: a tale of adaptation. Frontiers in Ecology and the Environment, Ecological Society of America 10, 390–391.

Santarém, F., Saarinen, J., Brito, J.C., 2020. Mapping and analysing cultural ecosystem services in conflict areas. Ecological Indicators 110, 105943. https://doi.org/10.1016/j.ecolind.2019.105943

Susser, E., 2004. Eco-Epidemiology: Thinking Outside the Black Box. Epidemiology 15, 519–520. https://doi.org/10.1097/01.ede.0000135911.42282.b4

Susser, M., Susser, E., 1996. Choosing a future for epidemiology: I. Eras and paradigms. American Journal of Public Health 86, 668–73.

Vayda, A.P., McCay, B.J., 1975. New Directions in Ecology and Ecological Anthropology. Annu. Rev. Anthropol. 4, 293–306. https://doi.org/10.1146/annurev.an.04.100175.001453

Walker, J., Cooper, M., 2011. Genealogies of resilience: From systems ecology to the political economy of crisis adaptation. Security Dialogue 42, 143–160. https://doi.org/10.1177/0967010611399616

Yackinous, W., 2015. Understanding Complex Ecosystem Dynamics. Elsevier. https://doi.org/10.1016/C2014-0-01057-X

APPENDIX THREE: SOURCES | LISTED BY TEN CHARACTERISTICS

Network

Baele, Stephane J., Lewys Brace, and Travis G. Coan. 2020. "Uncovering the Far-Right Online Ecosystem: An Analytical Framework and Research Agenda." Studies in Conflict & Terrorism 0 (0): 1–21. https://doi.org/10.1080/1057610X.2020.1862895

Conway, Maura, Moign Khawaja, Suraj Lakhani, and Jere-my Reffin. 2021. "A Snapshot of the Syrian Jihadi Online Ecology: Differential Disruption, Community Strength, and Preferred Other Platforms." Studies in Conflict & Terrorism 0 (0): 1–17. https://doi.org/10.1080/1057610X.2020.1866736.

Conway, Maura, Moign Khawaja, Suraj Lakhani, Jeremy Reffin, Andrew Robertson, and David Weir. 2019. "Disrupting Daesh: Measuring Takedown of Online Terror-ist Material and Its Impacts." Studies in Conflict & Terrorism 42 (1–2): 141–60. https://doi.org/10.1080/1057610X.2018.1513984

Department of Security Studies and Criminology. 2020. "Mapping Networks and Narratives of Online Right-Wing Extremists in New South Wales." (Version 1.0.1). Sydney: Macquarie University. http://doi.org/10.5281/zenodo.4071472

Felson, Marcus. 2006. "The Ecosys-tem for Organized Crime." Presented at the HEUNI 25th Anniversary Lecture: 7th Inkeri Anttila Lecture, Hel-sinki, Finland, October. https://www.peacepalacelibrary.nl/ebooks/files/HEUNI_2rreolo2h.pdf

Johnson, N. F., R. Leahy, N. Johnson Restrepo, N. Ve-lasquez, M. Zheng, P. Manrique, P. Devkota, and S. Wuchty. 2019. "Hidden Resilience and Adaptive Dynam-ics of the Global Online Hate Ecology." Nature 573 (7773): 261-2,265A-265D. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1038/s41586-019-1494-7

Dynamism

Baele, Stephane J., Lewys Brace, and Travis G. Coan. 2019. "From 'Incel' to 'Saint': Analyzing the Violent Worldview behind the 2018 Toronto Attack." Terrorism and Political Violence 0 (0): 1–25. https://doi.org/10.1080/09546553.2019.1638256

Baele, Stephane J., Lewys Brace, and Travis G. Coan. 2020. "Uncovering the Far-Right Online Ecosystem: An Analytical Framework and Research Agenda." Studies in Conflict & Terrorism 0 (0): 1–21. https://doi.org/10.1080/1057610X.2020.1862895.

Borum, R. (2011). Radicalization into Violent Extremism I: A Review of Social Science Theories. Journal of Strategic Security, 4(4). https://global.oup.com/academic/product/reassembling-the-social-9780199256051?cc=us&lang=en&.

Briscoe, Gerard. 2010. "Complex Adaptive Digital EcoSystems." In Proceedings of the International Conference on Management of Emergent Digital EcoSystems, 39–46. MEDES '10. New York, NY, USA: Association for Computing Machin-ery. https://doi.org/10.1145/1936254.1936262

Briscoe, Gerard. 2009. "Dig-ital Ecosystems." ArXiv:0909.3423 [Cs], October. http://arxiv.org/abs/0909.3423

Götz, F., Hamann, C., Meckl, R., Buck, C., Oesterle, S., & Eymann, T. (2020). Dynamic Capabilities as the Key Approach to Investigate Digital Ecosystems (pp. 1396–1411). https://doi.org/10.30844/wi_2020_m5-goetz

Johnson, N. F., M. Zheng, Y. Vorobyeva, A. Gabriel, H. Qi, N. Velasquez, P. Manrique, et al. 2016. "New Online Ecology of Adversarial Aggregates: ISIS and Beyond." Science 352 (6292): 1459–63. https://doi.org/10.1126/science.aaf0675

Latour, Bruno. 2005. "Reassembling the social: an introduction to actor-network-theory", Oxford Universi-ty Press.

Li, Wenbin, Youakim Badr, and Frédérique Biennier. 2012. "Digital Ecosystems: Challenges and Prospects." In Proceedings of the International Conference on Man-agement of Emergent Digital EcoSystems, 117–22. MEDES '12. New York, NY, USA: Association for Compu-ting Machinery. https://doi.org/10.1145/2457276.2457297.

Merali, Yasmin. 2006. "Complexity and Information Systems: The Emergent Domain." Journal of Infor-mation Technology 21 (4): 216–28. https://doi.org/10.1057/palgrave.jit.2000081

Classification

Baele, Stephane J., Lewys Brace, and Travis G. Coan. 2020. "Uncovering the Far-Right Online Ecosystem: An Analytical Framework and Research Agenda." Studies in Conflict & Terrorism 0 (0): 1–21. https://doi.org/10.1080/1057610X.2020.1862895

Conway, Maura, Moign Khawaja, Suraj Lakhani, and Jere-my Reffin. 2021. "A Snapshot of the Syrian Jihadi Online Ecology: Differential Disruption, Community Strength, and Preferred Other Platforms." Studies in Conflict & Terrorism 0 (0): 1–17. https://doi.org/10.1080/1057610X.2020.1866736.

Crenshaw, Martha. 1981. "The Causes of Terrorism." Comparative Politics 13 (4): 379–99. http://doi.org/10.2307/421717; Miller, Richard E. 2006. "Eco-Epidef miology as Anti-Terrorism." International Quarterly of Community Health Education 26 (3): 307–17.

Complexity

Conway, Maura. 2020a. "Routing the Extreme Right." The RUSI Journal 165 (1): 108–13. https://doi.org/10.1080/03071847.2020.1727157.

Conway, Maura. 2020b. "De-termining the Role of the Internet in Right-Wing Extremism and Terrorism: Nine Suggestions for Progressing Research." Presentation, The Avert Network: Online Series, December 9

Locicero, Alice, and Samuel J. Sinclair. 2008. "Terrorism and Terrorist Leaders: Insights from Developmental and Ecological Psychology." Studies in Conflict & Terrorism 31 (3): 227–50. https://doi.org/10.1080/10576100701879638.

Segre, D. V., and J. H. Adler. 1973. "The Ecology of Terrorism." Survival 15 (4): 178–83. https://doi.org/10.1080/00396337308441412.

Taylor, M., 2015. Criminogenic qualities of the Internet. Dynamics of Asymmetric Conflict 8, 97–106. https://doi.org/10.1080/17467586.2015.1065082.

Vayda, Andrew P., and Bonnie J. McCay. 1975. "New Directions in Ecology and Ecological Anthropology." Annual Review of Anthropology 4 (1): 293–306. https://doi.org/10.1146/annurev.an.04.100175.001453.

Walk-er, Jeremy, and Melinda Cooper. 2011. "Genealogies of Resilience: From Systems Ecology to the Political Economy of Crisis Adaptation." Security Dialogue 42 (2): 143–60. https://doi.org/10.1177/0967010611399616;.

Adaptation

Dawkins, Richard. 2015. The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design. 1 edition. W. W. Norton & Company.

Dawkins, Richard. 2016. The Selfish Gene. 4th edition, 40th Anniversary Edition. Oxford Landmark Science. Oxford, England: Oxford University Press.

Gould, Stephen Jay. 1979. Ever Since Darwin: Reflections in Natural History. New York London: W. W. Norton & Company. Dawkins, Richard. 1999. The Extended Phenotype: The Long Reach of the Gene. New York: Oxford University Press.

Johnson, N. F., M. Zheng, Y. Vorobyeva, A. Gabriel, H. Qi, N. Velasquez, P. Manrique, et al. 2016. "New Online Ecology of Adversarial Aggregates: ISIS and Beyond." Science 352 (6292): 1459–63. https://doi.org/10.1126/science.aaf0675.

Johnson, N. F., R. Leahy, N. Johnson Restrepo, N. Velasquez, M. Zheng, P. Manrique, P. Devkota, and S. Wuchty. 2019. "Hidden Resilience and Adaptive Dynamics of the Global Online Hate Ecology." Nature 573 (7773): 261-2,265A-265D. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1038/s41586-019-1494-7.

Self Organization

Briscoe, G., 2009. Digital Ecosystems. arXiv:0909.3423 [cs].

Johnson, N. F., M. Zheng, Y. Vorobyeva, A. Gabriel, H. Qi, N. Velasquez, P. Manrique, et al. 2016. "New Online Ecology of Adversarial Aggregates: ISIS and Beyond." Science 352 (6292): 1459–63. https://doi.org/10.1126/science.aaf0675.

Evolution

Baele, Stephane J., Lewys Brace, and Travis G. Coan. 2020. "Uncovering the Far-Right Online Ecosystem: An Analytical Framework and Research Agenda." Studies in Conflict & Terrorism 0 (0): 1–21. https://doi.org/10.1080/1057610X.2020.1862895.

Boyd, Katharine A. 2014. "Ecology of Terrorism: Cross-National Comparison of Terrorist Attacks." Doctor of Phi-losophy, Graduate Center, City University of New York: City University of New York. https://academicworks.cuny.edu/cgi/viewcontent.cgi?article=1174&context=gc_etds.

Boyd, Katharine A. 2016. "Modeling Terrorist Attacks: Assessing Statistical Models to Evaluate Domestic and Ideologically In-ternational Attacks." Studies in Conflict & Terrorism 39 (7–8): 712–48. https://doi.org/10.1080/1057610X.2016.1141003.

Dawkins, Richard. 2015. The Blind Watchmaker: Why the Evidence of Evolution Reveals a Universe without Design. 1 edition. W. W. Norton & Company.

Dawkins, Richard. 2016. The Selfish Gene. 4th edition, 40th Anniversary Edition. Oxford Landmark Science. Oxford, England: Oxford University Press.

Gould, Stephen Jay. 1979. Ever Since Darwin: Reflections in Natural History. New York London: W. W. Norton & Company. Dawkins, Richard. 1999. The Extended Phenotype: The Long Reach of the Gene. New York: Oxford University Press.

Mattheis, Ashley. 2022. Atomwaffen Division and its Affiliates on Telegram: Variations, Practices, and Interconnections. Washington, D.C.: RESOLVE Network. https://doi.org/10.37805/remve2022.1.AWD

Veilleux-Lepage, Yan-nick. 2020. How Terror Evolves: The Emergence and Spread of Terrorist Techniques. 1st edition. Lanham: Rowman & Littlefield Publishers.

Vila, Bryan. 1994. "A General Paradigm for Understanding Criminal Behavior: Extending Evolutionary Ecological Theory*." Criminology 32 (3): 311–60. https://doi.org/10.1111/j.1745-9125.1994.tb01157.x.

Swarm Intelligence

Boley, H., and E. Chang. 2007. "Digital Ecosystems: Principles and Semantics." In 2007 Inaugural IEEE-IES Digital EcoSystems and Technologies Conference, 398–403. https://doi.org/10.1109/DEST.2007.372005.

Fisher, Nico Prucha, and Emily Winterbotham. 2020. "Mapping the Jihadist Information Ecosystem: Towards the Next Generation of Disruption Capability." 6. Global Research Network on Terrorism and Technology. London: RUSI. https://rusi.org/sites/default/files/20190716_grntt_paper_06.pdf.

Fisher, Nico Prucha, 2014. "Eye of the Swarm: The Rise of ISIS and the Media Mujahedeen," USC Centre for Public Diplomacy. https://uscpublicdiplomacy.org/blog/eye-swarm-rise-isis-and-media-mujahedeen.

Non-Linear Behavior

Briscoe, Gerard. 2009. "Digital Ecosystems." ArXiv:0909.3423 [Cs], October. http://arxiv.org/abs/0909.3423.

Elliott, E., & Kiel, L. D. (2004). A complex systems approach for developing public policy toward terrorism: An agent-based approach. Chaos, Solitons & Fractals, 20(1), 63–68. https://doi.org/10.1016/S0960-0779(03)00428-4.

Huberman, Bernardo. 2001. The Laws of the Web: Patterns in the Ecology of Information. Cambridge, Mass: MIT Press.

Johnson, N. F., R. Leahy, N. Johnson Restrepo, N. Velasquez, M. Zheng, P. Manrique, P. Devkota, and S. Wuchty. 2019. "Hidden Resilience and Adaptive Dynamics of the Global Online Hate Ecology." Nature 573 (7773): 261-2,265A-265D. http://dx.doi.org.simsrad.net.ocs.mq.edu.au/10.1038/s41586-019-1494-7.

Johnson, N. F., M. Zheng, Y. Vorobyeva, A. Gabriel, H. Qi, N. Velasquez, P. Manrique, et al. 2016. "New Online Ecology of Adversarial Aggregates: ISIS and Beyond." Science 352 (6292): 1459–63. https://doi.org/10.1126/science.aaf0675.

Mesjasz, C. (2015). Complex Systems Studies and Terrorism. In P. V. Fellman, Y. Bar-Yam, & A. A. Minai (Eds.), Conflict and Complexity: Countering Terrorism, Insurgency, Ethnic and Regional Violence (pp. 35–71). Springer. https://doi.org/10.1007/978-1-4939-1705-1_2.

Okoye, C., Collins, O. C., & E, M. G. C. (2020). Mathematical approach to the analysis of terrorism dynamics. Security Journal, 33(3), 427–438. http://dx.doi.org/10.1057/s41284-020-00235-5.

Udwadia, F., Leitmann, G., & Lambertini, L. (2006). A dynamical model of terrorism. Discrete Dynamics in Nature and Society, 2006, 1–32. https://doi.org/10.1155/DDNS/2006/85653.

Emergence

Al-Lami, Mina, Andrew Hoskins, and Ben O'Loughlin. 2012. "Mobilisation and Violence in the New Media Ecology: The Dua Khalil Aswad and Camilia Shehata Cases." Critical Studies on Terrorism 5 (2): 237–56. https://doi.org/10.1080/17539153.2012.692509.

Barbre, Claude. 2011. Review of Review on: The Fundamenalist Mindst: Psychological Perspectives on Religion, Violence, and History, by Charles B. Strozier, David M. Terman, James W. Jones, Katharine A. Boyd, and Martin E. Marty. Journal of Religion and Health 50 (3): 521–26.

Elrick, Lauren E. 2021. "The Ecosystem Concept: A Holistic Approach to Privacy Protec-tion." International Review of Law, Computers & Technology 35 (1): 24–45. https://doi.org/10.1080/13600869.2020.1784564. Dominici, Piero. 2017. "Of Security and Liberty, of Control and Cooperation. Terrorism and the New Ecosystem of Communication." Italian Sociological Review 7 (2): 201–20;

Gould, Stephen Jay. 1979. Ever Since Darwin: Reflections in Natural History. New York London: W. W. Norton & Company. Veilleux-Lepage, Yannick. 2020. How Terror Evolves: The Emergence and Spread of Terrorist Techniques. Rowman & Littlefield Publishers.

Silke, Andrew, ed. 2003. Terrorists, Victims and Society: Psychological Perspectives on Terrorism and Its Consequences. Hoboken, NJ: Wiley.

About the Authors

Jade Hutchinson is a Cotutelle PhD Candidate in the Department of Security Studies and Criminology at Macquarie University, Australia, and the Research Centre for Media and Journalism Studies at Groningen University, The Netherlands. Jade's research is focused on understanding Australian and Canadian far-right violent extremism in the context of an 'online ecosystem' and in what ways social media platforms and websites shape far-right extremist disposition and engagement in terrorism. He currently holds research and teaching positions at the University of Wollongong, Macquarie University, and Leiden University.

Dr. Julian Droogan is is Associate Professor of Terrorism Studies and Director of Research and Innovation at the Department of Security Studies and Criminology, Macquarie University. He is also the Editor of the Journal of Policing, Intelligence and Counter Terrorism (Routledge). Julian has worked on project for the Australian and US Departments of Defence, and as chief investigator on numerous funded research grants. Topics include investigating how young people engage with online violent extremist content; examinations of online right-wing extremism and conspiratorial narratives across multiple social media platforms; and evaluations of online countering violent extremism programs. He was instrumental the creation of the $12 million COMPACT countering violent extremism program currently operated by the NSW state government and aimed at fostering societal resilience to extremist narratives. As well as supervising a number of PhD and Masters of Research students in the field of terrorism studies, Julian convenes the courses PICT2015:Terrorism in the 21st Century as part of the Bachelor of Security Studies, and PICT8020: Advanced Terrorism Studies as part of the Masters in Counter Terrorism.

Lise Waldek is a senior lecturer in terrorism studies at the Department of Security Studies and Criminology, Macquarie University. She has over 19 years professional experience in the security domain as a behavioural scientist, with roles in Defence Intelligence for the UK Ministry of Defence, the Home Office, and Defence Science and Technology Labs. Lise is chief investigator on numerous funded research grants. These have included an Australian Research Council (ARC) discovery grant investigating youth audiences understanding and engagement with online violent extremist content; empirical examinations of online right-wing extremism and conspiratorial narratives across multiple platforms; the design of the New South Wales COMPACT countering violent extremism program; and evaluations of countering violent extremism programs. She has published her findings in peer reviewed journal articles and book chapters. Lise recently co-edited a special issue journal on 'Political Emotions and Ideological

Performance'. Her recent co-authored book 'Feeling Terrified? The emotions of online violent extremism' was published by Cambridge University Press Elements in 2021.

Dr. Brian Ballsun-Stanton *is a Solutions Architect (Digital Humanities) with over 8 years' experience designing and delivering technical solutions for academic and student research projects at Macquarie University and University of New South Wales, Australia. He studies the philosophy of data, trends of far-right extremism within social networks, and is the Technical Director for the FAIMS Project: building electronic field notebooks for offline, geospatially enabled data collection. Brian has been Chief Investigator in grants and prizes across the humanities and social sciences totalling over AUD $2,610,000. He has been Technical Director for a field-data collection project, delivering 50+ field data collection modules since 2013, and lead instructor for 10+ carpentries workshops delivered since 2017. Brian has developed a partnership with Ubisoft that led to Macquarie University's engagement on the Google Arts and Culture Platform, using AI to assist researchers in translating Ancient Egyptian Hieroglyphs. He is an internationally respected researcher in the Digital Humanities with a significant track record of peer-reviewed publications, book-chapters, and conference presentations.*