Transmission: Insights on COVID-19

WEEK TWO

Welcome back to the *Complexity of COVID-19* course from the Santa Fe Institute. For the past few weeks, we have been collecting ideas from Santa Fe Institute researchers about the COVID-19 pandemic. These provide a broad range of insights from a variety of scientific perspectives. COVID-19 has very quickly proven to be a terrifying demonstration of complex systems. We are all suddenly witnessing the consequences of deeply entangled systems, and moving beyond this epidemic will require equally new ideas that can span all walks of life. These ideas pose hard questions. How long do the viral particles remain dangerous? What about this pandemic is causing such a political/ideological division between people who are all suffering? Is COVID-19 actually like the flu, or not? We want to explore questions like these, in real time, and bring those thoughts to you weekly in a format that gives your families and your communities important topics to discuss.

Included in this course packet are SUMMARIES for each piece (along with links to the original essays in their entirety), COMPLEXITY CARDS to highlight key concepts introduced in the packet, a link to an ONLINE QUIZ to test your knowledge, and a podcast INTERVIEW with SFI President David Krakauer about how this week's transmissions relate to one another.

By engaging with the content provided, we hope your family discusses and critically thinks through this pandemic. So read through the essays, listen to the podcast, try to match the Complexity Cards with their essay-counterparts, take the quiz, and discuss the key questions in-depth. SFI wants nothing more than to come together and think creatively through this shared experience with you.

The study of infectious disease is most commonly split between pathology (the focus on symptoms in the host) and transmission (how the pathogen moves from an infected individual to an uninfected one). Unlike pathology, in which you can see a person cough and can measure their fever, we almost never observe transmission as it happens. Using OID (other infectious disease) models, however, we can try to understand transmission based on related factors such as the lifespan of infective particles. In COVID-19, coughing and sneezing release a cloud of these particles, which may only be infectious for a couple of minutes. When infectious stages are short-lived like this, transmission is dependent on the density of hosts in the area — meaning if you sneeze on a crowded subway car, you infect many more people than if you sneeze in an empty one.

But what about transmission between different species? Genetic evidence suggests that COVID-19 is naturally hosted in a bat species, which themselves rarely show any overt pathology due to their dramatically different immune systems, body temperature, lack of body fat, etc. Usually pathogens such as these are unable to survive in new host species, as the cells it needs to infect so as to replicate are absent — however, when a pathogen does manage to infect novel cells (meaning “new” cells), it can lead to the emergence of novel disease. Our ability to understand rates of between-species transmission, in addition to using matrices such as WAIFW (Who Acquires Infection From Whom, which provides a framework to examine how a pathogen moves between different groups of hosts), will further inform our understanding of the size of this epidemic and how to control its spread.

READ FULL TEXT

Image: “Two Bats Nailed to a Timber Wall, Knife and Quill Pen” by Gabriel Orm. Oil on Vellum. 1738

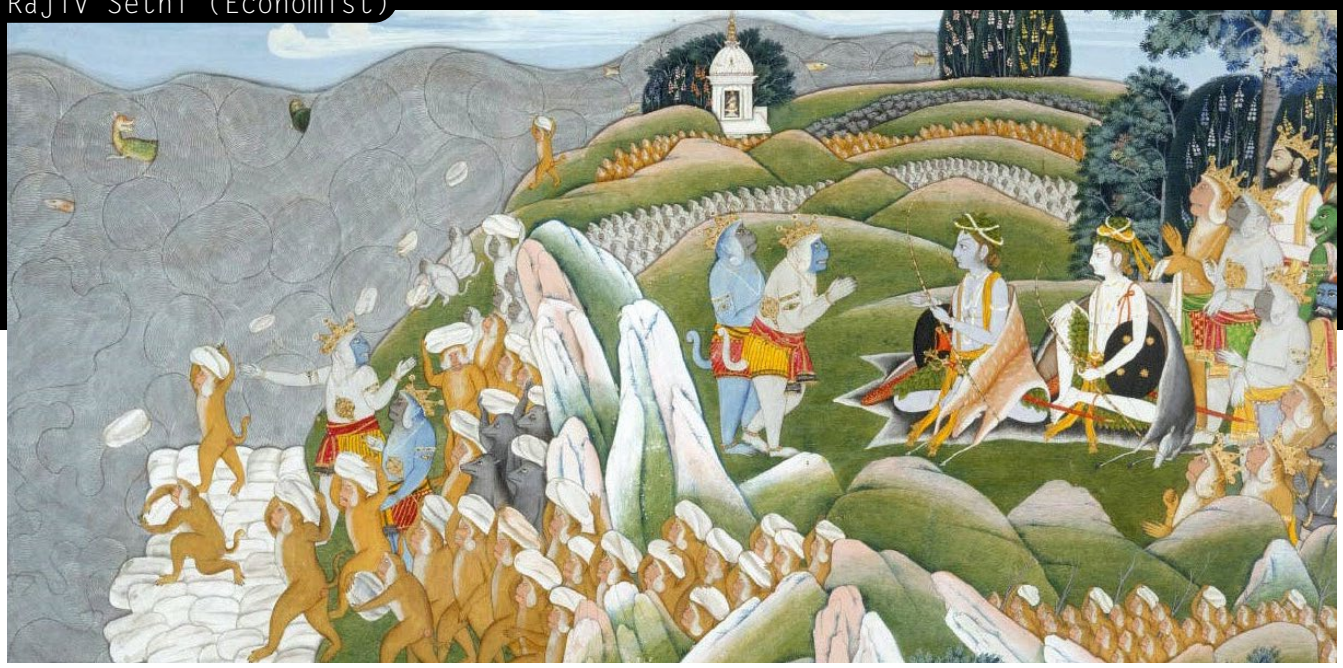
This global crisis has produced a variety of responses, both tangible and abstract. Characteristics of this crisis such as large-scale unemployment, social distancing and quarantine, and a concerted concentration on hand-washing are all clear indicators that things are not functioning as usual. When it comes to more ephemeral behaviors such as social unrest and fear, we can use social media activity to give us a better understanding of conversational characteristics that occur during these types of tumultuous events, and perhaps enable us to predict their eventual impact during earlier stages.

Based on the examination of large datasets of communication events on Twitter, analysis demonstrates a significant increase in direct conversations, and that said conversations are increasingly structured around a common set of themes. Gaining insight from these complex and nuanced interactions allows research to pinpoint signs of impending unrest — for example, these tactics were able to identify early warning signs more than a year in advance of the deep social crisis that began in Chile in October 2019. As research on the social response to COVID-19 continues, we can further explore the relationship between social media interactions during an ongoing crisis with predictive ones like in Chile, as well as how historical response events influence current reactions.

READ FULL TEXT

Image: Detail: "Three Figures" by Roberto Matta. c. 1958

Mobilize & Transition | Danielle Allen (Political Scientist), E. Glen Wyel (Economist), & Rajiv Sethi (Economist)



The economic impact of COVID-19 has been swift and devastating. In a few short weeks, unemployment claims jumped from 280,000 to 6.6 million over the next week (where unemployment claims had never previously exceeded 700,000 in the history of recorded data). The S&P 500 Index lost a third of its value in a month. In response, Congress passed a $2 trillion stimulus bill, a large chunk of which provides incentives and funding for businesses to keep their workers on payroll. Details like these indicate a plan of a temporary but drastic scaling-back of economic and social activity, with funding placed in an effort to spring back to strong economic conditions in two or three months.

But what if three months is not nearly enough, and we see ebbs and flows in confirmed cases over one or two years, creating cycles of these same social distancing measures we're experiencing now? The social, political, and economic implications of this would be dire. In order to mitigate such a situation, an alternate strategy, "mobilize and transition," would allow for some portion of the population to return to normal, economic life, long before the pandemic has been fully contained. This would be accomplished through an initial period of aggressive social distancing of up to three months, large-scale testing (on the order of several million individuals per day) in order to partition the population into those who are believed to be "safe," and those whose status remains undetermined. Those with negative tests can return to the workforce, and those with positive tests would continue to be isolated. This would result in lower mortality rates, while cushioning the decline in employment and leading to a more rapid recovery across all sectors. The economic hardship will nevertheless be extraordinary for years to come, but strategies such as "mobilize and transition," as well as potentially routinely distributed basic income payments, would work towards minimizing this impact.

READ FULL TEXT

Image: "The Ramu Setu Being Built by Monkeys and Bears." Artist Unknown. Made in Kangra, Himachal Pradesh, India Circa 1850.

In epidemiology, there is a central concept called the “basic reproductive number,” (R_0, pronounced “R-naught”) which is the expected number of new infections directly caused by a single infected person over a certain time. Estimates for this number for COVID-19 all consistently fall around 2.5, meaning that the number of cases roughly doubles about every three days. The power of exponential growth is what makes this number a clear danger: after merely one month in a population with two infected individuals, about 100,000 confirmed cases would have occurred had social distancing and isolation measures been absent. In developing control measures, we aim to get this number below 1 for a sufficient enough amount of time to progressively reduce case numbers to zero — but without that effort, we will experience a more protracted epidemic, with many more unnecessary infections and a correlated strain on health services.

However, simply reducing the reproductive number overlooks the importance of the size of the infectious population at the time of enacted quarantine measures, as well as how we can achieve a new baseline of physical distancing in order to avoid a future resurgence of this epidemic.

READ FULL TEXT

Image: “Shepherd and Flock at the Approach of a Storm” by Jean-François Millet. 1902

As humans, the only way we make sense of new situations is by relating them to ones we have previously experienced. How we conceptualize these analogies drives how we behave in that novel situation, and can be powerful forces — for better or worse — in determining how we act. So what is COVID-19 like? And how does that enhance or diminish our response to the situation at hand? Is it like the flu? Is it comparable to a natural disaster? Are we at "war" with this disease?

It may seem instinctual to compare COVID-19 to the flu; however, due to the drastic differences in contagiousness, the primary severity of COVID-19's pathology, and the dramatically heightened mortality rate, it really isn't. Scholar Zeynep Tufekci put it this way: "[It is] like the difference between a disease that drops you in the dangerous part of town late at night and one that does the mugging itself." The rampant seasonal flu analogy misleads many into minimizing the current situation, and fosters serious misunderstandings of Covid-19's real perils. The natural disaster analogy is more legitimate in terms of urgency, but has inspired unnecessary panic-buying of supplies like toilet paper — when there is no physical storm set to descend upon our grocery stores. The war analogy is appealing, and in many ways apt, but carries with it pitfalls of gratuitous suspensions of civil rights, susceptibility to political exploitation, and the stock-piling of guns and ammunition.

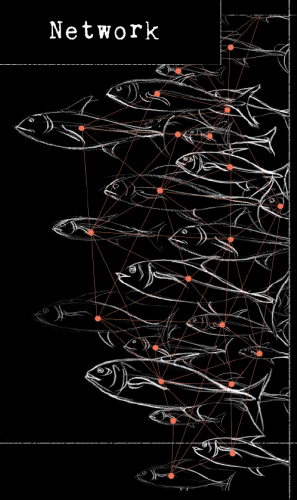
If you pay attention, you will encounter myriad variations of these and other analogies everywhere, which unconsciously but deeply shape our understanding of everything we encounter. Analogies can be buoys in troubled waters, our lighthouses in this dark storm, but we need to use them carefully to safely guide us to the other shore.

READ FULL TEXT

Image: Detail: "Nature Morte aux Pommes et aux Oranges" by Cézanne. Oil on Canvas. c.1895

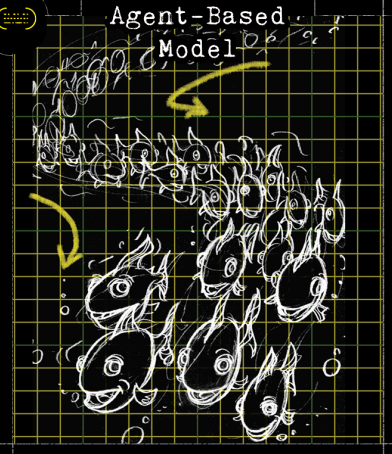
COMPLEXITY CARDS

Network



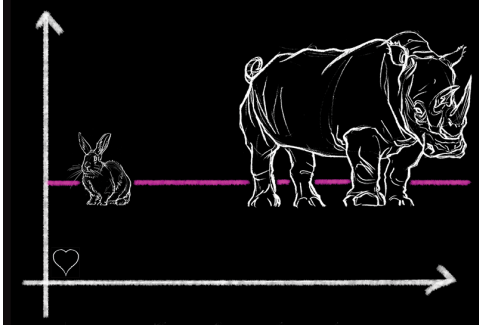
A collection of nodes connected by links, where NODES are individual agents and LINKS are the interactions between them.

Agent-Based Model



A model for simulating the actions and interactions of autonomous agents with a view to understanding their effects on the system as a whole.

Scaling



Scaling refers to how a system responds when its size changes. For example, when a circle's radius doubles, its perimeter doubles (linear-scaling) while its area quadruples (super-linear scaling).

Life Support Systems Legend

- Architecture, Cities, & Scale
- Astrobiology & Life Detection
- Intelligent Systems & Cognitive Design
- Motion & Energy Technology
- All Complex Systems
- Time Design
- Autonomous Ecosystems
- Social & Economic Engineering

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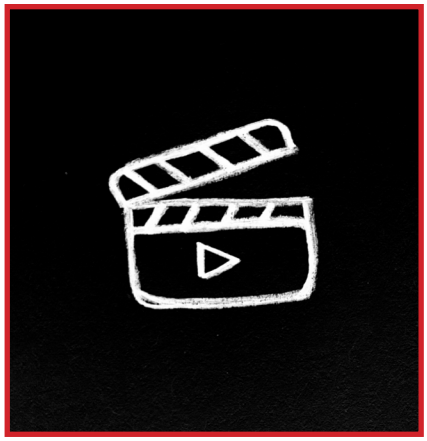
Complexity Podcast: Transmission Series Ep. 2

"Complex Time in Biology & Economics with David Krakauer"

In the second episode of this special supplementary mini-series with SFI President David Krakauer, we discuss this pandemic through the lens of complex systems science, helping us understand the central role of time in coordinating across scales, and how synchrony or misalignment leads to major consequences.

Transmission: Insights on COVID-19 Quiz 2

This weekly quiz will cover topics and details from this week's batch of articles so you can test your knowledge. Included in the quiz are more long-form discussion questions, which we hope will instigate interesting conversations between everyone in your household.



Related Recommendation: Video

Using VFX to Explain Why COVID-19 Surprised Everyone

by Corridor Crew

This week's essays speak a lot about exponential growth, and this video by YouTube Channel "Corridor Crew" does a great job of explaining exactly what that means, and why COVID-19 has proven to be so dangerous. As an added treat, watch out for the cameo by SFI's own Geoffrey West!