Transmission: Insights on COVID-19

WEEK FIVE

Welcome back to the *Complexity of COVID-19* course from the Santa Fe Institute. This week's batch of Transmissions essays speaks to the various ways we can utilize our collective knowledge through technology, history, and well-informed predictive models to assist us through this pandemic.

What have past epidemics taught us about our current situation, and how will the lessons of today reverberate through future generations? How can we improve upon available technology to increase activity levels among vulnerable groups, thereby improving their odds in fighting infection and disease? How do we continue the tug-of-war between our urgent decision-making needs and our long-term need to act on accurate data and information? Should we enact swift action using existing statistical formulas and models, even when their inputs and subsequent results are an uncertain array of situations? These are tough questions and scenarios that will continue to challenge us as individuals and as a collective society, and it is our duty to find novel and creative ways to solve these problems and help each other through.

It takes effort to embrace complexity. Simple models, simple narratives seem easier up front, their consequences only obvious in retrospect. These essays explore the ways in which an intuition for complexity will allow us to make better decisions in the nebulous uncertainty we occupy. Understanding systems helps identify good points of intervention, leading to complex, systemic solutions, and not simple band-aids.

Spiraling Frailty Syndrome | John Krakauer (Neuroscientist) & Michelle Carlson (Doctor of Mental Health & Epidemiology)

COVID spiraling frailty syndrome is a term recently coined in a paper analyzing the unique vulnerability of elderly patients in Italy. Outside of the context of COVID-19, *frailty* refers to a biological syndrome which is indexed by components such as weakness from loss of muscle tissue, slowed gait, sense of low energy or exhaustion, and unintentional weight loss; and demonstrates the urgent need for aging adults to increase their physical activity. The prevalence of frailty increases with age, and with it comes an increase in the risk of infection.

Monotherapies — the one-system-at-a-time approach employed by mainstream medicine — have largely failed. Instead, a case can be made for reframing physical activity as either an emergent therapy or a complex medicine. If AGING and chronic diseases are the consequences of a complex adaptive system gone awry, perhaps a sustained complex process is needed to fix it. There is overwhelming evidence that frailty syndrome and chronic diseases (hypertension, type-2 diabetes) are highly responsive to physical activity.

The WHO recommends that persons over 65 do at least 150 minutes of moderate aerobic activity weekly. However, for many older adults, internal and external barriers (loss of balance, gym expenses) mean that by the age of 75, about 1/3 of men and 1/2 of women are not physically active at all. The lingering fears about going outside when quarantine measures are lifted only exacerbate the need to create a systematic approach that takes existing evidence and transforms it to fit realistic conditions. What we can do is create an immersive, movement-based experience for aging adults through video-game technology. Indeed, 50% of people over the age of 50 already play. Given that COVID-19 is disproportionately targeting those at higher socioeconomic risk, the development of such virtual interventions is particularly urgent for those with few opportunities for safe, regular, and accessible physical activity.

READ FULL TEXT

Image: "Walking Quickly Under Rain" by Alberto Giacometti. Bronze. 1948/8. Courtesy MoMA New York. www.moma.org

What History Can Teach Us About Resilience | Stephanie Crabtree, Computational Archeologist

The practice of quarantine comes from the 14th-century convention of keeping ships at anchor outside Venetian harbors to protect citizens from unknown pathogens; the etymology of the word comes from *quaranta giorni*, the *40-day* period sailors had to wait before disembarking. Even Charles Darwin had to quarantine before exploring foreign shores as a naturalist.

There are many lessons to be learned from how turmoil can exploit weaknesses in society. Think about The Plague of Athens (430-427 B.C.), which many have speculated caused the demise of Athenian democracy. Thucydides points out that public health issues like poor sanitation and overcrowding led to increases in casualties. Doctors died, and the lack of understanding of the disease caused fear to spread across Athens fast as the plague, itself. His writings can help us identify commonalities between how citizens reacted in 430 B.C. and how they may react today.

Chaco Canyon, a large highly-**CENTRALIZED** polity in northern New Mexico, was a fast-growing society built upon innovative community structures to control farming productivity, which allowed them to thrive. But when drought reduced productivity, the hierarchical Chacoan societal structure fractured, and violence ensued. Eventually communities left, walking hundreds of miles to new regions, carrying with them accumulated knowledge of successful and detrimental cultural behaviors.

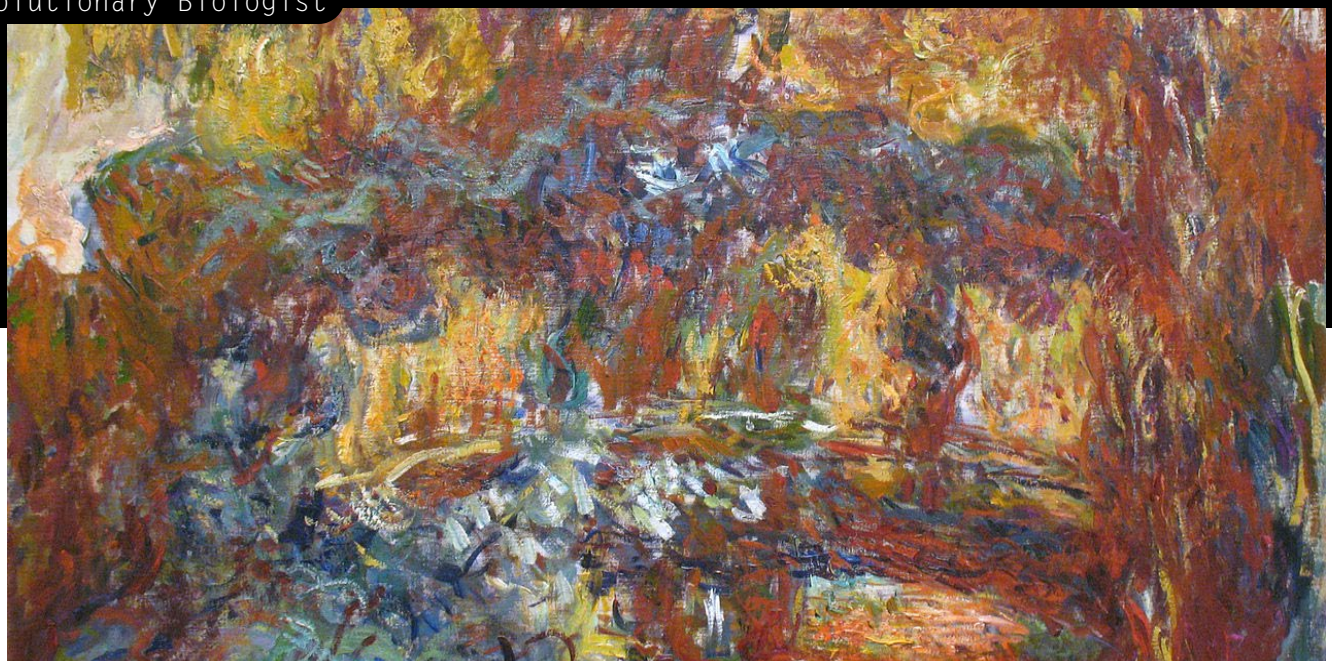
Humans are particularly good at is perceiving environmental cues, and ADAPTING our cultural practices around those cues. Societies that prevail ENCODE these lessons through oral tradition, writing, songs, and artworks. From these examples, we can see that bolstering citizen confidence (via clarity of communication from officials), increasing our COLLECTIVE knowledge of the disease, and thoughtful prosocial behavior by citizens (like mask-donation) may help avoid the same consequences Athenians and Chacoans experienced.

READ FULL TEXT

Image: "Incan Quipu" at the Museo de la Nacion. Lima, Peru.

Find out more at www.santafe.edu/COVID19

Informational Pitfalls of Selective Testing | Van Savage, Mathematical Ecologist & Evolutionary Biologist



Decisions about when and how to relax social distancing will ultimately come down to whether or not we think we're "flattening the curve" - but how will we know? The prevailing perception is that we can look at the curve's fit to reported new cases and deaths each day, but this might not be correct. In the U.S. we are primarily testing those with symptoms — but unfortunately, this only really tells us what proportion of respiratory illness and fevers are due to COVID-19, not what percentage of the population has COVID-19.

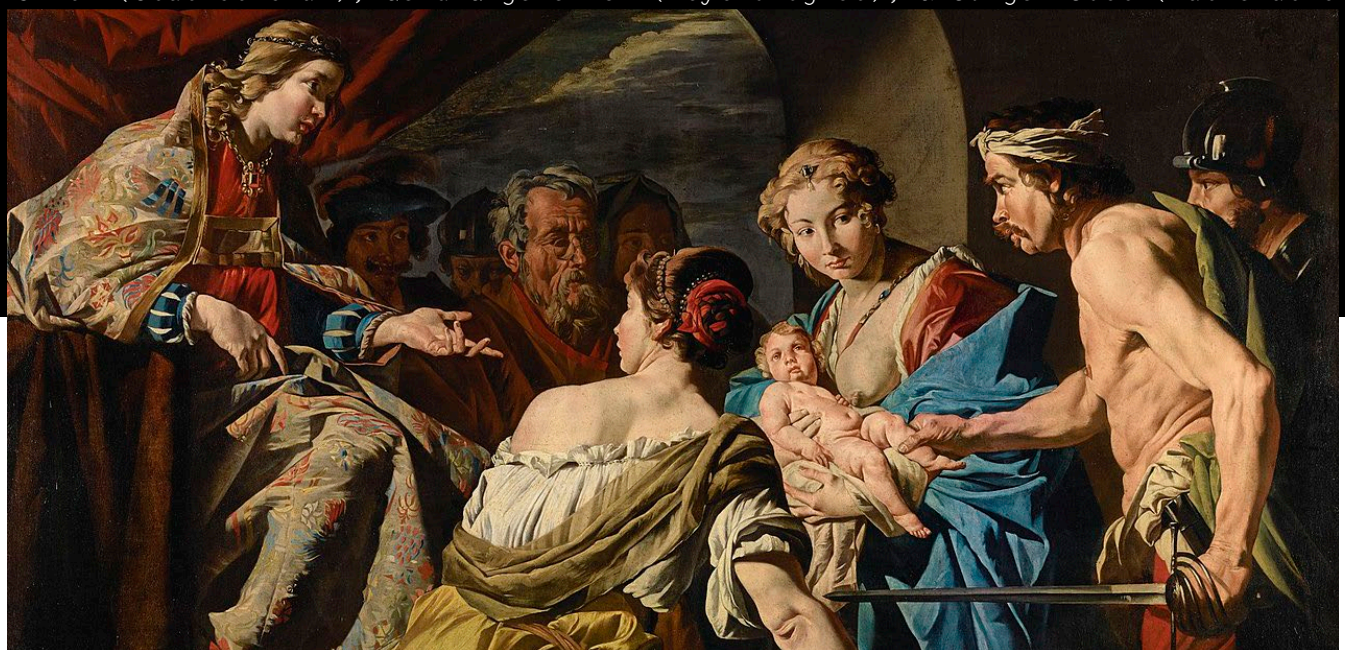
Early on when a disease is spreading, the number of cases will increase and look exponential either because (1) the number of cases is increasing exponentially and can be adequately measured by tests, or (2) the testing capacity is increasing exponentially and the positive test rate is roughly constant (meaning, even though there may be 150K tests given instead of 15K, the positive rate will remain around 20%). Or, both could be true. In the case of true exponential growth, where the number of cases could reach tens of millions relatively quickly, running ~100K+ tests per day can't possibly capture timely or accurate information on the number of actual infections. We'd require about 500K daily tests to determine whether or not we're flattening the curve.

We could be suffering a double whammy in our approach. By having limited testing capacity, we can't track true numbers, and by testing only those with symptoms, we aren't tracking how the per-capita growth is actually changing. In order to make informed decisions for the public health, we must dramatically ramp up testing capacity, and test more randomly (not just on symptomatic patients). Until then, we're flying blind.

READ FULL TEXT

Image: Detail: "Le Pont Japonais" by Claude Monet. Oil. 1922.

Making Good Decisions Under Uncertainty | David Tuckett (Economist & Medical Sociologist), Lenny Smith (Statistician), Gerd Gigerenzer (Psychologist), & Jürgen Jost (Mathematician)



The current COVID-19 pandemic presents decision-makers with situations where the range of possible actions and the probabilities of possible outcomes are not known or even imagined. Because data is unavailable or contestable, using it to make sense of exactly what is going on or how the pandemic will play out is unreliable. Actions are untested, their acceptance by populations is not guaranteed, and long-term societal and economic impacts are unclear. Should we aim to eradicate, to slow, or accept deaths of the vulnerable and minimize the collateral economic damage?

Radical Uncertainty (**RU**) is defined as a situation in which quantifying costs and consequences is contestable, but we must choose. Current scientific decision theory (which seeks optimal decisions based on known outcomes and their probabilities), can't help here. The financial crisis, the climate challenge, and now COVID-19 emphasize the need to fill this gap between certainty and UNCERTAINTY.

Our group is focusing on how to aid decision-makers in selecting data from diverse sources, to recognize structural instabilities, and to imagine possible "Big Surprises". We emphasize systematic ways to reduce complexity and to identify essential variables which have the largest effect, and which we can control. Progress requires novel cross-disciplinary research.

To make good decisions under uncertainty, decision-makers must act creatively, while recognizing the possibility of failure. And for those decisions to work, the public must have confidence in the conviction narrative presented. When decision-makers confront doubt and express it transparently, they generate cooperation. Assertions and phantastic-object solutions that pose as certainty generate blame rather than a creative culture - fragility rather than RESILIENCE.

READ FULL TEXT

Image: Detail: "The Judgement of Solomon" by Matthais Stom. Oil. c. 1640.

Find out more at www.santafe.edu/COVID19

Back in Week 2, we learned about the "basic reproductive number" (R_0), which is the expected number of new infections directly caused by a single infected person over a certain time. If R_0 is bigger than 1, cases grow exponentially and the epidemic spreads across the population; if R_0 is smaller than 1, we can limit the disease to isolated outbreaks and keep it under control. But we must remember that R_0 is only an average across the population, and individual impacts will vary based on occupation, governmental response, societal structure, etc.

Even when R_0 is less than 1, outbreaks can be surprisingly large. Suppose you meet 10 people while you're contagious, and you have an 8% chance of infecting each person. This means that the average number of people you would infect is 0.8 (less than 1) - but those you infect may infect others in turn, and so on (infective descendants). By modeling infection NETWORKS under these circumstances, we find that while the average number of infections caused by one person is 5, about 1% of those people will create 50+ infections. That heavy tail of infections can skyrocket even further in instances of "superspreaders," who attend densely populated events or places. Even if the average outbreak is small, large outbreaks will occur by superspreading or by chance.

It can be misleading to look at statewide or national averages and celebrate if R_0 seems to be falling below 1, as the epidemic could still be raging in particular places or among particular groups. Using both technology and human effort we will get this pandemic under control, even though flare-ups will occur and strain local resources. We have to do our best to help each other and hope that intelligent, generous voices prevail.

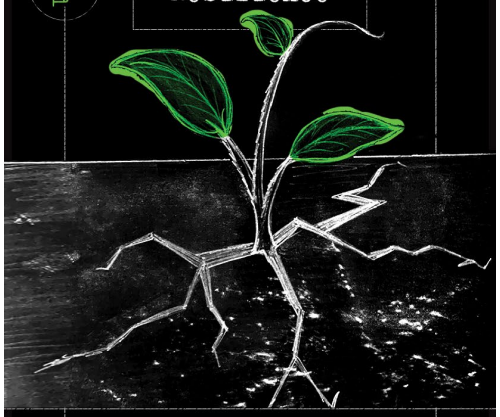
A complete breakdown of Moore's math can be found in the full text.

READ FULL TEXT

Image: Detail from "Ghent Altarpiece" of Angels Singing, by Jan van Eyck. 1429.

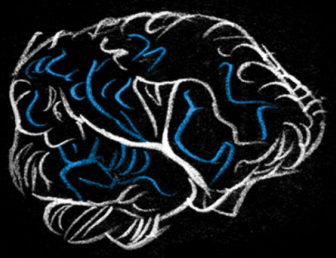
COMPLEXITY CARDS

Resilience



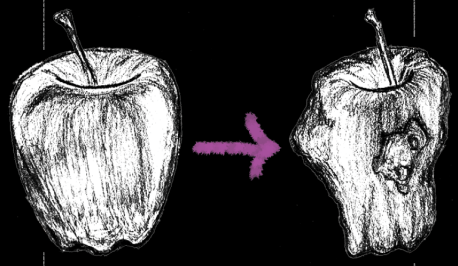
The ability of a system to persist and maintain its core functions/purpose in the presence of disturbance, stress, or change to its environment.

Encoding



Convert into a coded form (information storage for security and communication), as with memory or gene product production.

Aging



Deterioration, senescence, or obsolescence due to the accumulation of damage over time. Information loss.

Life Support Systems Legend

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

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Complexity Podcast: Transmission Series Ep. 5

"Embracing Complexity for Systemic Interventions"

In the fifth episode of this special supplementary mini-series with SFI President David Krakauer, we explore how simple models with simple narratives seem easier up front, though their consequences become obvious in retrospect. We'll also reflect upon our history and determine how and where to intervene — to enact systemic treatment.

Transmission: Insights on COVID-19 Quiz 5

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: Reading

Leiningen Verus the Ants

by Carl Stephenson

The InterPlanetary Team recommends this survivalist short story about a man determined to see his farm through an overwhelming invasion of ants. Were Leiningen's actions effective or farcical? This story illuminates the difference between reactive and proactive strategy.