

Transmission: Insights on COVID-19

WEEK ONE



Welcome 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. Why aren't people staying in? Is the reluctance to staying in related to a concern for the local economy? What do the improved air qualities in places like Los Angeles and China tell us about how our economy and our ecology are related? 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 these 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.



If cancer, or heart disease, or Alzheimer's could all be cured by collective non-action, I suspect we would all stay home and become an active part in one of the greatest prophylactic achievements in human history. Due to the complexity and vagueness of factors such as genetic inheritance in these common diseases, such a movement would be largely fruitless – but this eradication scenario is possible in this moment with COVID-19.

Unlike other diseases, COVID-19 contains a rather simple causality through transmission networks: from animal hosts to humans, then humans to other humans through contact, then through transportation systems and professional and social settings. These avenues of transmission are so intrinsic to our basic lives that nearly every foundation has been shuttered, from simple interaction to global economies. Luckily, unlike the complexity of genetics, the flows of human traffic can be relatively easily understood, and, by extension, controlled. We can use our understanding of transmission to adjust our behavior (quarantine, social distancing, thoughtful hygiene, new work and social routines, etc.) and enable the collective action needed to eliminate the transmission of the virus through this citizen-based-medicine.

READ FULL TEXT



There is a pervasive and long-lived idea that science ought to be free of value judgements, and exist in a vacuum separate from public policy. In the nineteenth century, W.E.B. Du Bois argued that public trust in science could only be preserved if science was insulated from social and political concerns, keeping the science pure from societal influence – but in turn, the results are then interpreted by policymakers, perhaps without the ideal level of understanding. In a 2012 paper, Australian National University’s Katie Steele argued just this, highlighting that scientists often can only offer wide ranges of uncertain probabilities – which, while more correct in the long run, tend to offer limited guidance when it comes to policy.

In times such as these, scientists must balance the need for action-guiding advice against the risk of their advice being wrong, and realize that though this may not be the ideal role they imagined for themselves, it is a necessary stance that must be taken by each epidemiologist, virologist, economist, and anyone else in a position to provide scientific advice to policymakers. Decisions will be made, one way or another, that will effect the larger population – and the advice those decisions are based on should come from those who are most relevantly informed in order to give the best chance of success.

READ FULL TEXT

Image: “The Village Lawyer’s Office” by Pieter Breughel the Younger, 1626.

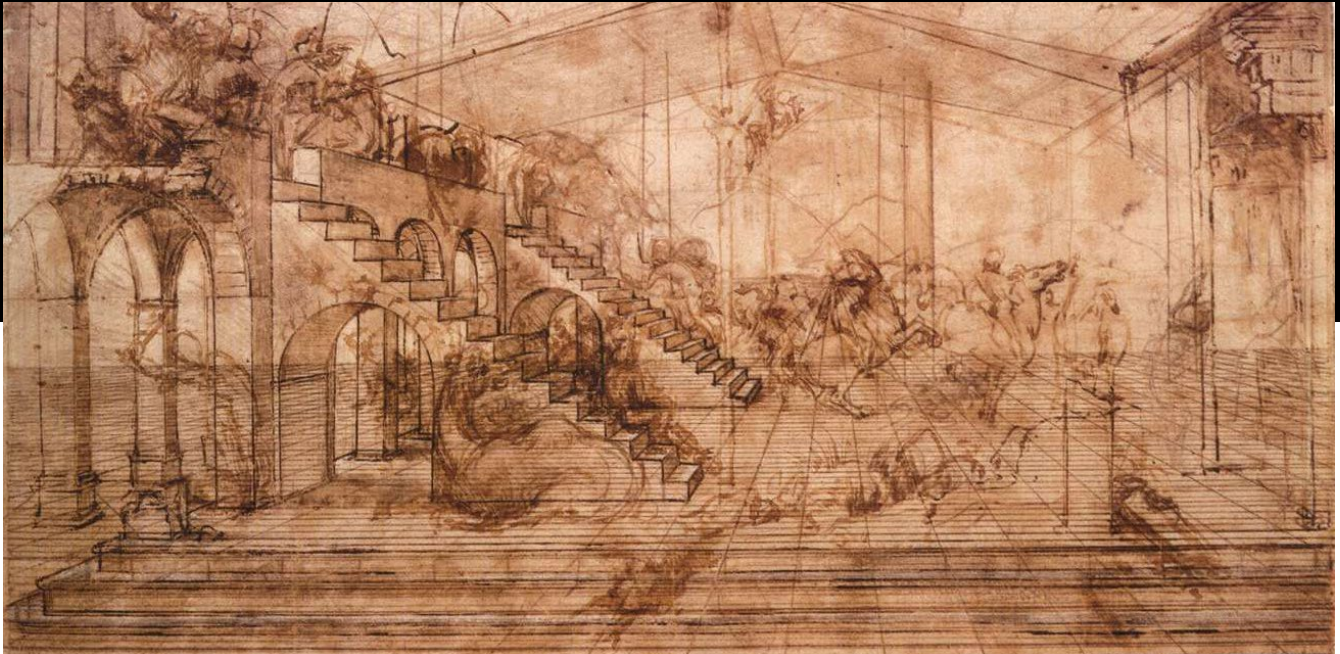


While there has been a unanimous consensus across the globe that social distancing and limitation of crowds was vital to limiting the spread of COVID-19, the actual number limit seemed only dependent on where you were getting your news. Perhaps you heard 200, or 20, or 50, or 10 – or that you could go to a bar but not a concert hall, that you could attend a small dinner party but not go to a restaurant. Eventually, the default became “stay at home”, which in itself implies a group size of a handful at most, largely because the questions surrounding group transmission are so complex. Does how long one stays in a crowd matter? What if the group is indoors vs. outdoors? What is the true effect of group size on transmission rates of infection disease?

Clearly, it’s complicated. If we assume that a population is segregated into a certain number of groups, each with a certain number of people, and assume that a certain number of randomly distributed individuals within the overall population are infected (and whatever group those individuals are in will also become infected), we will find that every doubling of allowable group size will result in a four-fold increase in the number of infected individuals. So while there isn’t a magic number that says “x or under is safe”, what this math does tell us is that group size has a huge effect on the spread of disease, and moving forward we must be aware that we cannot jump from 3-4 individuals to a gathering of thousands without risking a large resurgence of infection.

READ FULL TEXT

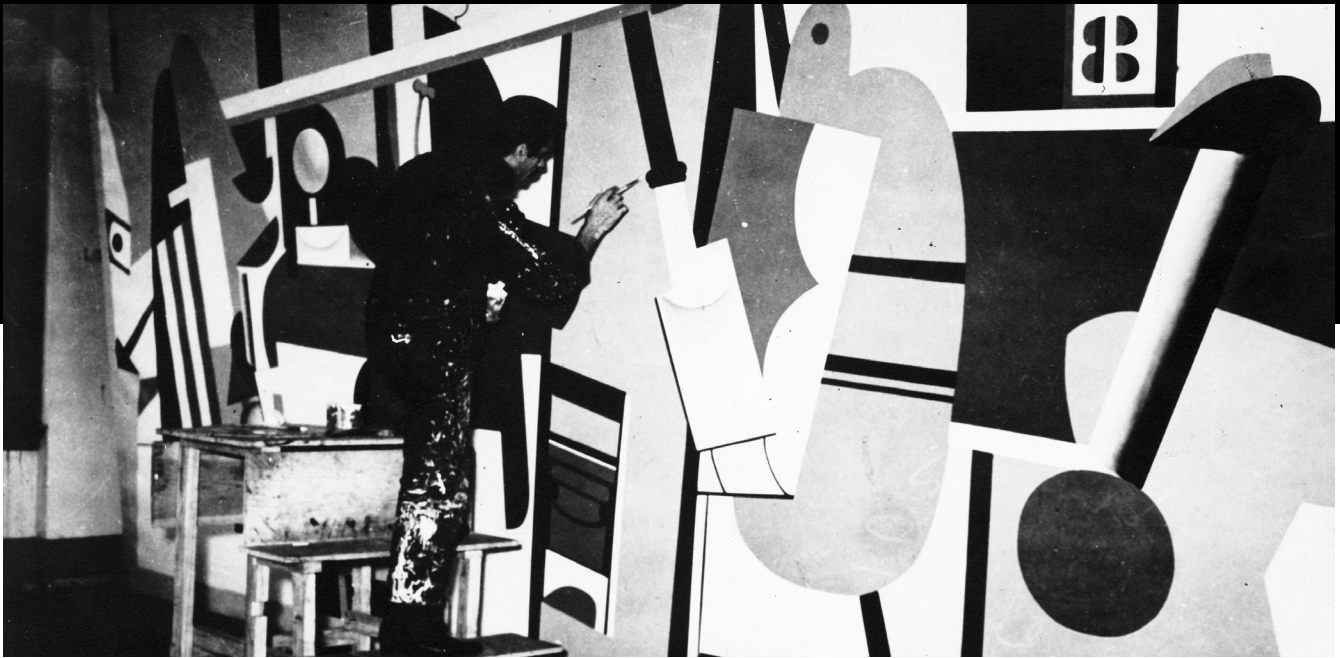
Image: Detail: “Ou gojunko matsushima tenran no zu” by Utagawa Hiroshige III (Ando Tokubei), 1876.



There is no shortage of data on the unfolding coronavirus, but quantity does not equal quality. Data between countries is not often compatible, are further internally inconsistent, and unfortunately in some cases politically manipulated. So how do complexity scientists establish regularities and gain useful insights from unreliable or inconsistent data? How can we deal with a data situation in which not all virus carriers show symptoms, where test density and methodology vary widely, where those who recovered at home may not report, and where even the death toll is uncertain due to the difficulty in distinguishing between those who died *from* corona versus those *with* corona?

In short: we need to simplify assumptions across the board. If we expect that the ratio of reported cases to actual cases will remain reasonably consistent, and the respective rates of increase will also be similar, then we can draw conclusions about the actual cases from the increase in reported cases. Through these simplified variables we can draw rough and tentative prognoses and expectations, and hope that a deeper understanding of the problems underlying data collection can allow us to better cope with such epidemics in the future.

READ FULL TEXT



In well-oiled systems, instinct is all you need to carry you through. When you get off of an airplane, you don't need to think, you just follow and the flow of good design carries you to Baggage Claim and to a taxi thereafter. You have dinner parties and let your kids play outside with their friends, you sit in a coffee shop to people-watch and get some writing done, and all of these actions are carried out to fulfill an internal balance of physical, psychological, and social needs. But here in a time of quarantine, we are forced to think on those decisions we've never had to think about before – and consider how we will handle reintegration when COVID-19 is tamed, but not yet defeated.


Do you risk throwing a dinner party, or would you only attend one at someone else's home? Or perhaps you'd make the decision based on who would be attending, and if you trust those people in particular. Would you feel obligated to let your child play outside with those friends, or feel that the risk would outweigh the benefits? Working through this quarantine endgame will mean changing the way we think about our instincts on a foundational level – but if evolution did indeed make us thinkers, we might as well get back to getting good at it.

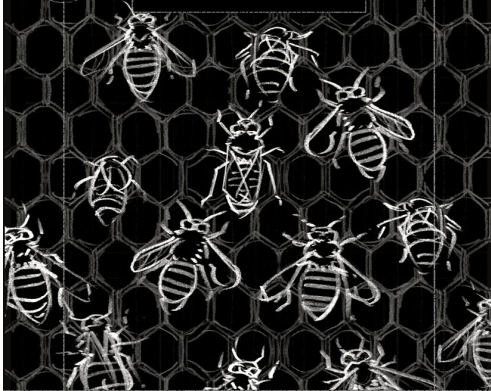
READ FULL TEXT

COMPLEXITY





CARDS


 **Collective**




A cooperative group of agents, such as ants or bees, that share at least one common interest. A group motivated by a common objective, like humans hoping to eradicate COVID-19.




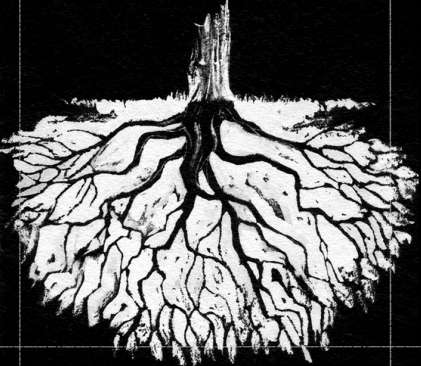
 **Coarse Graining**




Imagine looking at a painting, and then letting your eyes go all blurry - the details disappear and you see only colors and shapes. Scientists do this with complex systems in order to gain a general understanding of a noisy, complicated system made up of many smaller things.





 **Complex Causality**




When the underlying causes for something's emergence are multiple, various, and/or heterogeneous, making causal inference quite difficult.












 **Trade-Off**



When the characteristics that enhance one aspect of performance necessarily decrease another type of performance. A compromise.



 **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. 1](#)

“Rigorous Uncertainty: Science During COVID-19 with David Krakauer”

In this special supplementary mini-series with SFI President David Krakauer, we discuss and find the links between these articles on everything from evolutionary theory to economics, epistemology to epidemiology, in order to trace the patterns of a deeper order that, until this year, was largely hidden in plain sight.



[Transmission: Insights on COVID-19 Quiz 1](#)

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: Film](#)

Contagion (2011)

Available to rent and stream online

Contagion is a 2011 film revolving around the threat of a deadly outbreak of a fatal disease and the people determined to keep it at bay. As the fast-moving epidemic grows, the worldwide medical community races to find a cure and control the panic that spreads faster than the virus itself. In this film you’ll be able to witness *transmission* in action.