THE COMPLEX CONTAGION OF DOUBT IN THE ANTI-VACCINE MOVEMENT

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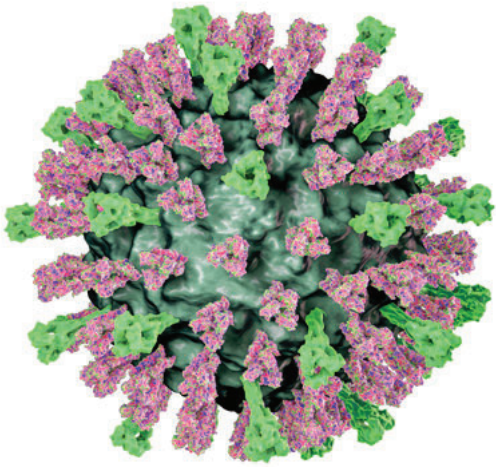
> "FUD" is the *fear, uncertainty, and doubt* that IBM salespeople instill in the minds of potential customers who might be considering [competitors'] products.... The idea, of course, was to persuade buyers to go with safe IBM gear rather than competitors' equipment.
>
> — *The Jargon File* (cited in Raymond, 1991)

INTRODUCTION

Measles virus



The measles virus is a "simple contagion" that is transmitted through contact between an infected person and a susceptible person. When someone who is newly infected becomes contagious, that person can transmit the disease to someone else who is susceptible, who in turn can transmit it to another, and so on. The result: One highly connected person can trigger an epidemic.

Information can act like a simple contagion as well. If I tell you recent news about the availability of a new measles, mumps, and rubella (MMR) vaccine, you can easily repeat it to someone who can then repeat it to someone else. Each new contact and repetition leads to more transmission of the information. The result is the same: One highly connected person can accelerate word-of-mouth transmission of news, allowing it to spread "virally" across a community (Centola & Macy, 2007).

But anti-vaccine sentiment is different. It is a "complex contagion." Simply hearing a piece of anti-vaccine propaganda does not change a person's beliefs. Rather, people need to be convinced—the hallmark of a complex contagion—through contact with several peers who can reinforce the legitimacy of a point of view. That kind of social reinforcement confers credibility to the idea that vaccines may be harmful (Centola, 2018).

The spread of vaccine hesitancy comes from the increased acceptance of the possibility that vaccines can be harmful, which grows not through the sharing of specific information (or misinformation), but rather from having that information socially reinforced to the extent that citizens believe it to be credible. Therefore, once the anti-vaccination view is perceived to be a legitimate side of a debate, it has already won because the goal is to create credibility for that view and spread doubt about vaccination.

THE PERCEIVED SAFETY OF INACTION

Doubt is a complex contagion reinforced through repeated contact with actors on both sides who unwittingly reinforce the belief that the debate itself is valid. A contagion of doubt is effective because it is asymmetric, benefitting one side more than the other. In this instance, the contagion of doubt benefits the anti-vaccination view and disadvantages public health campaigns (Jamieson, 2018).

Why?

Because the contagion of doubt raises the possibility that a parent's own actions may harm a child, while inaction will keep the child safe. Action and inaction are perceived differently. People feel greater moral responsibility for harms that they inflict through their own action than for harms that may or may not have been a result of their own inaction. The causal inference from action to harm is easier to understand and carries greater moral weight. Therefore, the contagion of doubt amplifies the moral urgency of *not* taking a wrong action—that is, of doing no harm (Oreskes & Conway, 2010).

In the vaccination arena, the contagion of doubt is framed as a contest between a safe behavior (inaction) and a potentially dangerous behavior (vaccination). The goal of the contagion of doubt is to trigger "fear, uncertainty, and doubt" about the possible consequences of action (Raymond, 1991). The logic that follows is not strictly rational, but is fairly clear and predictable: People retreat to the safety of inaction.

The contagion of doubt engages individuals in a series of cognitive biases. The two most pernicious ones are:

- Inferring future from past: Nothing bad has happened so far, so nothing bad will continue to happen as long as I don't make a dangerous decision.
- Post hoc ergo propter hoc: If something goes wrong after vaccination, it can be traced back causally to my decision to vaccinate.

The second of these biases is particularly difficult to address. Although there is enormous variation in human physiology (often compounded by environmental and social factors), and the causes of medical complications in an infant or very young child are too many to enumerate, the contagion of doubt focuses the vague anxiety of almost any parent into a specific threat. Anti-vaccination theories soothe that anxiety by suggesting that parents can protect their children from an unnamed multitude of harms by simply *not* taking the dangerous action of vaccinating their children.

Because anti-vaccine sentiment is not a simple contagion, a single voice will be ineffective at persuasion. But if this contagion is socially reinforced, then a contagion of doubt may spread through the peer networks of close-knit parent communities. A successful campaign of anti-vaccine sentiment does not need to convince every parent of every anti-vaccine fact or falsehood; it simply needs to generate sufficient credibility for the anti-vaccination perspective to engage the reasoning processes of fear, uncertainty, and doubt. These cognitive biases will typically lead citizens to choose inaction (anti-vaccination) over potentially dangerous action (vaccination).

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Speaking of IBM's use of the tactic of fear, uncertainty, and doubt, industry analyst Eric Raymond (1991) says, "The implicit coercion was traditionally accomplished by promising that Good Things would happen to people who stuck with IBM, but Dark Shadows loomed over the future of competitors' equipment or software. After 1991, the term [FUD] has become generalized to refer to any kind of disinformation campaign used as a competitive weapon."

"WEAPONIZING HEALTH CONVERSATIONS"

In 2015, the Defense Advanced Research and Projects Administration (DARPA) within the U.S. Department of Defense launched the Bot Challenge, an open competition for researchers to study the influence of social media bots (automated software programmed to pattern human behavior) on U.S. vaccination conversations (Broniatowski et al., 2018).

The results showed that Russian agencies were indeed hacking into Twitter conversations in the United States and using highly sophisticated tactics to engage in the vaccination debate.

Instead of merely promoting anti-vaccination messages, these malicious actors were seeding ersatz messages on both sides. Their goal was not simply to spread misinformation, but rather to amplify the scale of the debate, spreading not only doubt but going one step further by creating disruptive political animosity as well.

Here are a few examples of the conflicting messages from Russian trolls:

- "#VaccinateUS mandatory #vaccines infringe on constitutionally protected religious freedoms."

- "Your kids are not your property! You have to #vaccinate them to protect them and all the others! #VaccinateUS."
- "#VaccinateUS natural infection almost always causes better immunity than #vaccines."
- "#VaccinateUS You can't fix stupidity. Let them die from measles, and I'm for #vaccination!"
- "Did you know there was a secret government database of #vaccine-damaged children? #VaccinateUS."
- "Most parents in Victorian times lost children regularly to preventable illnesses. #vaccines can solve this problem #VaccinateUS."
- "Did you know #vaccines cause autism? #VaccinateUS."

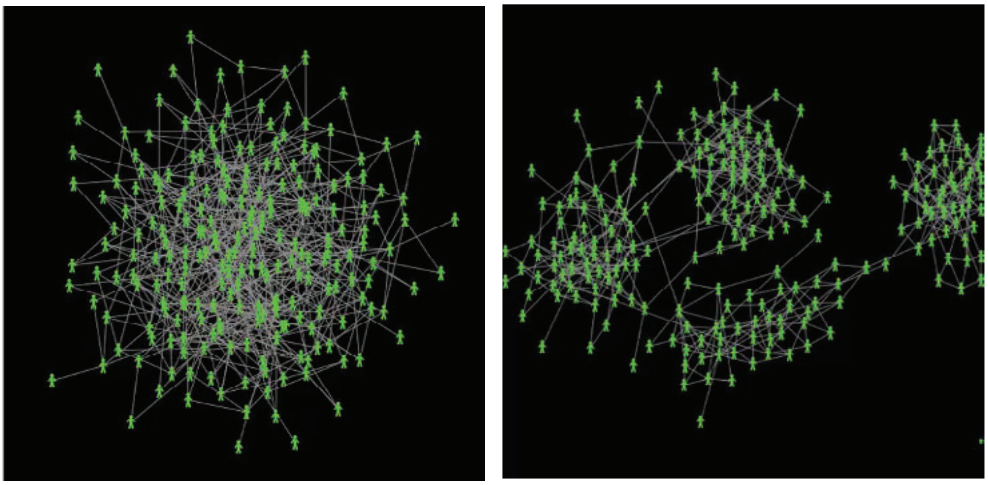
The impact of these digital messages on Twitter is difficult to measure, but at least one direct effect is known: Although none of these tweets were generated by sincere users, the conversations were picked up and retweeted, creating the illusion of an active debate. Citizens who engaged with these tweets, or simply read them, perceived controversy despite a complete lack of scientific disagreement on the issue. The perception of a true debate fueled further conversations, spreading seamlessly from social media to face-to-face interactions with neighbors and fellow parents, allowing the messages to be reinforced and further propagated (Broniatowski et al., 2018).

The conclusion from researchers engaged in DARPA's challenge was that these messages were activating the same principles of fear, uncertainty, and doubt first pioneered by IBM. They were, in essence, "weaponized health communications." Their aim was to encourage citizens to stick with the safe and known choice—namely, inaction—in the face of the vague, looming dangers presented by vaccination.

HOW SOCIAL NETWORKS SPREAD BEHAVIOR

Let's consider what all of this means for the ways in which social networks affect the success of anti-vaccination campaigns and their impact on the likelihood of a measles epidemic. The panel on the left side of Figure 1 represents a "random network" typical of an urban community in which people randomly encounter strangers on most days. Let's assume that this network lacks local community clusters and densely interconnected ties. The panel on the right represents a "clustered network" typical of some tight-knit suburban communities in which people are more likely to interact with their neighbors and their neighbors' neighbors at local events, school fundraisers, and so forth. Which network is more susceptible to a measles epidemic?

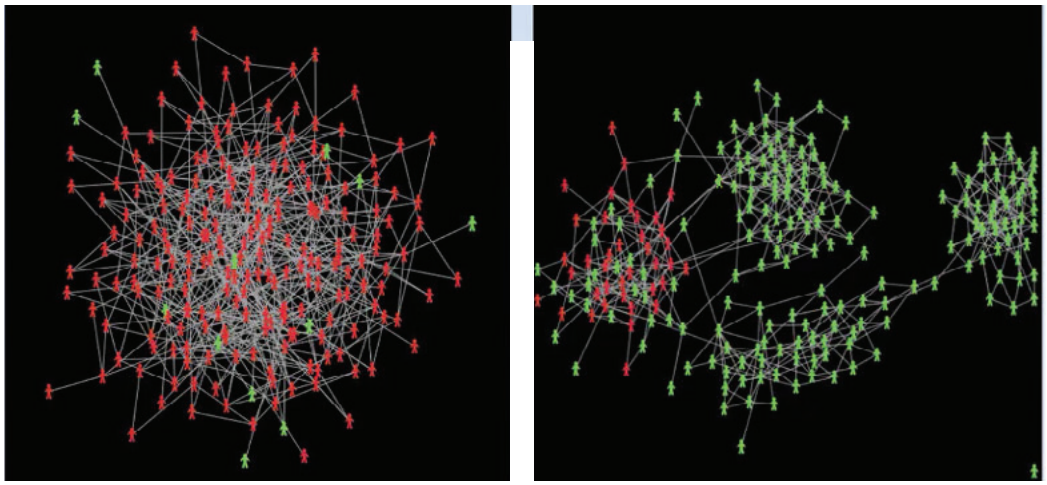
Figure 1. Urban and suburban social networks



If no one is inoculated, then one infected person who enters the urban (random) network will have contact with, and infect, lots of strangers. They will, in turn, infect other strangers with whom they come into contact, giving rise to an exponential growth of infections—an epidemic is almost certain. Contrast this with the situation in a suburban (clustered) network. One infected person will infect a small cluster of peers, but once the outbreak starts, the contagion is easy to contain. Unlike the urban network, in which each infected person's newly infected contacts have random contacts all over the city, the infected person's

contacts in the suburban network are likely to know one another. This social overlap limits the reach of the infection. In this instance, the urban network is clearly more vulnerable to a measles epidemic than the suburban network (see Figure 2; Campbell & Salathé, 2013; Centola & Macy, 2007).

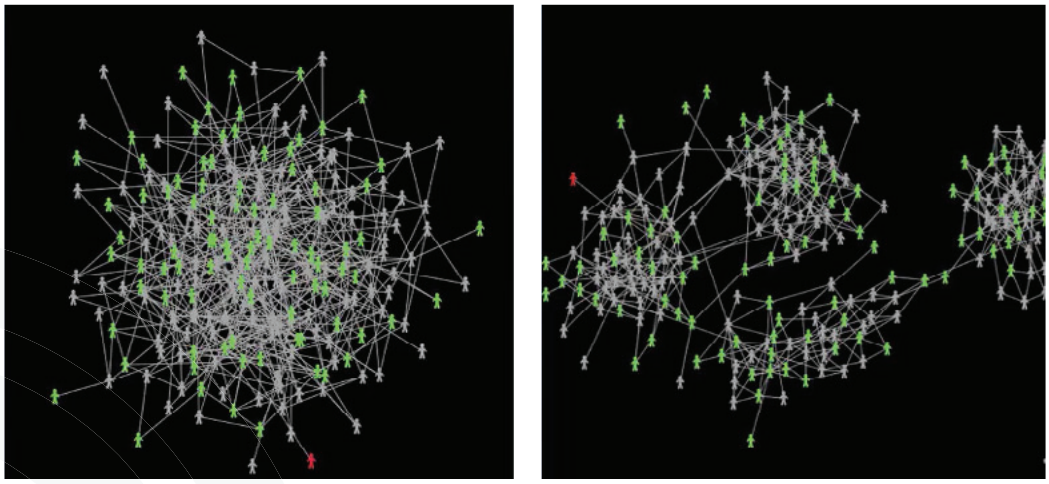
Figure 2. Measles outbreaks in urban and suburban social networks



Red = those infected with measles

Now, let's imagine that there is an inoculation campaign in the United States by the Centers for Disease Control and Prevention (CDC). Public health messages are broadcast throughout the urban and suburban networks with great informational saturation, resulting in the majority of both communities becoming vaccinated (Figure 3).

Figure 3. Effectiveness of vaccination campaigns in urban and suburban social networks



Gray = the inoculated; Green = the not inoculated

In this case, both communities have some protection and neither is susceptible to an outbreak. The vaccination campaign has effectively closed down the contagion pathways of spread, even if an infected person enters. In both communities, inoculation has eliminated the dangers of a measles epidemic and the virus simply cannot take hold.

Finally, let's suppose that there is an anti-vaccination movement within each network. A small group of anti-vaccination activists tries to spread the contagion of doubt in the urban network and an equivalent group attempts to do the same in the suburban network.

Let's assume that in the urban network, the activists are not well connected to one another's friends, nor are they internally terribly coherent. Rather, they are a few disconnected individuals, each trying to spread an anti-vaccination message. Because the urban network does not provide any social reinforcement, the messages are not convincing. There is not enough social support within the community to make these informational signals credible, and the contagion of doubt does not take hold (Centola, 2010). If the inoculation campaign succeeds as before, the anti-vaccination activists have not put anyone at risk but themselves (Figure 4).

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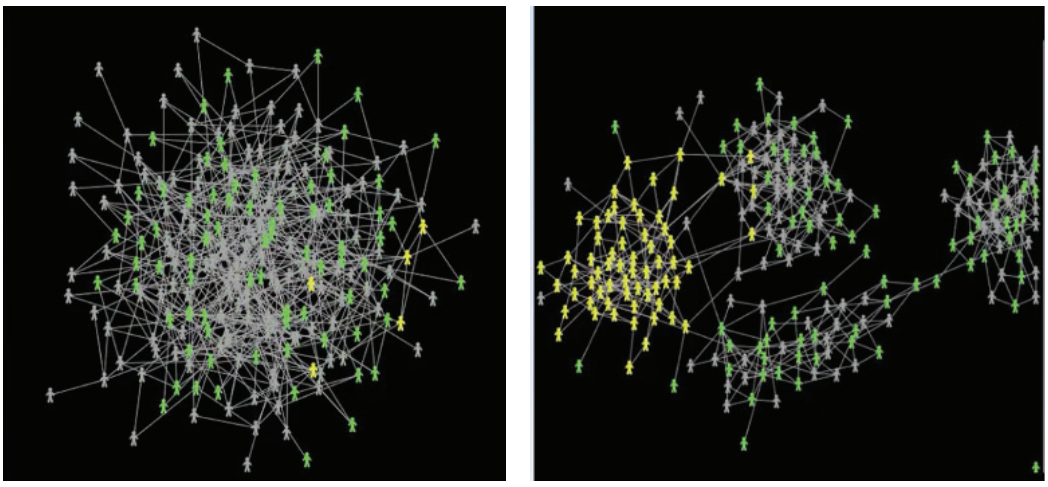
Figure 4. Success of anti-vaccine movements in urban and suburban social networks



Yellow = anti-vaccination campaign success

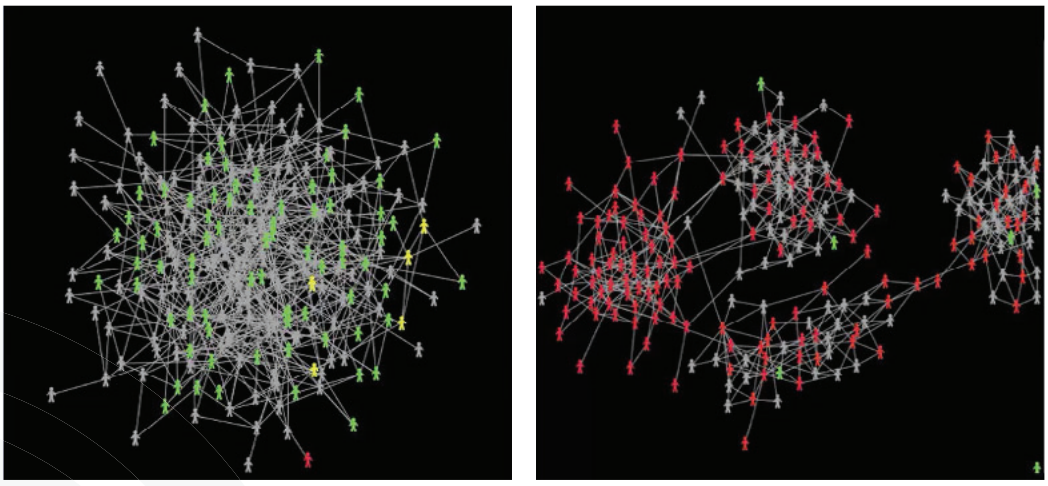
In the suburban network, the anti-vaccination activists cluster together within a small part of the community. Because they have less exposure to the population as a whole, they appear to be at a disadvantage compared to the activists in the urban network. However, because

they share contacts within their social cluster, they can reinforce the anti-vaccination message and propagate doubt among their peers. Those peers may then become convinced that there is a real debate and that concerns about the safety of vaccination are valid. As they, in turn, talk to other peers, social reinforcement within this network can lead to a contagion of doubt (Centola, 2010; Centola, 2011). Even if we assume that a vaccination campaign succeeds as before for the rest of the population, there will be no takers among the cluster of fearful anti-vaxxers.

As a result, an infected person entering this anti-vaccination cluster will infect everyone within it. This cluster then generates a critical mass of infected individuals that can overwhelm the herd immunity serving the rest of the population, allowing every non-vaccinated person in the suburban community to contract measles (Campbell & Salathé, 2013).

In summary, the urban network will be more vulnerable to epidemic outbreaks than the suburban network in the absence of an anti-vaccination movement, but a successful vaccination campaign can reduce that vulnerability (Figure 5). Even with a vaccination campaign, however, suburban networks become vulnerable to epidemic outbreaks if an anti-vaccination movement takes hold. The complex contagion of doubt changes the dynamics of disease spread, making the clustered suburban network a far more vulnerable social setting.

Figure 5. Measles outbreaks after anti-vaccine movements and vaccination campaigns in urban and suburban social networks.



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CONCLUSION

To put these issues in a larger context, consider the difference in public attitudes about antibiotics and vaccines. Why do some U.S. residents zealously overuse antibiotics, while fearfully underusing vaccines? The attraction of antibiotics reflects the perceived danger of immediate infection compared to the remote individual risk of antibiotic resistance. Temporal discounting and poor reasoning about risk can explain why an immediate danger has more influence on decision making than a remote risk (Thaler & Sunstein, 2008). The logic of the vaccination debate is the opposite. A possible viral epidemic is a distant risk, but the perceived danger from vaccination is that it can cause immediate harm, which encourages people to recoil into a position of safety—that is, a position of inaction (Raymond, 1991).

The complexity of social contagion is that it requires social reinforcement to spread. But, if the contagion of doubt spreads most effectively through clustered networks of peers, it may be possible to counteract that contagion with the same strategy. Creating networked communities—online and offline—in which social reinforcement is strategically harnessed to delegitimize the anti-vaccine arguments, is one promising approach. The strategies of complex contagions provide useful guidance for targeting places in the social network where reinforcement can either increase the credibility of the anti-vaccination movement or decrease its legitimacy (Centola, 2018).

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Damon Centola, Ph.D. is one of the world's leading experts on social networks and behavior change, whose work has been published in *Science, Nature, Proceedings of the National Academy of Sciences, The American Journal of Sociology, Circulation*, and *The Journal of Statistical Physics* and widely covered in the popular press. Centola has received numerous awards for his research, including, most recently, the James Coleman Award for Outstanding Research in Rationality and Society in 2017; and the Harrison White Award for Outstanding Scholarly Book in 2019. He was a developer of the NetLogo agent-based modeling environment and was awarded a U.S. patent for inventing a method to promote diffusion in online networks. He is a series editor for Princeton University Press and the author of *How Behavior Spreads: The Science of Complex Contagions*.

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