Grasping exponential growth

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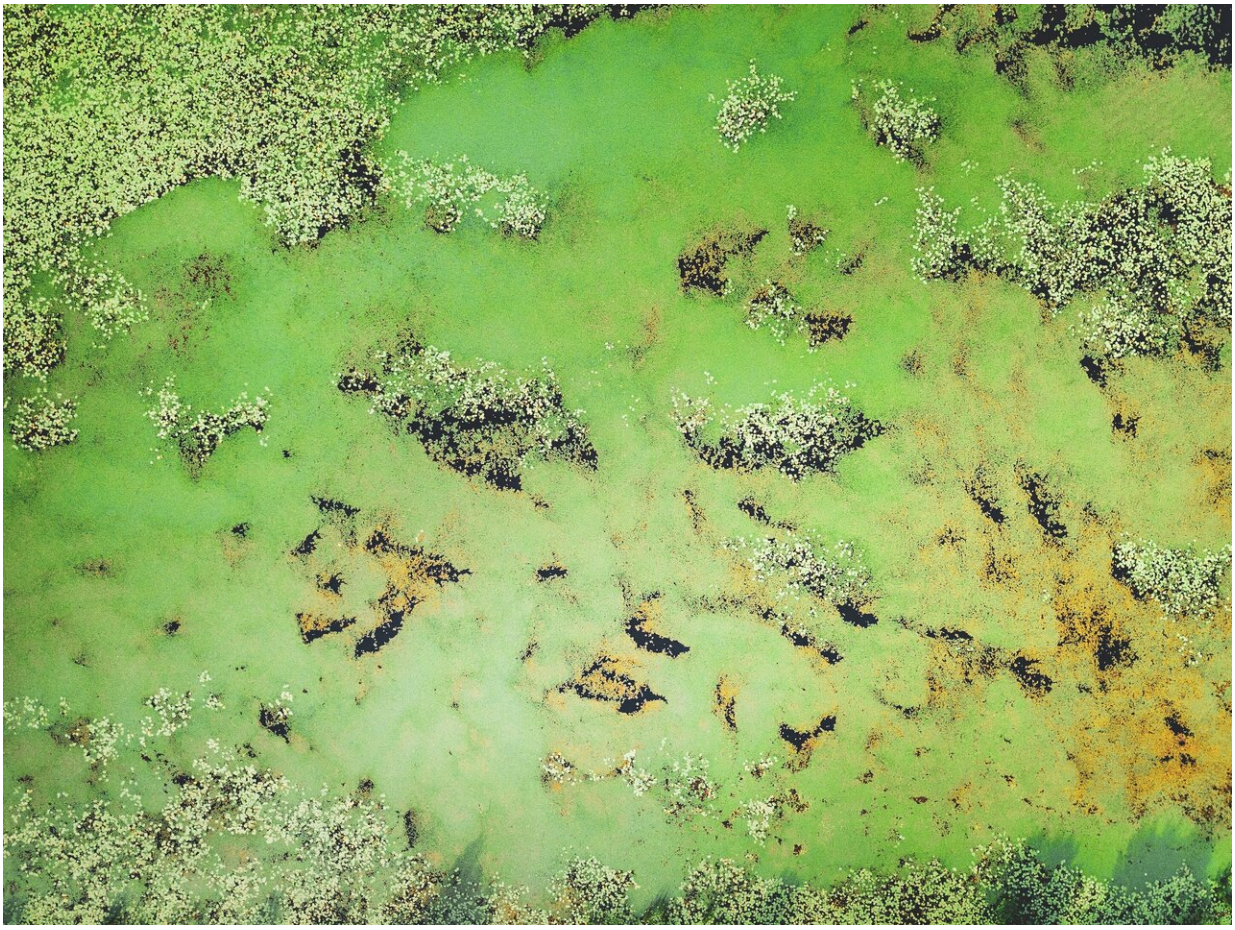

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The coronavirus outbreak offered the public a crash course in statistics, with terms like doubling time, logarithmic scales, R factor, rolling averages, and excess mortality now on everyone's tongue. However,

simply having heard these terms does not mean that someone will be able to comprehend the speed of the spread.

Exponential growth is a notoriously difficult concept to understand. This difficulty can be illustrated by an old Indian legend about a king who was tricked by one of his advisers, saying "Noble lord, I want nothing more than a chess board to be filled with grains of rice. Place one grain on the first square and double the amount of grain for each square that follows."

The king agreed to the deal, seemingly unaware of the explosive growth that would result from doubling the amount of grain for each of the 64 chessboard squares. At the end of the procedure, he would owe his adviser no less than 18 quintillion, 446 quadrillion, 744 trillion, 73 billion, 709 million, 551 thousand and 615 grains—the equivalent of around 11 billion train carriages full of rice.

The tendency to underestimate exponential growth can result in negative consequences during a pandemic. If people misjudge how quickly the virus can spread, then they are less likely to take measures such as mask wearing, social distancing, or working from home. Instead, people may perceive such measures as exaggerated.

A new research paper published by the journal *PLOS ONE* from ETH Zurich's Center for Law and Economics and the Lucerne University of Applied Sciences and Arts has taken a closer look at this behavioral phenomenon, known as exponential growth bias. Martin Schonger, lecturer and director of a study program at HSLU and Senior Research Fellow at ETH Zürich, and doctoral researcher Daniela Sele wanted to find out whether the way in which the exponential spread of infectious disease is communicated can affect the magnitude of this bias. From previous experiments, the researchers knew that people underestimate exponential growth even when they are aware of exponential growth

bias. In other words, informing the public of potential bias does little to improve perception: informed people still underestimate what exponential growth really means in practice, just like people who are unaware of the bias.

Doubling time—a concept easier to understand than growth rate

The research team conducted an experiment in which over 400 participants were presented with the same scenario: a country currently has a thousand cases, and this figure climbs by 26 percent every day. With this exponential spread of the virus, the country would reach one million cases in 30 days. However, there is a chance to reduce the growth rate from 26 percent to 9 percent by adopting mitigation measures.

Researchers quizzed participants on the situation, framing their questions from different perspectives: How many cases can be prevented by adopting mitigation measures? By adopting the measures, how much time can be gained before reaching one million cases? How many cases will there be after 30 days if mitigation measures lengthen the doubling time from three days to eight days? By the way, extending the doubling time like this is equivalent to reducing the growth rate from 26 percent to 9 percent—something that few people recognize intuitively.

Researchers stated that they were surprised by the clear and consistent results of the experiment. Their first finding: talking about growth rates is an ineffective way of communicating the spread of pandemic diseases. Over 90 percent of participants drastically underestimated the number of infections after 30 days of exponential spread. They were much more on the mark, however, when the question was framed using doubling times.

Imagining the impact of mitigation

The researchers' second finding was that people have trouble gauging how many infections can be prevented with mitigation measures. When asked how many infections could be prevented in the scenario above (starting from a thousand cases, a growth rate of 9 percent instead of 26 percent over 30 days), people responded with estimates that were extremely far off. The typical (median) participant believed that 8,600 cases could be prevented, when, in fact, the figure is almost one million.

However, when participants were asked about the number of days that could be gained by adopting mitigation measures—for example, until hospitals are overloaded, or until there is a vaccine on the market—their estimates were significantly better.

The experiment achieved its best results with questions framed from the perspective of time gained and the impact of slowing down doubling times. A statement that combines both of these would be, for example: "If each of us adopt preventative measures today, cases of the virus will slow down—we can estimate that they will double only every eight days, as opposed to every three days. This allows 50 additional days to implement preparatory measures to combat the virus (e.g., by providing much needed supplies to hospitals, or finding treatments and vaccines) before reaching one million cases."

Choosing the right words

The study, conducted during the Swiss partial lockdown in spring of 2020, did not focus on how public authorities and the media discussed the spread of the virus. However, Sele and Schonger have been following the way in which the drastic measures were communicated and comparing these observations with their research findings.

According to the authors, the Federal Office of Public Health (FOPH) and the scientific task force often use doubling times rather than growth rates. In the experiment, they found that this method of framing communication surrounding the coronavirus improved people's understanding. However, the FOPH made little mention of the potential for time gained, even though the research findings indicate that this information helps to better transmit the message.

The researchers suspect that the direct impact of official communication is limited. Reporting in the press might play a more significant role, but the media mostly focus on case numbers and rarely frame communication in the context of time gained.

Schonger and Sele see COVID measures as just one application of the framing theory when it comes to communicating exponential growth: similar phenomena might also be observed in the banking and finance industry, or when it comes to legal or environmental policy-making.

More information: Martin Schonger et al, How to better communicate the exponential growth of infectious diseases, *PLOS ONE* (2020). DOI: 10.1371/journal.pone.0242839

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