

VIEWPOINT

Science Denial and COVID Conspiracy Theories

Potential Neurological Mechanisms and Possible Responses

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The US public health response to coronavirus disease 2019 (COVID-19) has been dismal, characterized by antimask behavior, antivaccine beliefs, conspiracy theories about the origins of COVID-19, and vocal support by elected officials for unproven therapies. Less than half of the people in the US heed health recommendations to wear a mask when out in public.¹ Antiscience rhetoric has consequences. While only 4% of the world's population resides in the US, the US has accounted for 20% of the world's deaths related to COVID-19 and has performed less well than several other wealthy nations.² Low science literacy contributes to denial of science. The relationship between antiscience viewpoints and low science literacy underscores new findings regarding the brain mechanisms that form and maintain false beliefs.

Science Literacy Is Essential

COVID-19 science is complex, and the public is presented with a dizzying array of graphs, statistics, and proposed therapies. Also, communications by scientists changed as they learned about the infectivity and virulence of COVID-19, exacerbating mistrust of scientists by some. In 2015, in a survey of 11 000 12th-grade students

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who took the National Assessment of Educational Progress (NAEP) science assessment, only 22% were proficient or better in science, and 40% were rated as having "below basic knowledge."³ Education matters. In a study that included 9654 US adults, 48% of those who had a high school education or less believed there was some truth to the conspiracy theory that COVID-19 was planned but only 15% among those with some postgraduate training endorsed this idea.⁴

How does low science literacy cause otherwise rational and competent people to misunderstand the threat of COVID-19 and allow them to feel more comfortable with false data than with scientifically sound information? Beliefs grounded in false information, just like those grounded in truth, have neural origins and reflect connections in dedicated brain circuits. Individuals are organized to hold beliefs and to evaluate their merit based on facts and experiences. Studies of neurodegenerative disorders that target selective brain networks shed light on the neural mechanisms that underlie the creation and sustenance of beliefs that are not based in reality.

Neurological Mechanisms for False Beliefs

People hold beliefs with varying levels of truth. False beliefs are common in neurodegenerative disorders, particularly dementia with Lewy bodies and frontotemporal dementia. In neurodegenerative and psychiatric disorders, false beliefs range from accusations of theft, delusions of grandeur, to misidentification of people. Recent theories suggest that false beliefs emerge when there are neuropsychological impairments that (1) promote formation of false beliefs due to faulty sensory information and (2) hinder rejection of a belief due to faulty prefrontal systems that evaluate thoughts and beliefs.⁵ The content of false beliefs in dementia with Lewy bodies and frontotemporal dementia differ but may offer insights into the shared neural mechanisms by which humans misperceive information. With both, the brain receives distorted sensory information that interferes with accurate interpretation of the world and lacks the circuitry needed to determine whether information received is true or false.

A recognized manifestation of dementia with Lewy bodies is Capgras syndrome, the false belief that a loved one has been replaced by an impostor. Capgras is associated with dysfunction in the retrosplenial cortex, a brain region involved with encoding familiarity, and the right frontal cortex, a region involved with belief evaluation.⁶ Also, there is dysfunction in the fusiform gyrus, which feeds information about an individual's face into memory systems in the temporal lobe and familiarity systems in retrosplenial cortex, allowing comparison of each face with previously encountered faces. What seems like a bizarre delusion is a situation in which faulty information about a face and its familiarity leads to an internally consistent, but false, conclusion. Contributing to the false belief, many people with dementia with Lewy bodies have dysfunction in the frontal brain circuitry required to determine the plausibility of a conclusion.

In frontotemporal dementia, visual processing is intact, making Capgras rare, but other false beliefs occur. Sometimes, these patients believe they have won the lottery, leading them to spend money they do not have. With dementia with Lewy bodies, misbelief begins with a faulty perception of a face. With frontotemporal dementia, it begins with a gratifying idea about wealth. Evaluating the plausibility of a person's ideas requires functional prefrontal circuits. When people reflect on their thoughts, circuits in the frontal lobes are needed to confirm or refute whether the ideas are valid. When pondering wealth, circuits in the frontal lobes search the brain to verify or deny a desire to be rich with factual data. If frontal

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systems responsible for monitoring the credibility of ideas are dysfunctional, false conclusions are made about the veracity of an idea.

False Beliefs About COVID-19

How do these distinct mechanisms—distorted sensory information or faulty monitoring of ideas—have relevance to cognitively normal and healthy people without dementia who develop false beliefs? For someone without strong science literacy, absorbing and interpreting a graph of data about COVID-19 infections may be as difficult as it is for someone with dementia with Lewy bodies to interpret a face. Without reliable sensory data, individuals may be forced to look for other sources of information that resonate with their own feelings, including conspiracies that deny the existence of a threat. Rather than engaging with information that is difficult to “see” and that may require changes in behavior, it may be easier to take in data that are simple and reassuring. Conspiracy theories may bring security and calm, as with the patient with frontotemporal dementia who is content to believe they are rich. This problem is magnified by social media because before the internet, conspiracy theories usually remained siloed and quickly died off due to lack of supporters. Now, social media-fueled echo chambers amplify these theories, reinforcing false beliefs and discouraging people from seeking the truth.

False beliefs about COVID-19 are also more likely to occur in someone who has faulty systems for monitoring and evaluating scientific information. When physicians determine the efficacy of medication like hydroxychloroquine, they read research studies, evalu-

ate the adverse effects of the drug, and some may even study the pharmacokinetics before deciding whether prescribing the medicine is worth the risk. This process of logic and reasoning is not accessible just to physicians or scientists. It is learned in elementary school and high school and is later sharpened by solving problems in work, college, and graduate school. If that process of balancing and comparing all sides of an issue is not taught, an individual is more susceptible to believing false information. Developing frontal circuitry to support the process of reasoning is part of education and science literacy and stands at the core of a healthy democracy.

Possible Responses

The COVID-19 epidemic reinforces the challenges of science denial. The medical community should mount systematic efforts around science education beginning in childhood and across the lifetime. Scientists, clinicians, and public health experts should engage in dialogue on issues of public health such as masks, vaccines, and medications. Accessible presentations should be part of every medical office and health care system. Attractive and accessible websites that post reliable data on health should counteract the false narratives that harm the health of the US (and other countries). A systematic analysis of “what went wrong” with COVID-19 policies during and after this pandemic is the responsibility of the scientific community. In addition, working with politicians to establish national policies to support rational science is critical. The practice of medicine is at the front line of the national concerns and conflicts surrounding truth and health. When science wins, everyone wins.

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REFERENCES

1. Cornwall W. Just 50% of Americans plan to get a COVID-19 vaccine: here's how to win over the rest. *Science*. Posted June 30, 2020. doi:10.1126/science.abd6018
2. Bilinski A, Emanuel EJ. COVID-19 and excess all-cause mortality in the US and 18 comparison countries. *JAMA*. Published online October 12, 2020. doi:10.1001/jama.2020.20717
3. The Nation's Report Card. 2015 Student questionnaire results: classroom instruction for mathematics, reading, and science. Accessed September 8, 2020. https://www.nationsreportcard.gov/sq_classroom/#/science
4. Schaeffer K. A look at the Americans who believe there is some truth to the conspiracy theory that COVID-19 was planned. Pew Research Center; July 24, 2020. Accessed September 8, 2020. <https://www.pewresearch.org/fact-tank/2020/07/24/a-look-at-the-americans-who-believe-there-is-some-truth-to-the-conspiracy-theory-that-covid-19-was-planned/>
5. Coltheart M. The neuropsychology of delusions. *Ann N Y Acad Sci*. 2010;1191:16-26. doi:10.1111/j.1749-6632.2010.05496.x
6. Darby RR, Laganier S, Pascual-Leone A, Prasad S, Fox MD. Finding the imposter: brain connectivity of lesions causing delusional misidentifications. *Brain*. 2017;140(2):497-507. doi:10.1093/brain/aww288