Special Section: Clear Thinking about Climate

Misconceptions about Climate Change: An Educator's Guide

Bertha Vazquez

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The Cranky Uncle Game: A Way to Logic-Check Misinformation about Climate Change

John Cook

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When we think of the damage caused by misinformation, we tend to think of false beliefs. Misinformation reduces acceptance of the reality of climate change, raises doubts about the safety of vaccines, and inspires false beliefs such as flat-earthism. But the damage caused by misinformation goes beyond beliefs, affecting people's behavior in ways that harm society. For example, hearing a conspiracy theory about climate change makes people less likely to engage in politics (Jolley and Douglas 2014).

Given the damage misinformation can and is doing, it's imperative that we push back. The most common tool we have for countering misinformation is fact-checking. Explaining the facts is certainly valuable, and an analysis of many studies measuring the impact of fact-checking found that they tend to have a positive effect on political beliefs (Walter et al. 2020). However, there are limitations to what fact-checking can address.

One form of misinformation that is difficult to fact-check is *paltering*: the use of true statements to convey a misleading impression (Schauer and Zeckhauser 2009). A form of paltering often found in climate misinformation is the technique of *cherry picking*, which involves carefully selecting data that leads to a conclusion different from what you'd get if you considered all the available evidence (Cook 2020). For example, one might highlight a single growing glacier to argue that global warming isn't melting glaciers when globally most glaciers are shrinking. Another example of cherry picking is narrowing your focus to a short time period to make claims about long-term trends. A stark example of this is Bjorn Lomborg citing two years of sea level data when there was a temporary pause in sea level rise to argue that the problem was not as bad as scientists had been reporting (see Figure 1).

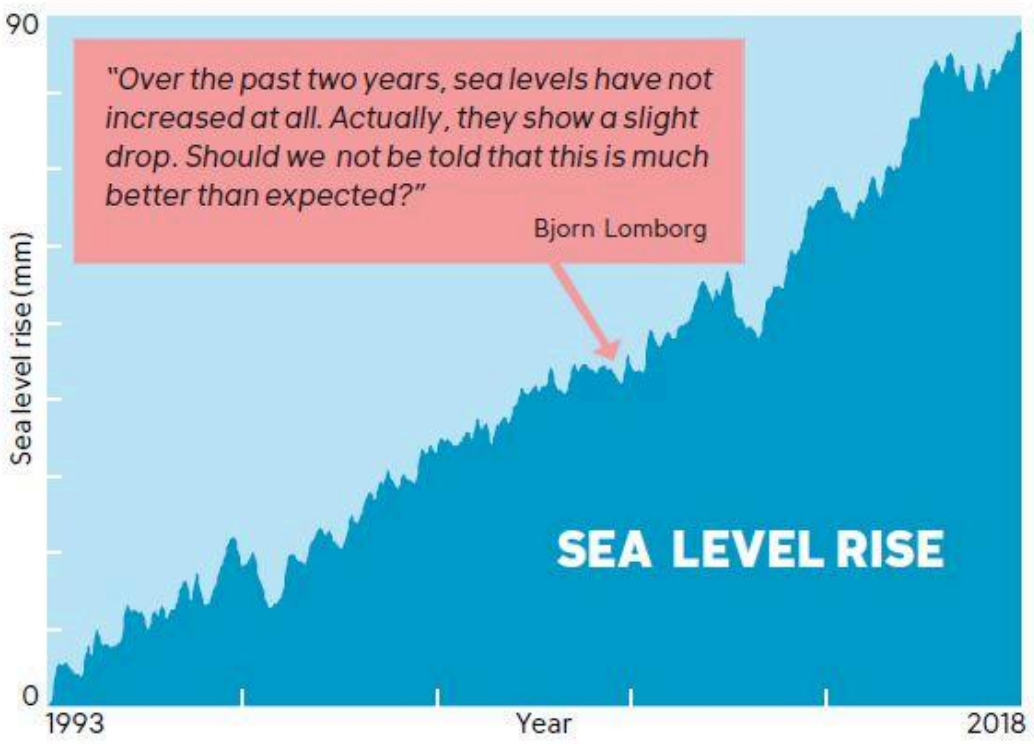

Figure 1: Cherry picking sea level rise by Bjorn Lomborg.

Greenwashing is another example of using factual statements to paint the false impression of an organization (or sometimes government) behaving in environmentally friendly ways. For example, a company will boast about how they've spent millions of dollars on renewable energy projects while failing to disclose that this outlay composes a tiny fraction of their overall budget, which is overwhelmingly spent on fossil fuels. This leaves people with the impression that the company is behaving responsibly, and the tactic works: greenwashing has been found to increase positive attitudes toward fossil-fuel companies (Friedman and Campbell 2023).

Another challenge for fact-checkers are *hidden premises* or *unstated assumptions* in misleading arguments. An example of this is when someone argues that "the climate has always been changing" and so climate change is nothing new. Statements such as this may sound superficially persuasive to some because they implicitly argue that the current climate change is not human-caused while relying on unstated assumptions. This kind of argument is difficult to fact-check, because the misleading part isn't explicitly stated, allowing the person spreading misinformation to cover their tracks and avoid accountability (Birks 2019).

Because of these limitations of fact-checking, we need to make more use of a complementary method of identifying misleading arguments: logic-checking. By this, I mean identifying the presence of logical fallacies and misleading rhetorical techniques. Logic-checking can address many of the types of misinformation that fact-checking is ill-equipped to deal with. In addition, there's another benefit to logic-checking. Not only does it help spot misleading content, but it also informs one of the most effective interventions for countering misinformation: logic-based inoculation.

In this article, I will outline how to logic-check claims using critical thinking. I will then delve into the research studying the powerful benefits of logic-based inoculation. I'll finish by presenting a real-world example of this approach in action

and a practical way you can counter misinformation with facts and logic.

Using Logic-Checking to Identify Misleading Content

Logic-checking involves identifying whether an argument possesses logical fallacies or misleading rhetorical techniques. But how do you logic-check? Critical thinking philosophers Peter Ellerton and David Kinkead and I developed a step-by-step methodology for deconstructing and analyzing misinformation (Cook et al. 2018). Figure 2 shows a simplified version of our flowchart (see http://sks.to/cafe for a three-minute video explainer at the Critical Thinking Cafe).

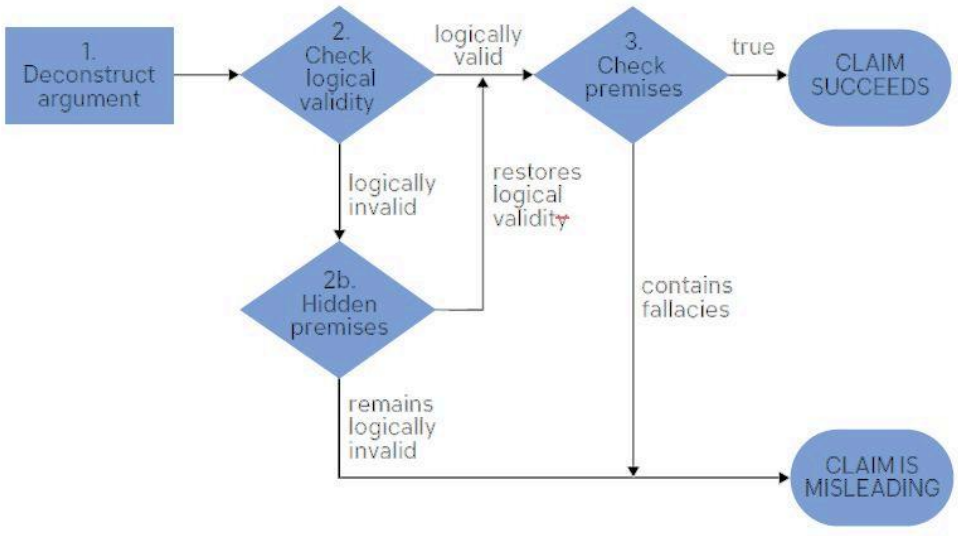

Figure 2: Flowchart for deconstructing claims (Cook et al. 2018)

Let's apply this approach to the earlier "the climate has always been changing" example. The first step is to deconstruct the original claim into an argument structure, consisting of premises (starting assumptions) and a conclusion. At this point, it's important that the deconstructed argument is a faithful rendition of the original claim. You don't want to construct a straw man that is a weakened version of the original claim, making it easier to debunk. Instead, you want to build a "steel man" version of the original claim—as strong an argument as possible. In our example, the premises are "climate has always changed" and "climate is changing now." The conclusion, implicit in this case, is "current climate change is naturally caused."

The second step is to check for logical validity. A logically valid argument is one where if you assume (for the sake of argument) that the premises are true, then it logically follows that the conclusion must also be true. If the conclusion does not logically follow from the premise, then the argument is logically invalid. In our deconstructed example, the argument is logically invalid. While it is true that climate has changed naturally in the past, it doesn't necessarily follow that the climate must be natural now. There might be other causes of current climate change, so in this case, the conclusion does not logically follow from those two premises.

If the argument is logically invalid, the next step is to add to the deconstructed argument any hidden premises that make the argument logically valid. The purpose is to add one or more premises such that if you assume all your premises are true, then logically, the conclusion must be true also. In our example, the hidden premise that makes the argument logically valid is the assumption that whatever caused climate change in the past must be the same as what's causing climate change now.

Once the argument has been made logically valid, the third and final step involves examining each premise for logical fallacies. In our example, the first two premises are true. Climate *has* changed naturally throughout Earth's history. The climate *is* currently changing. However, the third, newly added hidden premise is where the argument commits its logical fallacy. The assumption that what's driving climate change now must be the same as the past driver commits *single cause fallacy*, assuming that only one factor drives climate change. This assumption is fallacious

when there are potentially multiple causes, as is the case in climate change when you have both anthropogenic factors and natural factors driving it. Figure 3 visualizes the three steps involved in deconstructing and analyzing the "past climate change" argument.

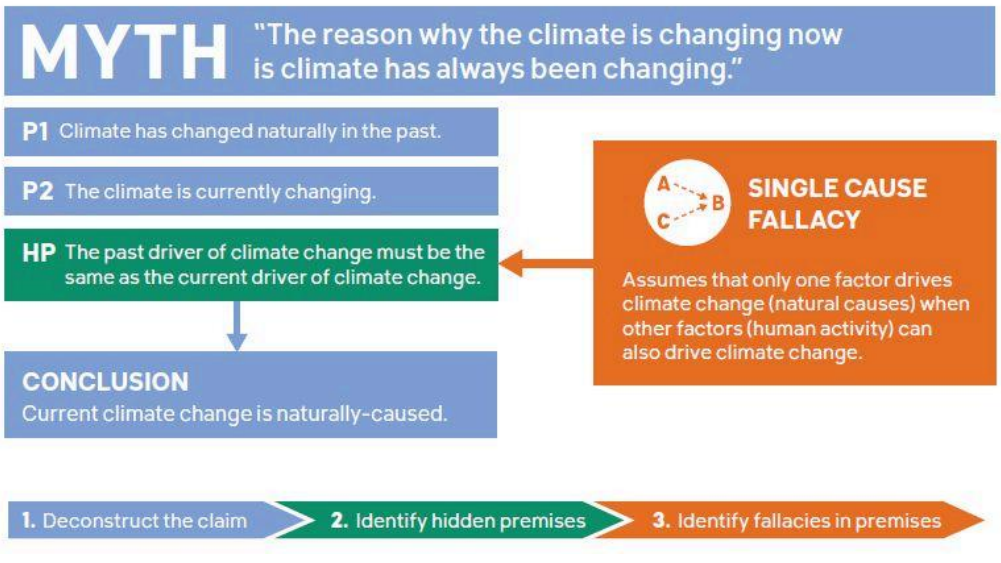

Figure 3: Deconstructing the "past climate change" argument

This example illustrates the potential of critical thinking deconstruction. First, it addresses implicit misinformation by making the argument explicit. Second, it identifies hidden premises not articulated in the original claim. Third, by breaking up a claim into its individual premises, it allows you to surgically identify where and how an argument misleads.

The importance of hidden premises was driven home in recent research where I collaborated with an interdisciplinary team to deconstruct a wide range of climate myths (Flack et al. 2024). Our goal in this research was taking another step toward the holy grail of fact-checking: automatic detection and debunking of misinformation. We had already trained a machine learning model to detect climate misinformation (Coan et al. 2021). To detect climate myths, first we must develop a comprehensive taxonomy of the different claims made by climate contrarians (Figure 4). However, our model didn't know whether the claims were true or false. We simply trained it to detect the claims in our taxonomy without making judgments about their veracity.

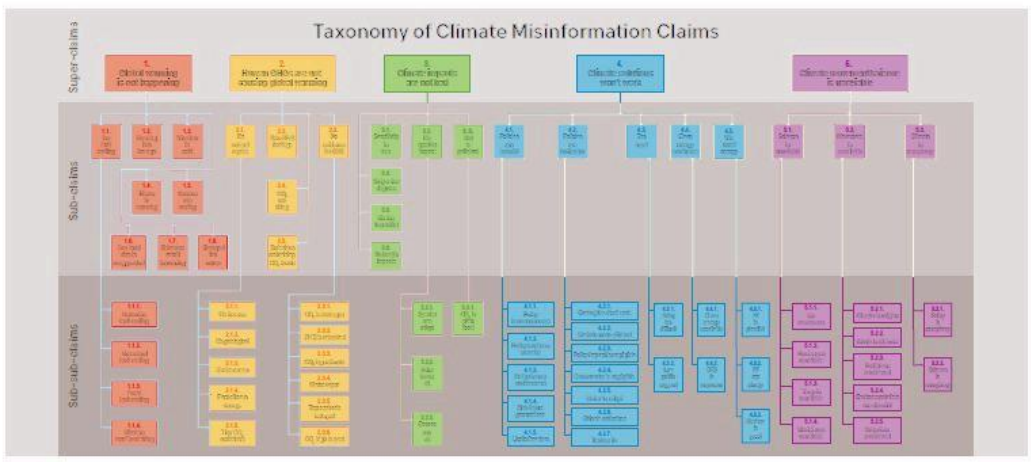

Figure 4: Contrarian claims about climate change (Coan et al. 2021)

To determine whether the claims in our taxonomy were misleading, we went through every claim in the taxonomy, deconstructing it using the critical methodology from Cook et al. 2018. We found that every claim in the taxonomy contained misleading fallacies. In fact, most claims committed more than one fallacy. Most important for the current discussion, we found that 91 percent of the claims contained hidden premises with logical fallacies. In other words, the overwhelming majority of climate misinformation contains misleading hidden premises. This underscores the importance of logic-checking to identify potentially misleading arguments.

As a communication researcher, my original motive for developing a critical thinking approach to deconstructing misinformation was needing a reliable way to identify logical fallacies. This was because of my psychological research into countering misinformation.

Logic-Based Corrections

It was during my PhD that I first stumbled upon the potential of using logic to counter misinformation. I designed an experiment where participants were warned with a message designed to "prime" them to be more resilient against misinformation (Cook et al. 2017). The research was based on inoculation theory, a branch of psychological research that borrows the idea of vaccination and applies it to knowledge (McGuire and Papageorgis 1961). Just as exposing people to a weakened version of a virus can convey immunity when they encounter the real virus, in a similar way, exposing people to a weakened version of misinformation can convey cognitive immunity so that they're less likely to be misled by real misinformation.

The misinformation used in the experiment was the Global Warming Petition Project, a website casting doubt on the scientific consensus regarding human-caused global warming. The problem was I had previously run experiments testing the powerful effect of communicating the 97 percent scientific consensus on climate change (Cook and Lewandowsky 2016). My goal as an experimenter was to warn people against misinformation casting doubt on the scientific consensus without mentioning the 97 percent consensus so I could measure the effectiveness of the warning. I achieved this by generally warning people against the misleading technique used in the Petition Project: fake experts. These are people who convey the impression of expertise but don't have the relevant expertise. The Petition Project featured 31,000 science graduates but only a small percentage had relevant climate expertise (Anderson 2011). In my warning, an example of the fake expert technique used in tobacco misinformation was provided to make the message more concrete. One randomly selected group of participants was warned about the fake expert strategy, then shown misinformation from the Petition Project. Another random group was shown just the misinformation.

The results from this experiment yielded several insights. First, when people were shown misinformation without a warning, the misinformation reduced people's climate perceptions. Climate misinformation has a negative effect, but it doesn't work the same for everyone—some people are more persuaded by misinformation. Climate misinformation is polarizing, causing people to move further away from each other in their climate beliefs. Second, for the group who were shown the warning before the misinformation, the misinformation was completely neutralized across the political spectrum. This tells us that whether people are conservative or liberal, no one likes being misled. Aversion to being deceived is bipartisan.

Finally, these results tell us that by explaining the misleading techniques used in misinformation, you can counter misinformation across topics. The Global Warming Petition Project was neutralized without being mentioned. You can tackle polarizing issues such as climate change by sidestepping cultural triggers and instead explaining general misleading techniques.

In a follow-up study, we pitted facts against logic to see which was more effective in fighting misinformation (Vraga et al. 2020). The climate myth used in the experiment was "CO2 is plant food so we should emit more CO2." The fact-based approach explained that plants need a range of factors to flourish, including a regular water supply and comfortable temperature range, both of which are disrupted by climate change. The logic-based approach explained that the plant food myth committed the fallacy of oversimplification by focusing on just one factor required for plant growth. I also tested whether it mattered if the corrections came before (*prebunking*) or after (*debunking*) the misinformation. Figure 5 shows both corrections, which also used cartoons as we were at that time experimenting with using humor in response to misinformation.

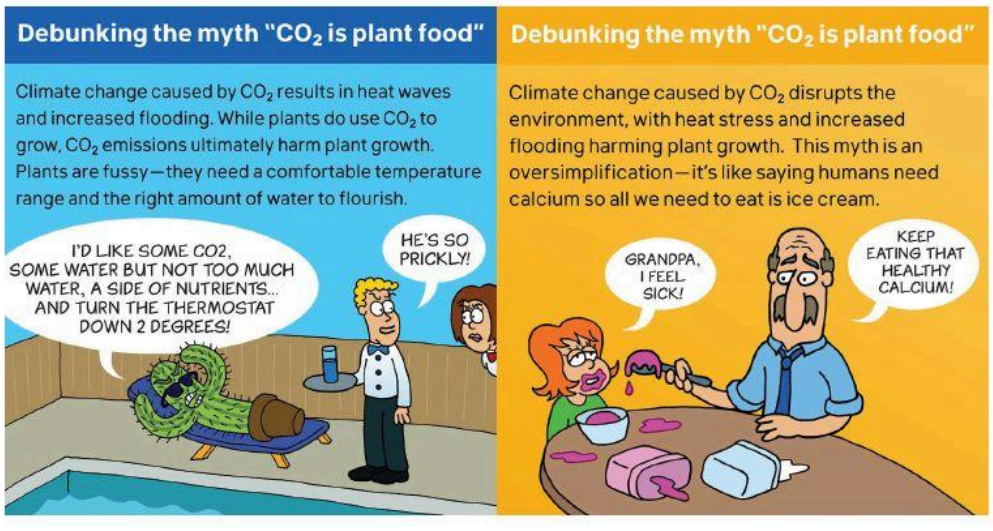

Figure 5: Fact-based correction vs. logic-based correction (Vraga et al. 2020)

We found that the fact-based approach only worked if it came *after* the misinformation. If people saw the facts first, then the myth was the last thing they saw; the myth canceled out the facts. This is consistent with other studies finding that misinformation can cancel out factual explanations (McCright et al. 2016; van der Linden et al. 2017). However, the logic-based approach was effective in countering the misinformation whether it came before or after. In either situation, the logic-based correction reduced belief in the plant food myth, showing it to be more robust than factual explanations.

Logic-based corrections work. They neutralize polarizing misinformation. They work across the political spectrum. They work regardless of the order in which people receive them. And they work across topics. We can create general logic-based inoculations targeting misleading techniques that are effective against multiple myths. This is particularly useful because we don't know what exact form misinformation will take in the future. We don't have to constantly play whack-a-mole against specific myths if we can inoculate people against general techniques.

However, the challenge with the logic-based approach is that there are a lot of logical fallacies and rhetorical techniques to be found in misinformation. People who spread misinformation draw on a vast array of techniques to mislead us. How are we to remember the long list of misleading techniques? I've found the acronym FLICC is helpful, listing five main techniques of science denial: fake experts, logical fallacies, impossible expectations, cherry picking, and conspiracy theories. However, the FLICC five aren't just individual techniques but categories summarizing a host of different techniques, fallacies, and traits of conspiratorial thinking. Over time, I have developed FLICC into a more comprehensive taxonomy of misinformation techniques (Cook 2020). A quick scan of the FLICC taxonomy in Figure 6 shows there are many techniques and fallacies to learn if we wish to develop resilience against misinformation (and the taxonomy isn't comprehensive; I continue to add more over time). How do you get the general public to learn all these techniques and internalize them deeply enough that they recognize them in real-world venues such as social media, mainstream media, and personal conversations?

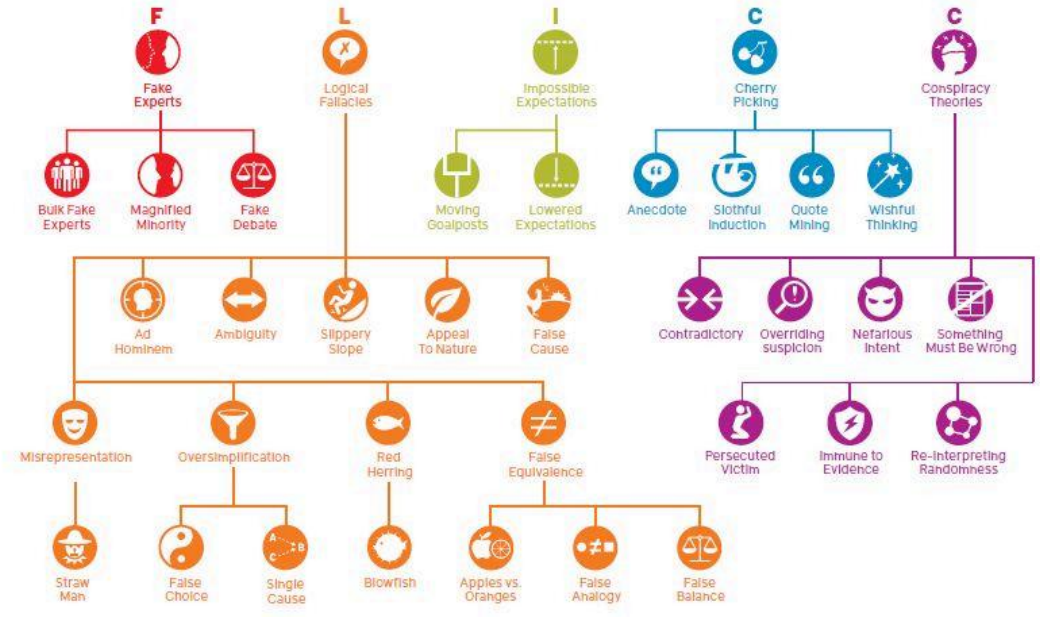

Figure 6: FLICC taxonomy, summarizing the five categories of science denial

To address this challenge, I turned to *gamification*. The advantage of games is you can use gameplay elements such as collecting points and leveling up to motivate players to progress farther into the game, which in the case of an educational game may serve to reinforce learning. In 2020, we ran a crowd-funding campaign to develop the *Cranky Uncle* game (Cook et al. 2022). See http://sks.to/cafe2 for a short video introduction (sequel to the original Critical Thinking Cafe video). After a successful campaign, we developed the game and released it free to the public, available on iPhone, Android, and browsers (crankyuncle.com).

Throughout the game, a cartoon character representing a science-denying cranky uncle explains how he casts doubt on science, running through the techniques in the FLICC taxonomy (Figures 7a and 7b). As players learn new techniques, they practice critical thinking via quizzes where they must identify the fallacy in misinformation examples (Figure 7c). Each time they answer correctly, they earn cranky points. When they level up, Cranky Uncle's mood gets a little crankier, from "sullen" to "huffy" to "peevish" and onward.

The advantage of the logic-based approach is it easily adapts to other topics because fallacies are found everywhere. Throughout the game, players are shown examples of fallacies from a variety of domains. A quiz giving an example of *cherry picking* might involve flat-earthism ("The world can't be round because the floor in this room is flat") or general fallacious logic ("I just ate a big meal; global hunger doesn't exist"). *Impossible expectations* quizzes could draw from evolution ("Until we find all missing links, we can't be confident of the theory of evolution") and vaccination ("We need more research before we can be 100% sure that vaccination is safe").

Figure 7: Cranky Uncle game. a) FLICC fallacies; b) Explanation of conspiracy theories; c) Quiz question

Conclusion

The effectiveness of the *Cranky Uncle* game, with its combination of facts and logic-checking, raises an important communication principle. We should avoid the false dichotomy (a fallacy found in the FLICC taxonomy) of thinking that we should either take a logic-based *or* fact-based approach. Ideally, we should try to use both. This is the approach recommended in the 2020 Debunking Handbook (Lewandowsky et al. 2020), where we suggest that debunkings should be arranged using the fact-myth-fallacy-fact structure, otherwise known as a "truth sandwich" (Figure 8). Debunkings should place the emphasis on facts rather than the myth. Unfortunately, many fact-checkers use the myth as their headline, placing undue emphasis on the misinformation rather than the facts.

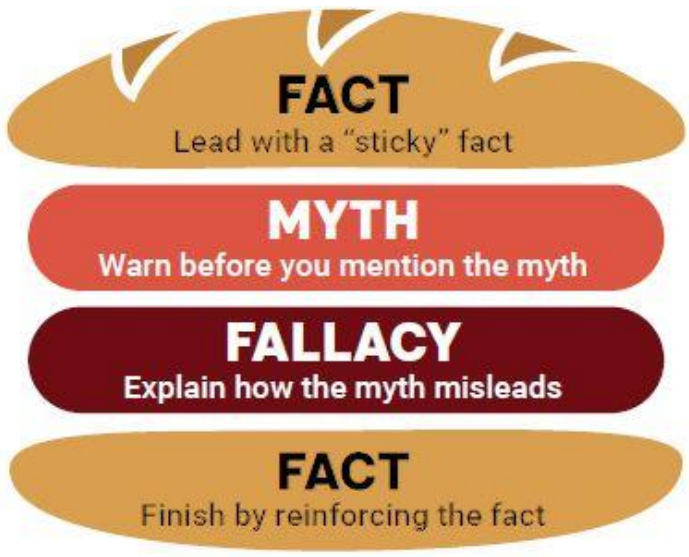

Figure 8: The truth sandwich format for debunking misinformation, adhering to the fact-myth-fallacy-fact structure (Lewandowsky et al. 2020)

When you debunk a myth, you create a gap in people's mental models and need to fill that gap with a "replacement fact," otherwise the myth will come back and continue to influence the person. Therefore, your fact needs to be carefully chosen to fill the gap left by the vacated myth (Johnson and Seifert 1994). For example, if you're debunking the myth that the Sun causes global warming, it's insufficient to merely explain how the Sun can't be causing global warming; you also need to explain what *is* causing global warming (which is the increased greenhouse warming from burning fossil fuels).

Once you've explained the fact, you can mention the myth (only once), while being careful to explicitly warn people that you're about to mention misinformation to put them cognitively on guard (Ecker et al. 2010). This can be something as simple as "One myth states …" or "Some people falsely claim …" But presenting fact and myth confronts people with two conflicting pieces of information. If they can't resolve the conflict between fact and myth, the danger is they cancel each other out (van der Linden et al. 2017). You resolve the conflict by explaining the fallacy that the myth uses to distort the facts. Finally, end the debunking by once again reinforcing the facts. This completes the truth sandwich, a seamless melding of fact-checking and logic-checking that is the most effective structure for a debunking.

Misinformation has exploded as a societal issue over the past decade, and the ways that it influences people are expanding in alarming ways through new technologies such as social media platforms and artificial intelligence. We need technology to respond at the speed and scale required. Consequently, I have been working on using AI to detect logical fallacies (Zanartu et al. 2024a). This is one component in our continued quest for the fact-checking holy grail—automatically debunking misinformation with AI generated truth sandwiches (Zanartu et al. 2024b).

But technology isn't a magic bullet that will solve all our problems. Misinformation is a multi-faceted, interconnected problem that requires a range of solutions—technological, cultural, political, legal, and educational. Part of the solution requires rolling up our sleeves and developing ways to boost people's critical thinking skills. Logic-checking alongside fact-checking gives us a more holistic and versatile set of tools to tackle the variety of misinformation that confronts us.

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John Cook

John Cook is the Climate Communication Fellow for the Global Change Institute at the University of Queensland, Australia. He created and maintains the Skeptical Science website and is co-author of Climate Change Denial (2011) and the 2013 college textbook Climate Change Science: A Modern Synthesis.

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