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Clifton P. Bueno de Mesquita

Ylenia Vimercati Molano

Lara Vimercati

P. Jacob Bueno de Mesquita

Roger Williams University, jbuenodemesquita@rwu.edu

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Using Evidence-based Scientific Research to Influence Dietary Behavioral Change: Taking a Look in the Mirror

Clifton P. Bueno de Mesquita¹ , Ylenia Vimercati Molano¹,
Lara Vimercati¹ and P. Jacob Bueno de Mesquita²

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Abstract

Science can provide accurate information to society to inform decision-making and behavior. One contemporary topic in which the science is very clear, yet behavioral change has lagged, is climate change mitigation. Climate change scientists use evidence-based research to advocate to the public to adopt emission-reducing behaviors in various sectors such as transportation and food. However, scientists themselves often do not change their own behaviors according to the scientific consensus. We present a case study of a group of natural sciences PhD students, who, when presented with evidence and an opportunity for a behavioral change with implications for climate change mitigation, demonstrated defensive reactions that would undoubtedly frustrate these same scientists if they were doing public outreach about their own work. Our goal is to raise awareness that we scientists do not always practice what we preach but could perhaps overcome this by understanding the defense mechanisms that impede meaningful change.

Keywords

Climate change, animal agriculture, diet, behavioral change, dietary shift

Introduction

Global climate change poses an immense challenge to humanity. Many have rightfully called it an existential crisis, as it threatens to drown inhabited islands, to reduce the quantity and quality of the food and water supplies, and to accelerate loss of biodiversity. In addition, global climate change contributes to extreme weather events, epidemics, and pandemics. Scientists have documented climate change using contemporary measurements as well as other techniques such as examining rocks, fossils, tree rings, sediments, and ice-cores to reconstruct temperature and atmospheric gas concentrations back tens of thousands of years. The conclusions are very clear – the Earth is now hotter than it has been since the development of human civilizations and is warming at an alarming and unprecedented rate.¹

The first challenge for scientists, after observing such trends in climate, was to study the cause of the problem. This challenge is, to a great extent, essentially complete, although evidence will continue to build with each additional day, month, and year of data. This was the purpose of Working Group I of the Intergovernmental Panel on

Climate Change (IPCC), which formed in 1988 and has since authored six comprehensive assessment reports on the physical science basis of climate change. The evidence is unequivocal that human activities generate emissions that alter atmospheric chemistry and alter the radiation budget of the whole planet. The IPCC has quantified the radiative forcing, or warming effect, of various activities on the planet, even taking into account variation in incoming solar radiation, and activities that cool the planet.¹ The greenhouse gas effect is a truth of physics that has borne out in the documented increases in temperature over the last century. There is no way to deny or avoid the heat-trapping effects of carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), the three largest contributors. Animal agriculture has emerged as a leading contributor to climate change because it is a key

¹Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO, USA

²Department of Public Health, Roger Williams University, Bristol, RI, USA

Corresponding author:

Clifton P. Bueno de Mesquita, Department of Ecology and Evolutionary Biology, University of Colorado, Boulder, CO 80309-0334, USA.
Email: cliff.buenodemesquita@colorado.edu

driver of deforestation and land degradation and due to methane and nitrous oxide emissions from farmed ruminant animals (bison, cows, goats, sheep).²⁻⁵ Worldwide, the appropriation of land by humans for animal agriculture accounts for the largest share of land use - about 3700 megahectares (Mha), or 9143 million acres including both pasture and cropland for feed. The total amount of agricultural land used for human food production is 4484 Mha, or 11080 million acres.⁶

The next challenge for scientists was then to assess the impacts of climate change for human societies and natural ecosystems and biota. This has involved both studying the impacts to date, as well as the future impacts based on different emissions scenarios. Again, this work is largely complete. This was the purpose of Working Group II of the IPCC, which has authored six comprehensive assessment reports on climate change impacts on both humans and natural ecosystems. The most recent report has extensively documented impacts including rising sea levels and increases in severe weather events, disease, heat strokes, food shortages, and biodiversity loss.⁷ Climate change is also a key driver of the ongoing 6th mass extinction event on Earth.⁸ According to the 2022 Global Living Planet Report, monitored wildlife populations across the globe have experienced an average 69% decline in relative abundance between 1970 and 2018.⁹ If emissions continue at the current rate, entire nations will be flooded by 2100 and tens of millions of people will be affected by sea level rise, flooding, storm surges, more severe tropical storms and hurricanes, and increased prevalence of vector-borne illnesses.⁷

Lastly, given the observed causes and impacts, natural scientists, in collaboration with other disciplines in the social sciences and humanities, must present and advocate for solutions to climate change. Since solutions are only possible with an understanding and self-awareness of the cause, the impacts, and the effectiveness of the intervention, they necessarily involve scientific research. The proposed solutions include emissions reductions and mitigation, as well as improving cutting-edge technologies and adaptation measures. However, implementation of solutions involves buy-in from both politicians and the general public. Meaningful solutions will occur through the combined efforts of governments and policy makers at larger scales² and through changes in the attitude and behavior among the larger general population.^{10,11} High-profile figures such as scientists who work to educate the public about climate change can have a domino effect on social change. Their personal decisions can undermine or bolster the credibility of their messages for urgent societal change (e.g., related to energy consumption including travel)¹² and set in motion a process known as social or behavioral “contagion.”¹³ If they preach the severity of the climate crisis and completely disassociate themselves from taking action against the biggest contributors to climate change, such as the food

system, this can discourage the public from making meaningful behavioral changes.¹²

While the challenge of documenting climate change and understanding its causes and consequences was an enormous task that involved the global effort of thousands of scientists across multiple generations, we are beginning to see now that conducting the scientific research may have been the easy part. Working group III of the IPCC has authored six comprehensive assessment reports on climate change mitigation strategies, and their calls to action have grown more and more urgent.¹⁴ The most recent report by the IPCC states that a livable future is still possible but only with immediate, radical, and sustained actions to curb carbon emissions. Among the actions with the greatest impact are: reduced conversion of forests and other ecosystems (of which animal agriculture is the leading cause),² ecosystem restoration, afforestation, reforestation (for which using less land for animal agriculture would free up), and “shifts to balanced, sustainable diets.”¹⁴ These actions dwarf all actions in the transportation and building sectors and are only rivaled by switching to solar and wind energy.¹⁴ The EAT *Lancet* commission performed a comprehensive global analysis on food consumption, and outlined a diet that would be sustainable environmentally, healthy nutritionally, and feasible economically. Notably, the authors, an interdisciplinary group of 37 leading scientists, suggested a drastic reduction in the consumption of animal products and even argued that climate change could not be successfully addressed without addressing animal agriculture.³ Multiple studies have demonstrated that there are health benefits, including lower rates of communicable and non-communicable diseases, associated with decreasing consumption of animal products, whose production involves high energy inputs and/or high pollution levels.^{3,15-18} The results of studies that calculated the benefits of reducing or eliminating animal agriculture are striking. At the extreme end, a rapid (15-year) and complete phaseout of animal products from the diet alone, without any other reductions from other sectors, can lead to a 61-68% reduction in greenhouse gas emissions.^{19,20} Partial reductions in animal agriculture, such as elimination of ruminant agriculture (but keeping the status quo of non-ruminants), could achieve a 55-61% reduction in greenhouse gas emissions.¹⁹

Work in this realm also goes well beyond the work of the IPCC and scientists, involving writers and film producers. Swedish scientist Svante Arrhenius was the first to claim in 1896 that burning fossil fuels and releasing carbon dioxide into the atmosphere would eventually lead to global warming of several degrees,²¹ yet his findings were largely ignored until later. Research on climate change proceeded throughout the twentieth century and led to an increased understanding of greenhouse gases and the history of Earth’s climate. Author Bill McKibben wrote one of the first books about climate change for the general public back in 1989, entitled *The End of Nature*.²² Since then the global population has nearly doubled, annual global carbon

emissions have doubled, and the impacts of climate change are being felt more and more each year, with many of the hottest years ever recorded in the past decade.¹ More recently, in 2022 *The Climate Book* was created by Swedish environmental activist Greta Thunberg and is an essential compendium of key findings in fields such as ecology, climatology, and economics, written for the general public by the world's leading experts. There have been many other widely viewed documentaries such as *An Inconvenient Truth* produced by Al Gore in 2006, its sequel in 2017, and others such as *Before the Flood* produced by Leonardo DiCaprio in 2016, *Cowspiracy: The Sustainability Secret* produced in 2014 by Kip Andersen, and its sequel *Seaspiracy* in 2021 produced by Ali Tabrizi, and the docuseries *Years of Living Dangerously* co-produced by Arnold Schwarzenegger from 2014-2016. Despite a lack of coverage by mainstream media,²³ these documentaries have been widely viewed and public awareness about links between animal agriculture and climate change is increasing. Still, after all this research and public outreach campaigns, meaningful action still lags behind. It has become clear that an even greater challenge than documenting climate change and identifying causes and solutions is to accept that policy makers, businesses, scientists, and the general public are all accountable for this environmental crisis. Different countries have made strikingly different contributions to the crisis.²⁴ Each of us must take responsibility and change our own behavior toward lifestyles that are less harmful to and more harmonious with the planet.

Previous work from the field of environmental psychology has delineated numerous psychological barriers that limit pro-environmental behaviors by individuals. These so-called “dragons of inaction” include limited cognition about the problem, ideologies, comparisons with others, sunk costs, discredence, perceived risks, and limited behavior.^{25,26} Limited cognition includes irrationality, ignorance, numbness, and uncertainty. With respect to climate change, beliefs that the problem is worse elsewhere or that it is a future problem that we don't need to act on now would fall under this category. Sunk costs are investments in money (including, for example, investments in fossil fuel companies), time, and behavioral patterns (including, for example, driving and flying). The argument is that because we have already invested so much in certain aspects of our fossil fuel-based economy, we have to keep on using them to get a return on our investment. Discredence is a preexisting disbelief in the messenger of a proposed behavioral change. Limited behavior includes tokenism (easy but low-impact actions) as well as rebound effects such as buying an electric vehicle but driving it more (which offsets the benefit).²⁶ Other work has discussed links between knowledge, attitudes, and intentions, but found weak correlations with behavioral change.²⁷ Much of this work has examined the public at large, and not populations of the people actually doing the science that drives the call to action. Furthermore, there has

historically been a focus on reducing emissions from transportation and household energy (e.g., turn off the lights, don't waste electricity, drive less, recycle) rather than dietary change.

Another factor is the proximity people feel to climate change – if they feel it is actually going to impact their lives in the near term. Although it had been hypothesized that highlighting the proximal consequences of climate change would spur willingness to take action, doing so has not yielded behavioral change to the degree anticipated.²⁸ Research by psychologists on people's responses to morally-driven social movements has shown that advocating for behavioral change on moral issues (including climate change, which is often framed as such) is a double-edged sword. Sometimes morality can encourage action, especially if the target population is in agreement, but other times it does not.²⁹ As another author put it, moral arguments sometimes lead to elevation and sometimes lead to resentment, the latter of which could be caused by feelings of moral inferiority, moral confusion, or anticipated moral reproach.³⁰

The focus of this paper is on behavioral change (or lack thereof) among a group presented with an option to take a small action towards reducing their carbon footprint. An interesting and important aspect about this case study is that the group consists of scientists, many of whom study the effects of climate change on ecosystems and various species across the tree of life including eukaryotes (plants, animals, fungi), bacteria, and archaea. Furthermore, as the majority of the population consisted of PhD students and PhD candidates (with the remainder being master's students), this population represents future professors, researchers, and change-makers in this field. We present an analysis of reactions to a simple behavioral request among these graduate students in a natural sciences academic department and discuss the implications of this for the scientific community, science communication, and the psychology of defensiveness and behavioral change. While the sample size is smaller than if we had sent out a questionnaire, the responses here represent the raw, unfiltered responses of these people in a real-life situation.

Case Study

The department that is subject to the current case study is an academic natural sciences department at a public university in the United States. The department offers undergraduate and graduate courses in a broad range of topics in biology, including theoretical and experimental biology, across a broad range of organisms from microbiology to zoology. The department offers training for master's and PhD students and ranges in size from a total of ~ 60-80 graduate students in any given year. Climate change is a major topic of research in the department, with various lab groups studying different aspects of climate change such as organismal responses, range shifts, and genetic adaptations. Every Friday during

the semester, the department hosts a colloquium series in which an outside speaker delivers a seminar and meets with graduate students over lunch. The department buys lunch for the graduate students and speaker to encourage more people to attend and interact with the visiting speaker. In August 2019, before the start of the fall semester, a group of graduate students in the department sent an email (available in the Supplementary Material) to ask if the department would like to agree to not serve meat at the Friday departmental-sponsored graduate lunches to lower the carbon footprint of the meal. Notably, to make the request potentially easier and more likely to be adopted, they did not ask to make the lunch completely vegan, which would have been more impactful due to the environmental impacts of the dairy and egg industries.² What followed was a chain of emails from a group of well-educated scientists (anonymized responses of those who consented to their publication are available in the Supplementary Material). One respondent (response 11) suggested a poll and provided a link to a Google poll, to which 53 people responded. In the poll that was conducted, a slim majority expressed a preference for only vegetarian or mostly vegetarian lunches (Table 1). However, despite this expressed preference, those in charge of ordering lunches decided that since responses were mixed, there should be a mix of options available, and the lunches proceeded mostly with the status quo.

There were 17 total responses (12 are shown in the Supplementary Material), only 2 of which supported the idea. We classified the other 15 according to psychological defense mechanisms that likely contributed to the responses. To classify the emails, we read each individual email response, delineated some themes and commonalities among them, and then classified each into predefined defense mechanisms (see below), with all four authors unanimously agreeing on the classification. The decision to analyze the email responses and publish the results occurred several years after the email responses. The Human and Animal Regulatory Committee of Lawrence Berkeley National Laboratory determined, in consultation with the Human Subjects Committee (HSC) Chair, that the proposed activity is not research involving human subjects. HSC

review and approval is therefore not required. The HSC is the Institutional Review Board for Lawrence Berkeley National Laboratory under the OHRP Federalwide Assurance (FWA) #00006253.

Defense Mechanisms

Defense mechanisms are strategies that humans use, usually subconsciously,³¹ for a variety of reasons to, for example, avoid guilt, shame, cognitive dissonance,^{32–34} discomfort, and other negative emotions. They can be defined as mental operations that occur outside of awareness and protect against the experience of excessive anxiety, protect self-esteem, and, in more extreme cases, protect the integration of the self.³¹ Self-integration is the process of connecting experiences to the self and is critical to identity. Below we outline four strategies from the blossoming field of dietary psychology³⁵ that were evident in the case study (Table 2). These are different from the seven “dragons of inaction” but there are many similarities and most of these behaviors fall into one of these seven categories. The four mechanisms are suspicion: denying virtue, tokenism, defensive avoidance, and trivialization: do-gooder derogation.^{26,30,36,37}

Suspicion: Denying Virtue

In this defense mechanism, the person is in denial and does not engage with the issues and simply states that they don’t care, don’t support the change, and don’t want to discuss the issue further. This is an “out of sight, out of mind” idea in which the person hopes to avoid any nuisances, inconveniences, or emotional discomfort. The first response in the case study (“Booo.” which was the entire content of the email) can be categorized as such. Deliberately ignoring the problem because we do not know, or perhaps know that we do not want to know,³⁸ only exacerbates the problem.³⁹

Tokenism

Tokenism is adopting an easy behavior that has relatively little impact. Tokenism is a major problem for the broader environmental movement. It is part of a phenomenon known as “greenwashing,”⁴⁰ in which companies deceive consumers by focusing on minor actions. For example, plastic straws have received a lot of attention, and companies love to say they are reducing plastic straw use to improve their image of sustainability and highlight their contribution to cleaner oceans. Yet the majority of pollution in the ocean comes from the fishing industry (another form of animal agriculture).⁴¹ The company improves its image but at the same time avoids taking more drastic and impactful actions. And consumers feel good about not using plastic straws but if they wanted to have an even more positive

Table 1. Responses (N = 53) of Graduate Students to a Poll About Departmental Lunch Preferences. Two People did not Respond to all Three Questions.

Category	Nearly always	1x monthly	When speaker is vegetarian
Only vegetarian	20	24	30
Mostly vegetarian	7	12	12
1/2 vegetarian, 1/2 meat	17	8	6
Status quo	9	7	3
Total	53	51	51

Table 2. Responses of Graduate Students to a Request for a Minor Behavioral Change that Would Serve to Reduce their Carbon Footprint. Responses 6 and 10 were from the Same Individual, as were Responses 3 and 12. Response 11, which Proposed a Poll, was not Classified into any Defense Mechanism.

Response	Suspicion: Denying virtue	Tokenism	Defensive avoidance	Trivialization: Do-gooder derogation	Agree & support
Response 1	X				
Response 2		X			
Response 3		X	X		
Response 4					X
Response 5		X			
Response 6				X	
Response 7		X	X		
Response 8			X		
Response 9		X			
Response 10				X	
Response 11					
Response 12			X		
Response 13					X
Response 14		X	X	X	
Response 15			X	X	
Response 16			X	X	
Response 17		X	X		
Total	1	7	8	5	2
Percent	5.9%	41.2%	47.1%	29.4%	11.8%

impact on oceans, they would reduce their consumption of seafood.

People often feel that too much is being asked of them, even when it is not. In this case, for example, it was suggested that lunch should be changed from meat to vegetarian, not even vegan. It would be only one of the 21 meals that a typical person in the department eats in a week. One could argue that the proposed action was tokenism in itself because, by itself, it would have had little impact on climate change. Yet tokenism was still an aspect of some of the responses. It also does not take any more effort for the people ordering the lunch to simply choose a vegetarian option instead of a meat option. However, this was the second most frequent defense mechanism found in the responses (seven people). People seem to be okay with taking a small action to feel better about themselves, but only if it basically doesn't cause them to make any real or perceived sacrifices. In this case, instead of agreeing to meat-less lunches, people proposed what they believed to be less harmful meat options such as chicken instead of beef or "humanely" slaughtered meat. While chicken is more environmentally friendly than beef, it is still substantially (~ 3 times) worse than a vegetarian option such as tofu, in addition to being an important driver of the emergence of new pandemic viruses.⁴² The mean carbon dioxide emission equivalents for 100 g protein of beef, poultry, and tofu are 50, 5.7, and 2.0 kg, respectively, while land use is 164, 7.1 and 2.2 m² year⁻¹, respectively.² And while "humanely" slaughtered meat may arguably be better than other meat for animal welfare, the proposal

for a meat-free lunch was even better both for animal welfare and climate change.

Several people complained that the change would be hard because it would be more work to order the food or to find an option they like. In this case, it was actually a *perception* of more work, because, in reality, ordering vegetarian options takes the same amount of effort as ordering meat options. The perception that change is too much to ask is related to the idea that people are more willing to make more minor changes because they do not want to compromise and actively change their habits. People often look for the easiest way to solve a problem. If there are other ways to combat climate change that require less effort and do not require them to change their diet, they will take that path. Unfortunately, the options that have the least impact on our daily lives are also the ones that do the least to solve the problem.

Defensive Avoidance

Defensive avoidance, which often involves deflecting to other issues, was the most frequent response in the email chain (8 responses) and is a frequent defense mechanism used by many people in various contexts, especially in politics, for example. Politicians use this technique all the time. When politicians are asked questions that they don't know the answer to, don't have a good answer for, or don't want to talk about, they immediately just spin the question in a different direction, avoid answering the question, and change the subject entirely. The same thing occurred in our case

study. In this case, responses included reusable plates and cups, composting, bus passes, sharing equipment, turning off lights, reproduction, and LGBTQ+ inclusion. Of course, these ideas are indeed valuable. We should be reusing dishes, composting more, and using sustainable transportation options. However, these actions are compatible with dietary change, and should not be used as excuses to avoid more effective (as quantified by the research to date) actions like dietary change. If we are to meet the 1.5 °C climate target set in the Paris Agreement, we must pursue an integrated system of food-production-and-consumption strategies that necessarily includes a shift to a plant-based diet.⁴³ Only if all strategies are implemented together at half their potential would we have a 67% chance of limiting global warming to 1.5 °C.⁴⁴ Recognizing that the food system has failed should lead us to redesign the food supply to achieve carbon neutrality.

Trivialization: Do-Gooder Derogation

This mechanism involves both sarcasm and direct criticism of the messenger. Sarcasm is not only a deflective mechanism to minimize the problem but can also be disrespectful and serve as an attack or way to undermine and belittle the messenger or message. When confronted with ideas or values that contradicted their own, some people exhibited psychological stress that eventually led to mocking and disrespectful reactions. In this case, one respondent sent a meme that mocked veganism and concerns about animal abuse. The meme featured a dancing Barney the Dinosaur, with the caption “when a vegan talks to you about veganism and animal abuse but you put your earbuds in. Cha cha cha real smooth.” Regardless of people’s views on dietary change, sharing this type of meme is unacceptable in the workplace, where in recent years there has been an emphasis on fostering inclusivity. Several other responses included sarcastic comments such as “Anybody tried those chicken sandwich from Popeyes yet?”, “let’s start fighting against parental leave for our employees!?” and “But that’s just my personal research agenda and I won’t suggest everyone adopt it” Criticizing the other person serves to place blame elsewhere and avoid guilt or shame. One response criticized the authors of the email, deflected to other issues, and made a sarcastic comment about babies and moral policing. Being critical not only changes the focus of the debate, but also fosters inaction. Research shows that when people respond to a proposed course of action by criticizing the one who proposed it, this is often done to avoid the guilt they feel for not agreeing to course of action.³³

The Carnistic Matrix

One key factor at play here is *carnism* - the invisible belief system that enables humans to believe that some animals are edible and some animals are inedible, and that eating

certain animals is normal, natural, and necessary.³⁹ Carnism relies on defense mechanisms and mostly unchallenged assumptions to remain ubiquitous in society. Our society is heavily plugged into this matrix, and that includes scientists, teachers, parents, policy makers, and religious leaders, such that new generations are constantly plugged in as well. In other words, carnism is institutionalized, making it an incredibly strong force in society. The responses in the email thread can mostly be explained by the entrenchment of carnism even into populations of evidence-based thinkers such as scientists. Discussion of carnism was first introduced into academic discourse in 2010.³⁹ Nevertheless, carnism is not typically included as a research topic by environmental psychologists, something we hope changes soon. One critical aspect of human psychology to consider is the difference between attitudes (i.e., values, beliefs, how one feels), and behaviors (i.e., actions, how one acts). Attitudes and behaviors are often closely linked; each one can influence the other.⁴⁵ Carnism enables the disconnect between attitudes and behaviors, which makes it difficult to change behaviors. For example, most people don’t support animal abuse (they feel it is wrong, their attitude and moral values are against it), yet buying animal products at grocery stores is in essence supporting the animal abuse that occurs in those industries, especially given that most meat and dairy products in the industrialized world come from concentrated animal feeding operations (CAFOs, “factory farms”). This creates what has been defined as “meat related cognitive dissonance” (MRCD).^{33,37} Mechanisms that prevent MRCD from occurring or reducing MRCD when it occurs include the four mechanisms displayed by the respondents in the departmental email chain, as well as other factors such as dissociation and denying animals’ intelligence and emotional and social capacities.^{33,37,46,47}

There are also other factors at play besides carnism, but carnism underlies and exacerbates these other factors. For example, the social norm effect is strong, as vegetarians and vegans are still a small minority⁴⁸ and subject to animosity,⁴⁹ even though there is a copious amount of knowledge and evidence supporting a plant-based diet to fight climate change. The carnistic matrix is so ingrained and normalized in our society that preliminary research has shown that vegans are rated significantly less favorably than vegetarians, gay people, and Black people.⁴⁹ The study surveyed 278 omnivorous Amazon Mechanical Turk workers in the U.S. (55% women, 84% white). It remains to be seen how generalizable these results are. Such biases can be a barrier to accurate perceptions about climate change.⁵⁰ This is a key factor here, because even though only two people responded in the email chain, many more responded privately that they supported the idea, and in the poll that was conducted, and a slim majority actually did express that they agreed to change (Table 1). However, despite this expressed preference, those in charge of ordering lunches decided that since

responses were mixed, there should be a mix of options available, and the lunches proceeded mostly with the status quo. This shows that people did not feel comfortable voicing support for the idea, especially given all of the negative feedback that was occurring. Sustainable diets need to become the default, rather than a fringe behavior,⁵¹ and climate norms need to be nurtured.⁵²

Convenience is another factor that may contribute to people's decisions as to whether or not to change their diets.⁵³ However, in this case, the lunch was free and conveniently provided (ordered, bought, and delivered) to the people and it would not be any less convenient if there were more vegetarian or vegan options. Similarly, it would have been no real inconvenience for the lunch organizers to place orders for vegetarian food, even though some people *perceived* that it would (e.g., response 14). There had also never been any democratic process or feedback on the lunch options before, and the existing menu was determined solely by the lunch organizers, presumably according to their preferences and/or their perception of the group's preferences.

Information campaigns can also help lead to behavioral change,⁵³ especially when using individual-level statistics rather than aggregated national statistics.⁵⁴ For example, Aberman and Plaks found that participants who received data aggregated at the national level on the environmental impacts of beef production perceived less of a connection between their behavior and the environment and expressed less intention to curb their meat consumption than those who received the same exact data scaled to the individual-level.⁵⁴ Social legitimization contributes to the effective delivery of vegan information. This can be done through authority figures or organizations and story narratives.⁵⁵ The diversity of approaches taken by various social media influencers allows consumers to relate to and engage with vegan information more personally.⁵⁶ de Boer and Aiking argue that authority-based guidelines and rationality-based legitimations are key for large-scale adoption of dietary shifts,⁵⁵ but empirical research on this topic is still lacking. Lack of information, or worse, disinformation, along with one of the greatest threats to our society which is that we are not aware of not being aware,¹⁰ remains a big problem, although more and more of the public is becoming educated on environmental issues and the costs of animal agriculture. For example, there is still a widespread belief that meat is the best source of protein,⁵¹ even though this myth has been systematically debunked in the scientific, medical, and nutritional literature, which has repeatedly shown benefits to well-planned plant-based diets, particularly those consisting entirely or primarily of whole foods.^{57,58} Consumers also generally underestimate the climate and ecosystem impacts of food, but informative labeling can help raise awareness and influence dietary choices,⁵⁹ as can advertising and "nudging."⁶⁰ While there is some evidence for success of informational campaigns, facilitating behavioral shifts even

after knowledge is acquired, as exemplified by our case study, remains a challenge.⁶¹ Furthermore, religion, values, culture, gender, identity, social status, and habits strongly influence individual behaviors and choices, and therefore sustainable consumption. Diets are deeply entrenched in cultures and identities, both of which are influenced by carnism, and therefore are hard to change.^{14,62} In the case of dietary change in particular, additional factors are taste and enjoyment,⁶³ an understanding of nutrition and vitality of the body, concerns about the conditions of meat provision, and the personal relationships and routine activities through which meals are sourced, prepared, and eaten.^{58,64}

In order to combat carnism, a new belief system is required. Veganism offers a directly opposing view to carnism, while vegetarianism offers a middle option. The core belief of veganism is that all human and non-human animals are individuals with rights (and needs). They are not to be bought and sold as commodities and are not to be harmed or exploited. It is useful to examine cases in human history in which groups of people have adopted similar belief systems and aligned their behaviors with it. A relevant example is the adventists, a large portion of whom are vegetarian or vegan.⁶⁵ As of 2003, 50% of Adventists in the U.S. were vegan, vegetarian, or almost vegetarian (ate meat once a week),⁶⁶ while more recently it was estimated that more than 40% were vegetarian.⁶⁷ A relatively well-known example is the Loma Linda Seventh-day Adventists, who practice a majority plant-based diet (84% plant foods) and are recognized as one of the longest-living populations on Earth.⁶⁸ The Adventist church has promoted vegetarian and vegan diets since shortly after its founding in 1863. Leader Ellen White began promoting vegetarian diets starting in 1866.⁶⁹ Adventists consider food to be part of their moral belief system. A second key factor was that a vegetarian diet became part of their identity and differentiated them from other groups.⁶⁵ Future research should investigate how religion and identity can be used to promote behavioral change.

Policy

Policies are important in driving societal mobilization and reorienting institutions.¹³ We could achieve significant results at the population level through legislative action that reflects what well-accepted scientific consensus tells us about how we must live to combat this urgent global crisis. The goal would be to make the default foodscapes plant-based to support ease of adoption at the population scale. Steps by corporations and institutions toward plant-based alternatives are critical to advancing this goal, but they could collapse with a change of president or CEO.¹¹ Codifying policies supportive of plant-based societies will create lasting institutional progress towards a plant-based future for food producers and consumers. The defense mechanisms on display in our case study demonstrate how unconventional a plant-based diet is in today's society, including in

the very scientific community sounding the alarm about the existential ecological and human health threats of climate change. Policies are needed to combat and overcome these defense mechanisms.

A population can be categorized by different responses to climate change termed the “Six Americas”: dismissive, doubtful, disengaged, cautious, concerned, and alarmed.⁷⁰ The scientists featured in the case study are part of the alarmed group, demonstrating a high belief that climate change is happening and a high likelihood of supporting both policies and personal consumer behavior.⁷¹ Despite this, a majority of public email responses rejected the vegetarian lunch proposal. Various suites of policies from local to global scales, tailored to each of the Six Americas could help encourage and compel each to choose plant-based options, which would in turn increase demand and drive the economic development of the plant-based foodscape.^{51,60} Policy could help make plant-based dining choices more “normal, natural, and necessary”³⁹ which would combat the default state of carnism in our society today.^{48,72} In particular, policies should increase the diversity and availability of plant-based options, decrease the cost of those options, make those options the default or “normal” choice, harness and reward individual motivation, and address individual resistance.⁵²

Although they were not surveyed on other climate change mitigation strategies, the case study responses that deflected to other issues suggest that other more convenient but less effective actions may be more readily accepted.⁷³ This is reflected both in institutional net-zero roadmaps that emphasize decarbonization of the building infrastructure over increased plant-based options on campus⁷⁴ and in national policies that provide numerous monetary incentives to decarbonize residential and commercial buildings and increase electric vehicle use, but not shift toward a plant-based diet.⁷⁵ Policies and public messaging regarding a shift to plant-based diets should seek to achieve a level of interest and action similar to that of a shift to renewable energy or electric vehicles.

At the global level, dietary shifts should be just as much at the forefront of international meetings and future commitments on emission reductions as the energy and transportation sectors. This would reflect the importance of animal agriculture as a contributor to climate change that was agreed upon at the international level as far back as the 2006 United Nations Food and Agriculture Organization report,⁷⁶ and more recently the IPCC Working Group III report,¹⁴ and the EAT-Lancet report.³ Such agreements would encourage each country to implement solutions at their respective national levels (see below).

At the national level, governments can have a major impact on the diversity, availability, and cost of plant-based versus animal-based foods by controlling the flow of subsidies to plant versus animal agriculture. In the U.S., substantial subsidies go to the meat and dairy industries. For

example, the dairy margin coverage program, which represents a small fraction of the total subsidies for animal agriculture, gave \$1.15 billion to dairy farmers in 2021.⁷⁷ Meat and dairy prices do not take into account external costs including those to health and environment. Subsidies mask the costs of production. Imposing a carbon tax is one national option to account for the environmental cost. The incorporation of societal health benefits into economic policy could balance the impact of the food system. Widespread benefits would result from reducing diet-related causes of mortality and morbidity in the U.S., which are among the leading causes. The EAT-Lancet reference diet for sustainability³ was found to be affordable for most but not all of the world; interestingly, in regions where it was not affordable, this was due to expensive animal products, which are still a part, albeit minor, of the proposed diet.⁷⁸ Still, policies are needed to lower costs for plant-based or majority plant-based diets to incentivize their adoption.

At the state or local level, it is possible to implement tax policies that promote plant-based diets. For example, in 2016 the city of Boulder, Colorado (USA) passed a tax on beverages with added sugar and other sweeteners. Something similar could be done for meat and dairy products. Alternatively, tax breaks could be given to companies developing new plant-based food products. Cities can also run events such as the successful meat-free Thursday campaign in Ghent, Belgium, in which at least 100,000 people participate. They can sponsor restaurant and grocery deals to promote Veganuary, which is an online campaign platform that reported at least 700,000 participants in 2023. School and university cafeterias are also excellent settings to implement food policies that initiate change in both present and future generations of consumers. Students and workers can reduce their ecological footprint in an environment where a low-meat diet is no longer the exception, but the norm.⁷⁹ There are at least 2 universities in the UK that now offer a 100% plant-based menu in their dining halls. This has normalized plant-based eating among the student population and likely would make people even more comfortable choosing plant-based options outside of the university setting.⁸⁰ This should be implemented in scientific institutions studying climate change. It will promote action among the “alarmed” group of citizens that act as early adopters and societal leaders. On the other hand, policies that inhibit change must be terminated. For example, the UK government requires state schools to offer meat for lunch at least three days a week.⁸¹

Lastly, policies can promote education and outreach on environmental impacts, health, and animal welfare.^{82,83} Despite the availability of the information, many people are still not aware of the environmental impacts of meat and dairy products.²³ Climate change education is under attack by climate change deniers.⁸⁴ Governments from the national and state level down to local school districts, must ensure that schools teach students about the causes and consequences of

climate change. This must include the impacts of animal agriculture. Such informational interventions have shown promising results for promoting shifts in behavior.^{53,85} Education is also necessary to combat think tanks seeking to manufacture ignorance and doubt on this topic in order to maintain the status quo.⁸⁶ Food policy makers have tremendous power in highlighting the attributes and benefits of a plant-based diet. Developing and using effective communication strategies to signal the values (e.g., price, nutrition, taste, eco-friendliness, ethics) of plant-based products can narrow the gap between consumers' attitudes toward plant-based products and their behaviors, while improving their satisfaction.⁸⁷ All these policies across multiple scales will make it easier for populations such as those represented by the Six Americas, including both scientists and non-scientists, to overcome the psychological defense mechanisms discussed in this paper and adopt climate-friendly behavioral shifts in dietary choices.

Conclusions

In this case study we presented the mostly negative responses of a group of educated scientists, many of whom study climate change, to a proposed minor behavioral change - a dietary shift for one meal a week to a meal with a lower carbon footprint and reduced harm to ecosystems. We observed some of the effects of what has been defined as "vegaphobia,"⁸⁸ particularly the erection of psychological barriers such as ridiculing veganism and thus the people involved, which formed the basis of personal discomfort on both sides and fomented a heated debate. We analyzed the psychological defense mechanisms demonstrated and hope to raise awareness about the importance of the scientific community practicing what it preaches when it comes to climate change. Existing hypocrisy among scientists undermines their potential to be effective leaders in promoting the societal adoption of the many good proposals for climate change mitigation options presented by the IPCC and the scientific literature. Professionals are key drivers of change because they can influence decision makers and lend credibility to the public as long as they set a valid example to follow. The overwhelming public rejection of a proposal for a once/week departmental lunch offering with a lower climate/ecosystem impact among a group that includes climate change scientists underscores the challenges involved in systemic population adoption of key behaviors and policies that the best available science tells us we must use to avoid the very worst effects of the climate catastrophe. The inconvenient truth that people are confronted with here, however, does not seem to be climate change, but the fact that we humans need to rethink our attitudes and behave according to a new and sustainable model that requires us to make what could be called an inconvenient change. In the case of dietary shifts, the potential for climate change mitigation is large and will be coupled with benefits for human health and animal welfare. Broader support for such shifts will in

turn make the foodscape and culture more plant-based such that default options and attitudes will become more consistent with climate change mitigation efforts.

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Author Contributions

All authors contributed to the study conception and case study interpretation. The first draft of the manuscript was written by Clifton P. Bueno de Mesquita and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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ORCID iD

Clifton P. Bueno de Mesquita  <https://orcid.org/0000-0002-2565-7100>

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Author Biographies

Clifton P. Bueno de Mesquita is a microbial ecologist who has studied the microbiomes of air, snow, soils, sediments, roots, leaves, seeds, and guts. He is fascinated by the taxonomic and functional diversity of microorganisms and has a particular interest in managing greenhouse gas emissions and mitigating climate change from both a scientific and behavioral perspective. He has previously studied methane production in coarse woody debris and is currently studying the microbial drivers of greenhouse gas emissions in coastal wetlands, industrial salt-erns, rice paddies, and manure-fertilized corn fields.

Ylenia Vimercati Molano is an independent scientific Illustrator and science writer who seeks to foster curiosity, appreciation, and respect for nature through her artistic expressions. She utilizes her creative side as a meeting point across various scientific disciplines, artistic endeavors, and exploratory pursuits. Her works serve as educational instruments in both environmental literature and travel narratives.

Lara Vimercati is an environmental microbiologist who studies microbial diversity and adaptation in some of the harshest environments on Earth, considered to be potential analogs for habitable zones on extraterrestrial bodies. Her work combines data from rDNA gene surveys, pure-culture physiological experiments, biogeochemical analyses, microcosm manipulations and comparative genomics and transcriptomics. She has had fieldwork experience in several extreme environments, including the high Atacama Volcanoes, Death Valley, Mt. Kilimanjaro summit, Svalbard and Antarctica. She is passionate about science, climate change, social justice, and animal rights.

P. Jacob Bueno de Mesquita, Assistant Professor of Public Health at Roger Williams University, is a trans-disciplinary environmental health scientist-educator focused on improving the environmental conditions to promote human, animal, ecosystem, and planetary health. He deploys exposure science and epidemiologic methods to evaluate and communicate the benefits of some of the most promising solutions to foster environmental quality supportive of equitable population wellness. These solutions include plant-based foodscapes for health, ethics, climate, environment, and pandemic prevention, germicidal ultraviolet light (GUV) for efficient air cleaning for pandemic resilience, and built environment decarbonization, in part, through electrification of fossil fuel burning appliances such as stoves and furnaces (e.g., using induction stoves and heat pumps).