Risk Communication on Climate: Mental Models and Mass Balance

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The strong scientific consensus on the causes and risks of climate change stands in stark contrast to widespread confusion and complacency among the public (1, 2). Why does this gulf exist, and why does it matter? Policies to manage complex natural and technical systems should be based on the best available scientific knowledge, and the Intergovernmental Panel on Climate Change (IPCC) provides rigorously vetted information to policy-makers. In democracies, however, the beliefs of the public, not only those of experts, affect government policy.

Effective risk communication is grounded in deep understanding of the mental models of policy-makers and citizens (3). What, then, are the principal mental models shaping people’s beliefs about climate change? Studies show an apparent contradiction: Majorities in the United States and other nations have heard of climate change and say they support action to address it, yet climate change ranks far behind the economy, war, and terrorism among people’s greatest concerns, and large majorities oppose policies that would cut greenhouse gas (GHG) emissions by raising fossil fuel prices (1, 2).

More telling, a 2007 survey found a majority of U.S. respondents (54%) advocated a “wait-and-see” or “go slow” approach to emissions reductions. Larger majorities favored wait-and-see or go slow in Russia, China, and India (1, 2). For most people, uncertainty about the risks of climate change means costly actions to reduce emissions should be deferred; if climate change begins to harm the economy, mitigation policies can then be implemented. However, long delays in the climate’s response to anthropogenic forcing mean such reasoning is erroneous.

Wait-and-see works well in simple systems with short lags. We can wait until the teakettle whistles before removing it from the flame because there is little lag between the boil, the whistle, and our response. Similarly, wait-and-see would be a prudent response to climate change if there were short delays in the response of the climate system to intervention. However, there are substantial delays in every

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Public confusion about the urgency of reductions in greenhouse gas emissions results from a basic misconception.
which the water level represents the stock of atmospheric CO₂. Like any stock, atmospheric CO₂ rises when the inflow to the tub (emissions) exceeds the outflow (net removal), is unchanged when inflow equals outflow, and falls when outflow exceeds inflow. Participants were informed that anthropogenic CO₂ emissions are now roughly double net removal, so the tub is filling.

Yet, 84% drew patterns that violated the principles of accumulation. If emissions followed the path in the typical example shown, atmospheric CO₂ would continue to rise. Nearly two-thirds of the participants asserted that atmospheric GHGs can stabilize even though emissions continuously exceed removal—analagous to arguing a bathtub continuously filled faster than it drains will never overflow. Most believe that stopping the growth of emissions stops the growth of GHG concentrations. The erroneous belief that stabilizing emissions would quickly stabilize the climate supports wait-and-see policies but violates basic laws of physics.

Training in science does not prevent these errors. Three-fifths of the participants have degrees in science, technology, engineering, or mathematics (STEM); most others were trained in economics. Over 30% hold a prior graduate degree, 70% of these in STEM. These individuals are demographically similar to influential leaders in business, government, and the media, though with more STEM training than most.

It is tempting to respond to these discouraging results by arguing that poor public understanding of climate change is unimportant because policy should be informed by scientific expertise. Many call for a new Manhattan Project to address the challenge (15, 16). The desire for such technical solutions is understandable. In 1939, scientists directly alerted President Roosevelt to the problem (17). The bomb was developed in secret, with nearly 100,000 individuals to cut their carbon footprints by, e.g., buying efficient vehicles, insulating their homes, using public transit, and, crucially, supporting legislation implementing emissions abatement policies. Changes in people’s views and votes create the political support elected leaders require to act on the science. Changes in buying behavior create incentives for businesses to transform their products and operations. The public cannot be ignored.

The civil rights movement provides a better analogy for the climate challenge. Then, as now, entrenched interests vigorously opposed change. Political leadership and legislation often lagged public opinion and grass-roots action. Success required dramatic changes in people’s beliefs and behavior, changes both causing and caused by the courageous actions of those who spoke out, registered voters, and marched in Washington and Selma (18).

Building public support for action on climate change is in many ways more challenging than the struggle for civil rights. Science is not needed to recognize the immorality of racism but is critical in understanding how GHG emissions can harm future generations. The damage caused by segregation was apparent to anyone who looked, but the damage caused by GHG emissions manifests only after long delays.

The scientific community has a vital role to play in building public understanding. First, the SPM is far too technical to change people’s mental models. The IPCC should issue its findings in plain language. Second, clarity, while necessary, is not sufficient. When “common sense” and science conflict, people often reject the science (3). Even if people sincerely wish to mitigate the risks of climate change, wait-and-see will seem prudent if they misunderstand basic concepts of accumulation and erroneously believe that stopping the growth of emissions will quickly stabilize the climate. The implications go beyond the failure to understand accumulation. People’s intuitive understanding of dynamics, including stocks and flows, time delays, and feedbacks, is poor (11). Analogous to common biases and errors in probabilistic reasoning (19), these errors are unlikely to be corrected merely by providing more information (13). We need new methods for people to develop their intuitive systems thinking capabilities. Bathtub analogies and interactive “man-

agement flight simulators” through which people can discover, for themselves, the dynamics of accumulation and impact of policies have proven effective in other settings (20) and may help here (21). Third, climate scientists should partner with psychologists, sociologists, and other social scientists to communicate the science in ways that foster hope and action rather than denial and despair. Doing so does not require scientists to abandon rigor or objectivity. People of good faith can debate the costs and benefits of policies to mitigate the risks of climate change, but policy should not be based on mental models that violate fundamental physical principles.

Of course, we need more research and technical innovation—money and genius are always in short supply. But there is no purely technical solution for climate change. For public policy to be grounded in the hard-won results of climate science, we must now turn our attention to the dynamics of social and political change.

References and Notes
2. Materials and methods are available as supporting material on Science Online.
22. Financial support from the Project on Innovation in Markets and Organizations at the MIT Sloan School.

A typical response to the climate stabilization task. Future emissions are erroneously correlated with atmospheric CO₂. Gold dashed line indicates the correct emissions path to stabilize CO₂ given the subject’s estimate of net removal.

Supporting Online Material
www.sciencemag.org/cgi/content/full/322/5901/532/DC1

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