



What shapes perceptions of climate change?

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Climate change, as a slow and gradual modification of average climate conditions, is a difficult phenomenon to detect and track accurately based on personal experience. Insufficient concern and trust also complicate the transfer of scientific descriptions of climate change and climate variability from scientists to the public, politicians, and policy makers, which is not a simple transmission of facts. Instead, worldview and political ideology, two elements of the cultural context of decisions, guide attention toward events that threaten the desired or existing social order, and shape expectations of change, which in turn guide the detection and interpretation of climate events. Action that follows from climate change perceptions can be informed by different processes. Affect-based decisions about climate change are unlikely to motivate significant action, as politicians and the general public are not particularly worried about climate risks, and because attempts to scare people into greater action may have unintended negative consequences. Analysis-based decisions are also unlikely to result in significant action, because of large discounting of uncertain future costs of climate risks compared to the certain and immediate costs of climate change mitigation. Rule-based decisions that determine behavior based on moral or social responsibility may hold out the best prospects for sustainable action. © 2010 John Wiley & Sons, Ltd. *WIREs Clim Change* 2010 1 332–342

Despite four increasingly unanimous and urgent reports issued by the Intergovernmental Panel on Climate Change (IPCC) since 1990,¹ national and international public debate about climate change (its likely magnitude and causes) does not seem converge to a common opinion and reach a consensus at the rate that a rational analysis of accumulating scientific evidence would suggest.² There are multiple reasons for why members of the general public, politicians, and policy makers, members of the media, and scientists may disagree about climate change,³ many of which are strategic and political.⁴ However, some of those reasons are psychological and cultural, and related to the perception of climate change. US National Research Council committees, e.g., the Committee on the Human Dimensions of Global Change, have also identified people's perception of global phenomena like climate change as a crucial contributor to both environmental problems and possible solutions.^{5,6}

What shapes the perception of climate change, both of its extent or even existence and of its causes? What accounts for the variability of such beliefs? What imbues perceptions of a changing climate with varying degrees of urgency that motivate people to take protective or mitigative action? This article will review social science evidence that speaks to these questions. Anthropology,^{7,8} sociology,^{9,10} cultural psychology,¹¹ and behavioral decision research¹² have all converged on a constructivist account of human perception and action that acknowledges the power of individual, social, and cultural forces, without denying the reality and power of external, physical, and environmental forces. Understanding the psychological, sociological, and cultural reasons for variations in the perceptions of climate change has implications for the design of educational and policy interventions that can lead to greater convergence in beliefs and willingness to act.

VARIATIONS IN THE PERCEPTION OF CLIMATE CHANGE

The existence and extent of climate change is a topic of great importance to climate scientists as well as

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individuals, groups, and organizations with long-term strategic decisions that are crucially affected by climate, projected climate change, and potential climate change mitigation measures. This includes utilities and other companies in the energy and transportation sector, reinsurance companies, and governments at different levels. Average citizens are typically more concerned about the weather, rather than the climate in their region.¹³ However, climate forecasts and beliefs about changes in existing climate variables can also drive individual or household decisions, e.g., the decision to buy a beachfront property or whether to support collective action at local or national levels to mitigate greenhouse gas emissions.¹⁴

Learning about Climate Change from Personal Experience

Despite its environmental, social, and economic importance, climate change is a phenomenon that is not easily and accurately identified by the lay public, using their normal tools of observation and inference. Climate is a statistical phenomenon, a term that describes average weather conditions or their typical range for a region. Climate change in the meteorological sense refers to systematic (yet usually gradual) changes in average conditions, i.e., to reliable trends embedded in the random fluctuations of conditions that can be expected for both stable and changing climates. Observations are spaced in time, and memory of past events can be faulty.¹⁴ As a result, climate change is not easily detected by personal experience, even though it appears to be open to personal observation and evaluation, as most people consider themselves to be experts on the weather and do not differentiate very strictly between climate (the statistical expectation) and weather (what we get). The climate of a region (and changes in its climate) obviously determines weather. People often falsely attribute unique events to climate change and also fail to detect changes in climate.

Expectations of change (or stability) play a large role in people's ability to detect trends in probabilistic environments, as illustrated by the following historic climate example (Kupperman,¹⁵ as reported in Refs 13, 14). English settlers who arrived in North America in the early colonial period assumed that climate was a function of latitude. Newfoundland, which is south of London, was thus expected to have a moderate climate. Despite repeated experiences of far colder temperatures and resulting deaths and crop failures, colonists clung to their expectations based on latitude, and generated ever more complex

explanations for these deviations from expectations. In a more recent example, farmers in Illinois were asked to recall salient temperature or precipitation statistics during the growing season of seven preceding years.¹⁴ Those farmers who believed that their region was undergoing climate change recalled temperature and precipitation trends consistent with this expectation, whereas those farmers who believed in a constant climate, recalled temperatures and precipitations consistent with that belief. Both groups showed about equal amounts of error in their memory for salient weather events, but the *direction* of the errors was biased to be in line with farmers' beliefs and expectations.

Recently, behavioral researchers have shown differences in the way people learn about uncertain phenomena or environments from personal experience versus from being provided with a statistical (typically numeric or graphic) description of possible outcomes and their likelihood.¹⁶ This distinction between learning from experience versus learning from description has received much attention because ostensibly the same information about events and their likelihoods can lead to very different perceptions and actions.¹⁷ Learning from repeated personal experience with outcomes involves associative and often affective processes, which are fast and automatic. Learning from statistical descriptions, on the other hand, requires analytic processing that needs to be acquired and requires cognitive effort. When given the choice between attending to information provided in the form of statistical summaries or to information provided by personal experience, personal experience is far more likely to capture a person's attention, and its impact dominates the often far more reliable and diagnostic statistical information.¹⁸

People's choices under risk and uncertainty can differ in important ways under the two information conditions, mostly and especially when small-probability events are involved. For better or worse, most extreme weather or climate events (frosts, flooding, or droughts) that are the result and indicative of climate change still occur with only small probability at this point in time in most regions of the world. Insights into how these rare events will be processed and incorporated into perceptions of climate change is thus highly relevant. The evaluation of risky options under the repeated sampling in decisions from experience follows classical reinforcement learning that gives recent events more weight than distant events.¹⁶ Such updating is adaptive in dynamic environments, where circumstances might change with the seasons or according to other cycles or trends. Because rare

events have a smaller probability of having occurred recently, they tend (on average) to have a *smaller* impact on the decision than their objective likelihood of occurrence would warrant. When they do occur, however, they have a much *larger* impact on related decisions than warranted by their probability. This makes learning and decisions from experience more volatile across respondents and past outcome histories than learning and decisions from description.¹⁹ The public's perceptions of climate change over time (as reflected by Gallup or Pew opinion polls, e.g., Refs 20, 21) seem to reflect a general under-concern and greater volatility than warranted by scientific evidence. Existing laboratory studies of these learning-from-experience processes (e.g., Ref. 16) have used repeated choices between cards from card decks that differed in the likelihood and magnitude of wins or losses. The relevance of these observed learning-from-experience processes with their strong recency bias to the perception of climate change still awaits systematic investigation. However, anecdotal evidence and general observation suggest that the general pattern of generally underweighting small-probability climate events, coupled with a noticeable volatility in risk perception as the result of recent events (e.g., a hotter or colder than usual season) is consistent with learning from personal experience.

The distinction between decisions from personal experience versus from statistical description maps onto another, more general distinction in cognitive,²² social,²³ and clinical psychology,²⁴ namely between processing of information in more associative and affect-driven ways versus more analytic ways. Associative processing is a very basic human ability that does not need to be learned and cannot be turned off. Associations are made very quickly and automatically. They turn experienced adverse aspects of the environment into feelings of fear, dread, or anxiety, which then influence decisions.²⁵ Analytic processing, on the other hand, works by algorithms and rules (e.g., the probability calculus, Bayesian updating, formal logic, and utility maximization) that must be learned explicitly. Analytic processes are slower and require conscious effort and control. The perceptions of climate change and its risks by climate scientists are based in large part on analytic processing, as these experts have been trained as scientists in the necessary analytic tools and have the necessary input required for these tools. Nonscientists, on the other hand, typically rely more on the more readily available associative and affective processing of climate-related information that comes their way.

The two types of processes tend to operate in parallel and also interact with one another.²⁶ In

cases where the outputs from the two processing systems disagree, the affective, association-based system usually prevails, because it comes in faster and is more vivid. For most people in the United States, judging the likelihood of climate change based on personal experience will lead to judgments that are low. Even individuals whose economic livelihood depends on weather and climate events (e.g., farmers or fishers) and who are thus motivated to attend to them, might not receive sufficient feedback from their daily or annual personal experience to diagnose systematic changes sufficient to become alarmed. Surveys conducted in Alaska and Florida, where residents in some regions have increasingly been exposed to physical evidence of climate change show that such personal exposure greatly increases their concern and willingness to take action.^{27,28}

Personal experience alone may not be a panacea. Experienced adverse consequences need to be seen as causally connected to the phenomenon or mechanism whose perceived likelihood and severity is being studied, to lead to increases in concern or worry. The absence of such perceived connection might be responsible for instances where greater personal experience of adverse events (i.e., flooding) did not result in increased concern about climate change.²⁹

Learning about Climate Change from Statistical Description

Because climate change is so hard to detect and judge accurately based on personal experience, one might argue that its detection should be left to experts, namely climate scientists, and to their social amplifiers, the media and educators. Such delegation makes climate change a phenomenon for whose existence and likely magnitude and time course people have to rely on their beliefs in scientific observation and modeling, in expert judgments, and/or on reports about all of these in the mass media. Indeed, most people's knowledge and exposure to climate change has been almost entirely indirect and virtual, mediated by news coverage and film documentaries of events in distant regions (such as melting ice sheets in Greenland or Antarctica) that ascribe these events to climate change, events and arguments for which people's personal experience does not provide concurring evidence. Reliance on external sources of evidence and expertise to form beliefs about climate change raises two important issues, attention and trust.

Attention is a very scarce cognitive resource.¹² Unlike money or other material resources, which can be saved or borrowed, the amount of attention available to anyone to process the vast amount

of information potentially available on innumerable topics is small and very finite. Statistical evidence provided by scientists and anecdotal accounts of climate change provided by the media only become information that influences subsequent perceptions and behaviors when the general public attends to them. Everyday life provides plenty of competing targets for attention, such as economic survival or family problems. Climate change typically ranks low to last among the concerns that Americans are questioned about.²⁰

People's fundamental values and worldviews³⁰ influence which phenomena and risks they attend to and which they ignore or deny. Douglas and Wildavsky⁷ identify five distinct 'cultures' or distinct interpretive communities (labeled hierarchical, individualist, egalitarian, fatalist, and hermitic, respectively) that differ in their endorsed patterns of interpersonal relationships in ways that affect perceptions of risk. Perceptions about the existence of climate change, its causes, and likely consequences are socially constructed within these communities that are predisposed to attend to, fear, and socially amplify some risks while ignoring, discounting, or attenuating others. Hierarchical cultures, perceive industrial and technological risks as opportunities and thus less risky, whereas more egalitarian cultures tend to perceive them as threats to their social structure and thus more risky.³¹ O'Connor et al.^{32,33} provide evidence that such differences in worldview result in differences in the perceptions of climate change risks.

Group membership of different sorts may also influence perceptions of climate change. Knowing that someone is a rancher or an environmentalist is a good predictor of their opinions and beliefs about environmental risks and interventions.³⁴ Leiserowitz et al.³⁵ describe several distinct interpretive communities in the United States ('six Americas') who share values, socio-demographics, and climate change perceptions. Climate change 'naysayers' perceive climate change as a very low or non-existent danger, and climate change 'alarmists' hold high-risk perceptions and extreme images of catastrophic climate change. These groups have significantly different values and beliefs about social and political issues and about the necessity of individual behavior change and governmental intervention. Political party affiliation has also shown an increasing relationship to belief in the existence and relative threat of climate change in the United States.^{21,36}

A second important issue related to learning about climate change from external sources is that of trust. People pay attention to information about climate phenomena and incorporate it into

their decisions and actions, if it comes from a trusted source⁷³. The importance of trust for the use of climate information has been well documented in the context of climate variability, where seasonal to interannual climate forecasts are often provided by multiple (commercial as well as non-commercial) sources, and are only used when provided by trusted intermediaries.¹³ Different user groups put their trust into different organizations, from national Meteorological Services to independent farm organizations.^{37,38} Even though the IPCC was founded as an ostensibly nonpartisan scientific body by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to summarize the scientific evidence about climate change and its potential environmental and socio-economic consequences, there is of course no value-free way of framing an issue and of selecting and presenting information about it.³ Factual information interacts with social, institutional, and cultural processes in ways that may amplify or attenuate public perceptions of risks like climate change.³⁹ This social and cultural amplification of risk by the news media, cultural groups, interpersonal networks, vested interests, and other groups and institutions occurs in the transfer of information about the phenomenon.^{40,41} Evidence from the health literature, the social psychological literature, and the risk communication literature suggests that these social and cultural processes serve to modify perceptions of risk in ways that may generally be socially adaptive, but may also bias reactions in socially undesirable ways in specific instances.⁴²

In summary, both learning from personal experience and vicarious learning from statistical description contribute to people's perceptions of climate change. A better understanding of the mechanisms and challenges in both types of learning helps explain both the generally low level of concern about the phenomenon, as well as cultural and other group variations in perceptions and concerns. Differences in climate change perceptions have been documented between climate scientists (and other scientists) and the general public. A Pew Research Center⁴³ poll, e.g., found that while 84% of scientists said the earth is getting warmer because of human activity such as burning fossil fuels, just 49% of the general public agreed. These differences can be attributed to both learning mechanism. Climate scientists often have personal experience with climate change in connection with their research activities that take them to regions of the world where climate change is apparent. In addition, by virtue of their education and training, climate scientists and other scientists, more

generally, can also be expected to rely more on their analytical processing system than members of the general population, and put greater trust and weight on extrapolations from statistical evidence and model outputs, that will thus make them more likely to consider global climate change to be a more serious risk than typical nonscientists. For others, including the general public and politicians, variation in climate change perception seems to be associated with political beliefs and other deeply held values in ways that go beyond simple personal and strategic concerns. These cultural values and allegiances influence information processing and causal attribution processes by guiding attention to messages and shaping trust in the messengers.^a

Even for those citizens across different regions of the world who believe that climate change is occurring, an understanding of its causes and likely effects is limited.⁴⁴ As described in a recent report by an American Psychological Association task force,⁴² psychological research has started to examine reasons for these limitations. Analogies from failures to fully understand and take action in other domains provide hypotheses about cognitive and motivational challenges that need to be overcome. Tests of these hypotheses applied to climate change are starting to emerge, though much work remains to be done to illuminate the special questions and challenges related to cognitive and emotional shortcomings that the proper understanding of the anthropogenic causes of climate change and their action implications bring. Many of these are summarized in the next section, as the perceived causes of climate change and the extent of worry expended on the risk are often highly related.

VARIATION IN CONCERN AND ACTION ON CLIMATE CHANGE

Citizens' perceptions of the importance and severity of climate change do not seem to match those of most climate scientists. In 2006, the Pew Global Attitudes Project, an international representative opinion poll, showed that 75% of Americans assessing global warming as a 'very' or 'somewhat' serious problem.²⁰ This level of concern is similar to the level in Russia (73%) and lower than that in many other nations (87% in Canada, 81% in Mexico, 95% in France, 88% in China, 97% in Japan, 96% in Brazil, and 94% in India). Thus concern might seem high, but it does not appear to be either very stable or very committed.⁴⁵ A recent²¹ report found that the proportion of Americans who view climate change as a 'very serious' problem dropped from its high

of 47% in 2006, which was maintained through April of 2008, to only 35% in October of 2009, consistent with the 'finite pool of worry' hypothesis described below. Greater concern about other risks, like the late 2008 global economic melt down and subsequent unemployment, replaced concern about environmental issues.

Regardless of stated levels of concern, few Americans see climate change as an immediate risk and tend to rank it as less important than other social issues like the economy and terrorism.^{46,47} While giving lip service to its importance, the Obama administration also appears to have assigned a low priority rank to climate change legislation, putting it close to the bottom of its list of legislative concerns, in a similar location to where the US public has placed it.

This section explores reasons for the generally low level of concern about climate change among citizens, as well as factors that account for variations in the worry and concern that motivates action. Following a similar organization as in the previous section, I will review different classes of factors that shape concern about and action on climate change. These influences are organized around the different ways or modes (affect-based, rule-based, and analysis-based) in which environmentally relevant decisions can be made.

Affect-Based Processing of Environmental Decisions

If the understanding of climate scientists is driven to a large extent by analytic processes (e.g., by the probability estimates of adverse consequences provided by climate models), the discussion in the previous section about the speed and automaticity of affective and associative processing of information suggests strongly that the general public will rely far more on affective processes in their climate change decisions. A series of seminal studies in the 1970s identified several psychological risk dimensions that influence the public's judgments of the riskiness of physical, environmental, and material risks in ways that go beyond, and often disagree with, their objective consequences (e.g., Ref. 48). People's judgments of the similarities between pairs of different health and safety risks could be placed into a two-dimensional space that has been replicated across numerous studies in multiple countries.⁴⁹ The first dimension of this space, 'dread risk,' captures emotional reactions to hazards like nuclear weapons fallout, nuclear reactor accidents, or nerve gas accidents, i.e., things that make people anxious because of a perceived lack of control over exposure to the risks and consequences that

are catastrophic. The second dimension, 'unknown risk,' refers to the degree to which a risk (e.g., DNA technology) is seen as new, with unforeseeable consequences not yet tested by time, and with hazards and exposures not easily detectable.

What then is known about the general public's emotional reactions to the prospect of climate change? Public opinion data in the US document a low level of concern.⁵⁰ Leiserowitz⁵¹ applied a methodology developed by Slovic et al.⁵² to quantify people's emotional reactions to the risk of climate change, asking people to provide the first thought or image that came to mind when they heard the term 'global warming,' which was subsequently rated on a scale ranging from -5 (very negative) to $+5$ (very positive). Associations to distant events like melting glaciers and polar ice were most common, followed by generic associations to heat and rising temperatures, and impacts on non-human nature. Mean affect scores indicated that these images of 'global warming' had only moderately negative connotations for almost all respondents.

Differential personal experience affects risk perceptions, as discussed above, often by way of people's affective reactions.⁵³ Whereas personal exposure to adverse consequences increases fear and perceptions of risk, familiarity with a risk acquired by exposure without adverse consequences can also lower perceptions of its riskiness.⁵⁴ One non-climate example of reduced risk perceptions due to greater familiarity is the home bias in equity portfolios in financial investing, where investors overinvest in equities from their home country, with which they are familiar and about whose risks they therefore worry less⁵⁵ and therefore fail to diversify sufficiently internationally. Thus greater familiarity with climate change and its risks, unless accompanied by alarmingly large negative consequences may actually lead to smaller rather than larger perceptions of its riskiness.

If people conceive of climate change as a simple and gradual change from current to future values on variables such as average temperatures and precipitation, the risks posed by climate change would appear to be well-known and, at least in principle, controllable (e.g., by moving to a different part of the country). Of course, in most cases, people do not move away from hazards even when they are aware of them. Status quo biases or change inertia have been documented in many situations, e.g., for organ donations⁵⁶ and insurance decisions.⁵⁷ The perceived ability to take corrective action is an important determinant of emotional reactions. Potential catastrophes from climate change (of the

kind graphically depicted in the film 'The Day after Tomorrow') have the ability to raise visceral reactions to the risk.⁵⁸ Climate change that is construed as rapid is more likely to be dreaded than climate change that is expected to be gradual.

Analysis-Based Processing of Environmental Decisions

People consider climate change risks to be considerably uncertain and as being mostly in the future and geographically distant, all factors lead that them to discount their possible consequences. Economic analysis allows for the discounting of future and distant costs and benefits by some amount (e.g., by the rate of interest offered by financial institutions) as a function of the time delay, a mechanism that is described mathematically by an exponential discount function. However, contrary to the assumptions of rational-economic discounting, people are inconsistent in their discounting, applying different discount rates to outcomes in different domains (e.g., financial, health, or environmental outcomes^{59,60}), showing a strong present bias (i.e., strongly preferring immediate benefits and disliking present costs relative to delayed options), and discounting future benefits far more than future costs.^{61,62} Whereas the costs of actions that could lead to a mitigation of CO₂ emissions are incurred immediately, their uncertain and future benefits are heavily discounted, making the deliberative consideration of such actions unlikely to arrive at socially responsible and long-term sustainable behavior.

To explain people's large impatience when immediate rewards are an option,⁶³ Trope and Liberman suggest that future events are construed differently from events in the present. In particular, events in the distant future (an invitation to give a paper at a conference 2 years from now, or the prospect of coastal flooding 30 or 50 years from now) are construed in abstract terms, whereas events closer in time (the upcoming trip on Monday to attend the long-scheduled conference, or the prospect of a major hurricane passing through town tomorrow) are construed in more concrete terms. Abstract versus concrete representation of the consequences of possible actions differ in their affective strength and impact. Abstract representations of consequences in the distant future usually lack the concrete associations connected to present or near-present events and thus may not be feared as much.

Protective or mitigating actions against global climate change can require the sacrifice of concrete,

immediate benefits for the sake of abstract, distant goals. The strong negative affect associated with the concrete, immediate costs and sacrifices may well drive ecologically damaging consumption decisions and actions. However, this tendency is moderated by the way people think about changing their consumption. When asked to delay consumption, people first generate arguments for the status quo, immediate consumption, and only then latter generate arguments for delaying consumption. Yet, argument generation for the first action considered (e.g., immediate consumption) tends to interfere with the subsequent generation of arguments for other action.⁶⁴ Weber et al.⁶⁵ succeeded in drastically reducing people's discounting of future rewards by prompting them to first generate arguments for deferring consumption, followed by a prompt to generate arguments for immediate consumption. Social norms and/or positive or negative affective reactions to a choice options typically determine which option is considered first. Therefore, Hardisty et al.⁶⁶ found that 65% of Republicans were willing to pay a CO₂ emission reduction fee on such purchases as airline tickets when the fee was labeled as a carbon offset (and first generated arguments for purchasing it), but that this percentage dropped to 27% when the fee was labeled as a carbon tax, a label that generated negative visceral reactions in this group and led them to first generate arguments for not purchasing it.

Rule-Based Processing of Environmental Decisions

Many decisions, including environmental decisions are made by recognizing the situation as one for which a rule exists. These rules can be laws ('stop at a red traffic light'), self-imposed admonishments ('never eat after 5 pm'), or social norms ('if you broke it, you fix it').⁶⁷ Many such rules of conduct derive from the social roles of decision makers,⁶⁸ including positions of responsibility within society (e.g., professor, parent, or Christian). Implicit rules and role-related obligations are often acquired through observational learning and imitation. Copying the observed behavior of others is a widespread phenomenon of which the imitator is typically unaware and plays a large role in human development.⁶⁹

Since rule-based decision habits often develop to prevent undesirable decisions made as the result of applying analysis- or affect-based processes (e.g., overriding impulsive eating), promoting a more widespread use of rule-based processes in environmental decisions may be an effective way of encouraging more long-term oriented, sustainable behavior. Recent

appeals of American evangelical churches, reminding their members of their duties as stewards of the earth fall into that category. Rule-based decision making also highlights the importance that people's attributions of responsibility for climate change can have. Whereas only 35% of all American respondents believed that climate change was a serious problem deserving of action in the²¹ poll previously mentioned, this figure went up to 97% for the subset of respondents who believed that the observed warming was due to human activity. Attributions of responsibility seem to have a high likelihood to trigger corrective action rules.

IF THERE IS INSUFFICIENT WORRY OR CONCERN, SHOULD WE GENERATE MORE?

One might conclude that the research reviewed in the previous section suggests that we should find ways to evoke stronger affective reactions toward the risk of climate change in citizens, managers, or public officials, by making expected climate change effects more vivid or concrete. Such a course of action may, however, have some unintended consequences. As worry increases about one type of risk, concern about other risks has been shown to go down, as if people had only so much capacity for worry or a finite pool of worry.⁷⁰ Increased concern about global warming may result in decreased concern about other risks. Hansen et al.⁷¹ tested this hypothesis in a climate context, examining whether increases in concern about climate variability on the part of Argentine farmers resulted in a decrease in concern about other risks. In two scenarios of a farm decision experiment, farmers rated the extent that they worried about (a) the political situation in Argentina, (b) weather and climate, (c) prices of input variables, and (d) prices of crops at harvest, on a scale from 0 ('not at all worried') to 10 ('extremely worried'). The two scenarios involved the same crop-selection and cultivation decisions, but differed in the provision of a seasonal climate forecast that indicated unfavorable La Niña conditions for the upcoming growing season. Not surprisingly, stated concern about climate risks among the farmers significantly increased from the first to the second scenario, essentially providing a manipulation check for the provided climate information. At the same time, however, concern about political risk decreased from the first to the second scenario, even though the objective political risk was identical.

There was some indication that concern and worry was a finite resource even *within* each scenario.

For both climate scenarios, farmers who worried more about political risk tended to worry less about climate risk. Judgments of worry or perceived risk were not inconsequential, in that differences in farmers' perceptions of the degree of risk posed by political, climate, input costs, and crop price variables were associated with differences in their production and pricing decisions. Other illustrations of the finite pool of worry effect are provided by the observation that increases in the concern of the US public about terrorism post 9/11 resulted in decreased concern about other issues such as restrictions of civil liberties as well as climate change,⁷² or that the recent financial crisis reduced concern about climate change and environmental degradation.²¹

As another caution against inducing stronger concern about climate change,¹⁴ Weber coined the phrase *single-action bias* for the following phenomenon observed in contexts ranging from medical diagnosis to farmers' reactions to climate change. Decision makers are very likely to take one action to reduce a risk that they worry about, but are much less likely to take additional steps that would provide incremental protection or risk reduction. The single action taken is not necessarily the most effective one, nor is it the same for different decision makers. However, regardless of which single action is taken first, decision makers have a tendency not to take any further action, presumably because the first action suffices in reducing the feeling of worry or vulnerability. Weber¹⁴ found that farmers who showed concern about global warming in the early 1990s were likely to change either something in their production practice (e.g., irrigate), their pricing practice (e.g., ensure crop prices through the futures market), or lobbied for government interventions (e.g., ethanol taxes), but hardly ever engaged in more than one of those actions, even though a portfolio of protective actions might have been advisable. The fear of climate change seemed to set a 'flag' that some action was required, but remained in place only until one such action was taken, i.e., any single protective action had the effect of taking down the 'impending danger flag.' While such behavior might have served us well in our evolutionary history where single actions generally sufficed to contain important risks, in more complex environments where a portfolio of risk management actions is advised, purely affect-driven, single-action biased responses may not be sufficient. Hansen et al.⁷¹ found evidence for the single-action bias in farm practices that can be interpreted as protective actions against climate change and/or climate variability. Thus farmers who

indicated that they had the capacity to store grain on their farms were significantly less likely to indicate that they used irrigation or that they had signed up for crop insurance.

CONCLUSIONS

Behavioral research over the past 30 years strongly suggests that attention-catching and emotionally engaging informational interventions may be required to engender the public concern necessary for individual or collective action in response to climate change. Such interventions would need to be conducted with full awareness about unintended side-effects (e.g., reductions in concern about other important risks) and in ways designed to help people overcome cognitive and affective capacity limitations (e.g., the single-action bias). To the extent that time-delayed consequences of our actions do not attract the attention or generate the concern ex-ante that they would seem to warrant ex-post, behavioral research provides some corrective actions. The concretization of future events and moving them closer in time and space seem to hold promise as interventions that will raise visceral concern. Guided protocols by which decision makers consider arguments for energy conservation and climate change mitigation before they are allowed to consider arguments against such actions may help to improve the balance between the desire for immediate gratification and the goal of sustainable development. Finally, for at least a subset of the public, better (environmental) science and statistics education can create the familiarity with the scientific presentation of information and the mental habits that will create citizens who give greater weight to the output of their analytic processing system, moving the risk perception of the general public and its officials closer to that of climate scientists. A better understanding of the human contributions to climate change promises to activate norms about social responsibility to rectify problems caused by human action. Even though changes at a social or cultural level are harder to effect, they may have the most lasting consequences. Changes in the prevalence and salience of different goals, roles, and obligations related to the human interface with its natural environment may result in greater attention to climate change, more accurate perceptions of its scope and possible consequences on the part of policy makers and the general public, and a greater willingness to act on these perceptions.

Failing these efforts, the problem discussed in this paper is ultimately self-correcting. Increasing

personal evidence of climate change and its potentially devastating consequences can be counted on to be an extremely effective teacher and motivator, if and when they occur and are recognized as the result of human activity. Unfortunately, such lessons may arrive too late for corrective action.

NOTES

^aThere is need, however, for empirical evidence about differences in concern or risk perceptions related to climate change between climate scientists and members of the general public, which have not yet been compared directly.

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