Perceptions and communication strategies for the many uncertainties relevant for climate policy

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Public opinion polls reveal that the perception of climate change as an uncertain phenomenon is increasing, even as consensus has increased within the scientific community of its reality and its attribution to human causes. At the same time, the scientific community has sought to improve its communication practices, in order to present a more accurate picture to the public and policy makers of the state of scientific knowledge about climate change. In this review article, we examine two sets of insights that could influence the success of such communication efforts. The first set questions which uncertainties matter for effective climate policy. While the literature has focused disproportionately on uncertainties with respect to the climate system, we draw attention here to uncertainties associated with the solution space. The second set examines which factors lead people to take slow and deliberated decisions versus quick and spontaneous ones, and looks at the results of these two systems of thought on climate change action. From the review of these two sets of literature, we propose a new hypothesis: that the gap between public and scientific attitudes toward climate change will narrow not because of greater attention to and communication of climate system risks and uncertainties, but rather out of growing experience with the policies and technological systems needed to address the problem.

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INTRODUCTION: THE GROWING GAP BETWEEN CLIMATE SCIENCE AND CLIMATE PERCEPTION

In 1989, as the Intergovernmental Panel on Climate Change (IPCC) was preparing its first assessment report, and as national delegates were gearing up for the process of negotiating the United Nations Framework Convention on Climate Change (UNFCCC), the world's largest oil company, Exxon, was also hard at work. Together with several other oil companies, they formed the Global Climate Coalition, an advocacy group opposed to policies that would limit the burning of fossil fuels. Their main approach, according to a report on their activities written by the Union of Concerned Scientists, was to 'manufacture uncertainty' on the science of climate change and people's role in it.[1] A 1998 memo made clear that their objective would be achieved 'when average citizens [recognize] uncertainties in climate science,' and hence their strategy was to 'develop and implement a national media relations program to inform the media about uncertainties in climate science'[1] (p. 10). In the seven years following, the company pumped $16 million into this information campaign.[1]

Consistent with the intent of the Exxon strategy, it has long been conventional wisdom in the climate change research and policy community

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that any perception by the public that there is uncertainty in the science behind climate change and its attribution to human actions has been and will continue to be the death knell for effective policy-making to combat it. At the same time, the climate change research and policy community has long sought to improve uncertainty communication, attempting to describe it accurately, completely, and free of value. The IPCC has commissioned three iterations of guidance notes to identify the issues associated with uncertainty communication.[2–4] Countless articles have highlighted the importance of uncertainty in climate policy debates,[5–7] suggesting important aspects of climate uncertainty that need to be communicated[8,9] and how to best communicate them.[9–11]

For those concerned that public skepticism concerning the existence of climate change may contribute to a lack of effective climate policy, the last few years have not been encouraging. In the United States, people are regularly polled about their top concerns. In 2007, when climate change was first included on the list, 38% of those surveyed placed it as a top concern. By 2010, that number had fallen to 28%, and by 2012 to 18%.[12] People have also been asked whether they believe climate change is actually occurring; between 2007 and 2012 the proportion saying 'yes' declined steadily from 84 to 60%).[12,13] In a series of polls taken in Hamburg, Germany, between 2008 and 2011, the proportion of people who felt that climate change was a serious problem fell from 63 to 44%.[13] In the United Kingdom, polls taken over the four-months period between November 2009 and February 2010, the time of the so-called 'Climategate,' showed a decline in the number of people believing climate change to be a reality, from 83 to 75%.[13] In New Zealand, the number of people who felt that climate change was not a problem rose from 8% in 2007 to 17% in 2010, and a similar trend could be seen in Australia.[13] Across the board, these polling data reveal that concern about climate change had fallen, by 2010, to below 1990s values, after a brief period around 2007 and Al Gore's movie *An Inconvenient Truth*, when concern about climate change and belief that it was real, was highest.[14]

The change in public perceptions runs counter to the trend in scientific assessments.[15] The IPCC, for example, has since 1990 continually bumped up its language to describe the certainty about global warming, from rather ambiguous language involving the 'balance of the evidence' to 'likely' in the Third Assessment Report and then 'very likely' in the Fourth,[16–19] reflecting the growth of evidence within the scientific literature. Several researchers have studied the factors that mediate this disconnect between mainstream science and popular perceptions. Boykoff and Boykoff attribute it, in part, to the media and their effort to present a balanced view, which (by aiming for an equal voice given to scientists supportive or skeptical of climate change) has actually been presenting one that is biased toward uncertainty, as the number and scientific qualification of skeptics is far outweighed by those of proponents.[20] Other researchers have identified problems in communication practices more generally, such as the use of 'climate change' instead of 'global warming' to describe the problem, as playing an important role in perceptions of climate change.[21–23] Patt found the presentation of uncertainty as derived from model results, or from model disagreement, to play a role in the formation of belief.[24] Lorenzoni and Pidgeon identified cultural factors that gave rise to difference in perception between the United States and Europe,[25] as Leiserowitz did within the United States.[26] A review of this literature shows similar factors at work in both industrialized and developing countries.[27]

There is clearly a disconnect in the perceptions of the science of climate change between the expert and lay communities, as numerous studies have documented.[28] Past review articles have summarized how improved communication practices could help to lessen it.[15,29,30] In this review article, our intention is not to again summarize what is known about this disconnect in climate science perception, or what to do about it through communication, but rather to place it into the larger context of what it means for climate policy. It is, after all, a concern for climate policy that drives many people to consider this disconnect troublesome.

First, we review literature from a number of policy-relevant disciplines suggesting that climate policy itself may be becoming less and less sensitive to the existence and perception of climate uncertainty, and at the same time more and more sensitive to uncertainty in other systems, social systems in particular. Based on this literature, we argue that it is time to move discussions of uncertainty perception and communication away from a sole focus on the climate system, and toward a consideration of a wide range of other sources of uncertainty. Second, we present the results of psychological and other behavioral research studies in the areas of climate adaptation and energy use that show the importance of both communication and formal and informal institutions in promoting effective choices that improve the welfare of both the individuals making those decisions and society at large. We argue that within this wider uncertainty space that is now relevant for climate policy, it is important to carefully consider the ways in which uncertainty about both climate information and climate action choice options is presented. Third, we continue to review the behavioral literature—recognizing the contributions of other disciplines, but not covering them—on the lessons for how best to communicate climate change response options and their uncertainty in order to promote efficient and effective decision-making and action. While there is an extensive literature on how to communicate uncertainties,[11,31–33] our focus here turns more to the issue of what uncertainties to communicate in the first place, and for what purpose.

UNCERTAINTIES THAT MATTER FOR CLIMATE POLICY

Climate policy, or at least climate policy discourse, has not stood still. Ten years ago, political discussions still focused on what an appropriate target for climate mitigation policy ought to be.[34,35] Articles dealing with uncertainty and climate policy typically examined issues such as hedging against the risks that climate change presents. Since then, there has been political buy-in to the desirability of a 2 °C target and associated emissions reductions, reflecting a shift in the decision-analytic framework from cost benefit analysis to one of risk management and prevention, the latter informed by cost effectiveness analysis.[36,37] This buy-in is reflected in high-level political statements at United Nations negotiating forums, international meetings such as the G20, and concrete targets in political jurisdictions ranging from subnational (e.g., California) and national (e.g., the United Kingdom) to multinational levels (e.g., the European Union), and has been supported by extensive research projecting the economic costs of achieving such a target to be manageable and almost certainly less than the avoided damage costs.[38–41] Today's political and scientific debates are concerned less about the single question of where to set the climate mitigation 'control knob'—whether to limit global average warming to 4, 3, or 2 °C—but have instead moved on to address the much wider group of questions about what policy instruments and behavioral changes can achieve the desired level of mitigation.[42]

Even as estimates of the precise level of climate change may now matter less for policy-makers engaged in mitigation, the same may be true for adaptation. Climate change adaptation decisions can be sensitive to how people perceive climate change and the causes for change. At the same time, however, it is also clear that many adaptation and climate risk management decisions are not or should not be sensitive to the precise probabilities or expectations of long-term climate change,[28,43,44] or the precise attribution of current climate hazards to anthropogenic influences.[45] A greater influence on the motivation to adapt appears to be people's belief in their own ability to alter their future and to imagine positive results from self-protective behavior.[46] Within the adaptation policy research and policy community, efforts have centered on innovations that make societies better adapted to today's climate—such as improvements in building insulation, flood management practices, or the use of seasonal climate forecasts—or which build adaptive capacity for the future. Both strategies are robust to the great deal of uncertainty that surrounds anticipated future climate impacts.[47]

In the context of this progress, then, the effect has been a reframing of the type of problem that climate policy-makers face. There exists a wide literature on framing in the context of climate change policy, which we do not cover here.[48–51] What is important here is that this reframing has effectively removed from many political discussions the need to know with specified levels of precision how much climate change may take place, and what it would do to society in the absence of steps to reduce emissions. A decade ago, for example, Yohe et al. considered the issue of developing mitigation policies to hedge against an uncertainty level of climate sensitivity[52]; more recently, Rozenberg et al. considered how the design of climate policy could hedge against uncertainties in the future oil supply.[53] With this change in policy focus has come as a change in the set of uncertainties seen as obstacles to action and whose reduction is thus viewed as most important.

In this new world of climate policy, what then are the key risks or uncertainties that matter? In the remainder of this section we describe what these are, before turning in the next section to insights from psychology and behavioral decision theory about the factors that shape how people perceive and react to them.

Uncertainties Associated with Climate Sensitivity and Impacts of Greenhouse Gas Emissions

Most of the literature on the importance of uncertainty for climate policy has focused on uncertainty with respect to the climate system and the social cost of carbon: the extent to which CO_2 and other greenhouse gases will change the climate, and the harm that those changes bring to people.[54–56] While there is reason to believe that an agreement on a 2 °C target and a recognition of the importance of adaptive capacity have both lessened the importance of expected climate impacts and the degree of uncertainty about them for policy and decision-making, the importance has not altogether disappeared. Patt and Schröter,[57] for example, documented how in Mozambique an unwillingness on the part of subsistence farmers to implement the adaptation measures that policy-makers had designed for them resulted from a different attribution of the causes of locally experienced climate change (to a moral failure on the part of local residents—their failure to observe traditional practices and rituals—rather than pollution generated outside the community), and a much lower estimation of the seriousness of the effects of observed climate changes. Likewise, climate uncertainty remains important for decision-making in those political jurisdictions where a decision on a 2°C target remains tentative or provisional. In California, for example, political agreement on climate impacts was instrumental in the development of unilateral climate commitments.[58,59] In the United States more generally, greater consensus on the importance of climate change could shift the locus of climate policy from the state to the federal level.[60]

Uncertainties Associated with Present and Future Stocks and Flows of Greenhouse Gases

Some of the greatest assessed uncertainties in the physical science of climate change concern not the sensitivity of the climate system to changes in radiative forcing, but rather the sensitivity of the carbon cycle to changes in land management practices and environmental conditions.[61,62] Two critical aspects of global climate policy that are sensitive to these uncertainties are the design of monitoring, reporting, and verification systems for carbon emissions,[63,64] and the design of land-use policy instruments such as reduced emissions from deforestation and degradation, REDD.[65,66]

Uncertainties Associated with Costs and Benefits of Future Adaptation Actions

In theory the mitigation 'control knob' problem ought to be sensitive to uncertainties concerning the costs and benefits of adaptation.[67–69] To the extent that the net costs of adaptation are lower, the optimal and anticipated level of adaptation will be greater, the residual climate impacts less, and the optimal degree of climate mitigation less of a departure from a business-as-usual scenario.[6,70] But this theory is no longer considered particularly useful. First, the uncertainties associated with the optimum level of mitigation far exceed the marginal effects of adaptation costs on that optimum; second, to the extent there has been political buy-in of the 2°C target, uncertainty with respect to adaptation costs has ceased to be relevant for climate mitigation policy.[71] Where it remains vitally important is for adaptation policy itself,[72,73] such as decisions with respect to international adaptation finance.[74,75]

Uncertainties Associated with Costs, Benefits, and Risks to Society of Technologies and Technological Systems

The transformation of local, regional, and global energy systems to decarbonized sources is the *sine qua non* of climate mitigation policy. Policy discussions often revolve around the perceived risks associated with particular technology options, pathways, and systems. These risks can be to human health and safety, as in the case of discussions of nuclear energy[76,77] and fossil fuels,[78,79] as well as underground carbon storage.[80,81] They can also be risks to national energy security, often an argument for replacing imported fossil fuels with domestically produced renewable energy.[82,83] They also revolve around the expectations of future costs and co-benefits—such as reduced local air pollution—of decarbonized sources of energy.[84] A growing body of empirical research and theory-grounded analysis suggests that the sensitivity to uncertainties in these factors is high.[85–87] As with uncertainty about the climate system, there is evidence that the popularly perceived degree of uncertainty and risk concerning technologies and technological systems may be much higher than, and hence largely unsupported by, the estimates generated by formal scientific and technology assessments.[83,88,89]

Uncertainties Associated with Climate Policy Instruments

As governments have begun to experiment with different policies and policy instruments for both mitigation and adaptation, it has become clear that these instruments alter the decision space for private actors, often in ways that are highly uncertain.[90–92] In the area of mitigation in particular, a growing body of research has focused on the issue of regulatory risk: the effects on investors of uncertainties in the future state of climate policy, as well as the interactions between climate policy and other market forces that determine both carbon and fossil fuel prices.[93–95] Such research has now demonstrated that regulatory risk, or indeed the perception of regulatory risk, can decrease the effectiveness and raise the costs of many policy instruments,[96–99] and lead to a substantial change in the relative attractiveness of different policy instruments for promoting technological change.[100,101] Interestingly, almost all of the modeling studies that have identified the costs of regulatory risk have taken for granted that investors and firms are risk neutral, despite abundant evidence to the contrary. Two studies have explored the effects of risk aversion on regulatory risk. Fan et al. found that risk aversion magnifies the effects of regulatory risk in the case of a grandfathered permit scheme, but reduces it in the case of an auctioned permit scheme.[85] Pahle found that the combination of regulatory risk and risk aversion could explain the surprising fact that Germany's implementation of the European Emissions Trading System led to a short-term investment boom in new coal-fired power plants.[102] There is clearly a lot more research to be done.

Uncertainty About Human Demography, Culture, and Preferences

An important set of factors influencing the anticipated costs and benefits of both climate impacts and the technologies and systems that could influence the timing and magnitude of those impacts is associated with the state of human society at the time those costs and benefits will be felt. Revi analyzed adaptation policy options in India, the effects of which are especially sensitive to the degree of urbanization that is likely to occur in the coming decades, and which at the same time will affect that urbanization trend.[103] Patt et al. projected human losses from climate-related extreme events in least developed countries, and found the results to be highly sensitive to economic and demographic factors associated with alternative IPCC scenarios, suggesting differences in the immediate need for international support for adaptation in these countries based on expectations of socio-economic development.[104] A great deal of debate about an appropriate discount rate to apply to future costs and benefits hinges on issues of future population, whether humanity faces a threat to its existence, the extent to which future consumption will be different from what it is today, and the influence of changes in consumption patterns on the relevant preferences between market and nonmarket goods.[105,106]

This list of factors and variables that we have presented, for which either actual epistemic uncertainty or the popular perception concerning the level of that uncertainty matter, is short, and no doubt incomplete. At the same time, however, it is dramatically longer than the list of questions that polls on perceptions of climate change and climate policy currently include. These polls typically ask people whether they believe climate change is real and caused by humans, but they do not ask whether they believe the costs of solar and wind energy will fall sufficiently to outcompete coal and gas, whether they believe that future generations can and should be left to deal with climate change consequences, whether they believe a carbon tax is an effective tool to stimulate low carbon development or a renewable energy subsidy a cost-effective use of funds, or whether they have sufficient knowledge of existing climate hazards to make wise risk management decisions. Yet the literature is clear that uncertainties in these latter areas, how people perceive them, and how scientists communicate them, are at least as important.

PSYCHOLOGICAL DRIVERS OF UNCERTAINTY PERCEPTION AND RESPONSE

Social science disciplines conceptualize the perception and reaction to uncertainty in different ways. Sociology conceptualizes people's processing of certain or uncertain information at a community level. Social roles and institutions have evolved to solve social problems, with scientists charged to ascertain facts and causal relationships and policy makers charged with coming up with ways of changing socially damaging behavior. Clear and present dangers (like a pending military invasion or pandemic) get immediate action, but uncertain dangers often result in inaction, especially when solutions are seen as costly.[107] The rational framework of traditional economics assumes that decision makers will attempt to appraise projections and their degree of certainty as accurately as possible and will integrate across all possible outcome values and their likelihoods in an attempt to compute the best possible decision, as formalized by normative models like expected utility theory.[108] Under this theory, individuals estimate the utility they will experience with each possible outcome of a given choice option, calculate the average of those utility levels (taking into account the assessed likelihood of each possible outcome), and choose the choice option offering the highest average utility value. More uncertainty simply means that a broader set of possible future states of the world need to be considered and integrated.

Psychology, in contrast, takes a more complex view of people's processing of information that is not known with complete certainty, compared to the approach of economics. The fact that human attention and processing capacity are finite allows for only bounded rationality,[109] which means that not all information gets considered to the same degree all the time, and that perception and response to information has to be selective. This provides for entry points for individual and cultural differences in decisions under uncertainty, as different parts of a distribution of possible consequences get differential attention as a function of people's past experience and current needs and goals.[110] In addition, psychology considers a broader set of processes used by human decision makers, not just the analytic processing implicitly assumed by economic models, but also emotional (or affective) reactions and other automatic processes that associate antecedents with consequences, as well as ethical or moral rules of conduct that get instantiated in appropriate situations.[111] Situations of high uncertainty or ambiguity typically trigger (mostly negative) emotional responses, with human decision makers being fearful of unpredictability.[112] Such fear can be used to motivate action if simple solutions are apparent, but may also lead to problem denial in situations where solutions are not apparent or seem costly.[113]

Within psychology and the closely related field of behavioral economics, researchers have identified a number of factors influencing how people perceive, and ultimately respond to uncertainty. These include:

Systems 1 and 2

Summarizing a large body of research, Kahneman characterizes two modes of human thinking.[114] System 1 is fast, automatic, requiring little or no effort, and uses simple associations, including emotional reactions, that have been acquired by personal experience with events and their consequences; it leads to good outcomes in cases where an individual has a great deal of personal experience on which to draw. System 2 initiates and executes effortful and intentional mental activities as needed, including simple or complex computations or use of formal logic. While the two systems often operate cooperatively and in parallel,[115] the distinction between them helps to make clear the tension between automatic and largely involuntary processes and effortful and more deliberate processes in the human mind. System 1 processes tend to focus the decision maker on the here and now, reducing the relevance of the future, while System 2 analyses recognize the need to develop long-term strategies. There is evidence that experience and training in a given problem area, as well as institutional factors such as mandates to engage in formal decision analysis, can lead to increased use of System 2 processes.[114] Likewise, there is evidence that the more emotionally laden an issue is, the more likely that decision-makers will employ System 1.[116] One might suppose that employing a System 2 thinking mode leads to superior outcomes, as decisions will be taken on the basis of careful consideration making use of all available evidence. The evidence suggests, however, that people have a greater motivation to implement decisions made in the System 1 mode; often, the best outcomes occur when people learn, at a subconscious level, how to apply System 1 thinking successfully to a particular decision domain.[117]

Psychological Risk Dimensions

Slovic and collaborators identified two risk dimensions that influence people's intuitive perceptions of health and safety risks across numerous studies in multiple countries.[118] Dread risk, the first factor, describes the anxiety that people feel because of a perceived lack of control over exposure to the risks and because consequences may be catastrophic (e.g., a nuclear reactor accident). The second factor, unknown risk, refers to fear when a risk (e.g., DNA technology) is perceived as new, with unforeseeable consequences and with exposures not easily detectable. The human processing system maps both the uncertainty and the adversity components of risk into these affective responses and represents risk as a feeling rather than as a statistic.[119] Psychological research over the past decade has documented the prevalence of affective processes in the intuitive assessment of risk, depicting them as essentially effort-free inputs that orient and motivate adaptive behavior, especially under conditions of uncertainty.[120,121] Weber suggests that risks associated with the climate system do not score very highly on either of these two psychological risk dimensions, thus depriving us of an intuitive and automatic basis of concern that might motivate action.[116]

Concrete Personal Experience Versus Abstract Scientific Information

People have the ability to learn about uncertain consequences either from personal experience or by being provided with statistical summary descriptions of possible outcomes and their likelihoods. The former, personal experience, capitalizes on the automatic, effortless, and fast associative and affective processes of System 1.[122] Learning from statistical descriptions, on the other hand, requires System 2 processes (e.g., understanding numerical probabilities and probability theory) that need to be learned and require cognitive effort. With personal experience of climate change impacts still being infrequent in many regions of the world, the perception that the impact of climate change is neither immediate nor local persists,[123] leading people to think it rational to advocate a 'wait-and-see' approach to emissions reductions.[124,125] Surveys conducted in Alaska and Florida, regions where residents have been exposed more regularly to physical evidence of climate change, show that such personal exposure greatly increases their concern and willingness to take action.[123,126,127] It is not surprising that people respond more strongly to concrete representations of uncertainty that relate to their personal and local experience,[128] and there is reason to believe that such representations translate into greater motivation to take action,[129] especially when people do not have strong pre-existing beliefs about climate change.[130]

Familiarity Reduces Perceptions of Risk

Behavioral studies with financial investors show that familiarity with investment options reduces perceptions of their riskiness, controlling for objective projections of future returns and their uncertainty.[131] Similar results have been reported in the climate policy domain. Komendantova et al. and Lilliestam and Ellenbeck examined the perceived risks associated with importing solar energy from Arab countries among members of the European public and many policy-makers.[83,88] For the majority of respondents, the unknown risks associated with terrorism and state extortion loomed large. For those respondents, however, used to doing business in Arab countries—investors in existing renewable energy projects—these risks were seen as minimal, and the risks of inefficient bureaucracy and state corruption were ranked more highly. A number of studies have examined local opposition to wind farms born out of fears of detrimental effects on the landscape, wildlife, and human health. Interestingly, for proposed wind-farm developments, there is evidence that the level of opposition to the proposed turbines increases with how close a person lives to them. But the relationship is the reverse for existing wind-farms, where personal experience lessens the level of unknown risk.[132]

Individual or Cultural Differences in Perceptions or Reactions

People's perceptions and reactions to risks and uncertainty depend not only on objective reality but also on their own internal states, that is, their needs, goals, past experiences, expectations, and reference points.[115] Some of these states are chronic, that is, determined over time by people's physical, cultural, and historic environment, for example, their socio-economic status or their commitment to worldviews like individualism versus collectivism, which are known to affect their evaluations of climate change uncertainty (i.e., belief that climate change exists).[124] At the same time, people's internal states and thus their perceptions and responses to risk and uncertainty are also surprisingly malleable and labile, that is, can be shaped and influenced by variations in the way uncertainty information and information about choice options is presented and how choices are elicited, factors that do not play a role in normative models of choice such as expected utility theory.[133]

As with the previous section, the list of insights that we present is incomplete, merely illustrating that there are a many factors that can influence the perception of risk and uncertainty that will have far greater influence on their actions than the confidence interval placed by scientists around an uncertain climate system prediction. Two general lessons are worth highlighting. The first is that concern is more easily translated into motivation to act when developed through System 1 pathways. Two people may be highly concerned about climate change, but the one whose concern was elicited by direct personal experience, touching him or her at an emotional level, will likely be more motivated to act on the basis of that concern than the one whose concern is driven by an intellectual understanding of the problem. The second is that factors influencing perceptions of risks and uncertainty can vary from individual to individual, and also from risk to risk.

Consider, for example, a national level policy to promote renewable energy development. This could be framed as a response to the threat of future climate change. Support for such a future-thinking strategy would rely on people's making sense of abstract scientific information, utilizing System 2 thinking. For those wanting an 'excuse' not to support the policy, uncertainties associated with the climate system could provide a reason to delay action. The policy could also be framed as a way to lessen people's exposure to oil price volatility, and the actions of oil exporting states. As a response to an immediate threat, support for the policy could be based on System 1 thinking. In this case, uncertainties associated with the oil supply would be the very factor triggering support *for* the policy.

CONCLUSION: INSIGHTS FOR COMMUNICATING UNCERTAINTY

The primary purpose of communicating uncertainty effectively is to help decision-makers make informed judgments that allow them to achieve their long- as well as short-term objectives. There have been a number of guidelines developed for the communication of climate uncertainty, with this goal in mind. These include a series of guidance notes for IPCC authors to follow when drafting text for the last three assessment reports.[2–4] They also include guidance notes commissioned by the governments of the United States[134] and the Netherlands.[135] A recent review of these efforts[136] suggests that they converge on a somewhat common set of insights garnered from the evolving fields of behavioral economics and risk communication, even though there is always room for improvement when recommendations are subjected to empirical tests.[33] Common insights include substantive suggestions, such as the idea of communicating mental models of processes to allow uncertainties to be fully appreciated,[136] and the need to communicate not just the quantitative state of scientific knowledge about a given uncertainty, but also a qualitative indication of the observational basis on which that knowledge is based.[137] They also include procedural insights, including the need to engage stakeholders early and often, as partners, in risk and uncertainty management issues,[32] or the desirability of allowing stakeholders to discover progressively more information about relevant uncertainties, until they feel they have enough to make an informed choice.[11]

Here, we can offer a potentially new hypothesis, to supplement the existing reviews that have been written: in a great many decision contexts having to do with climate change, perceptions about the existence and extent of climate change may vary less as a result of how climate risks are communicated, and more as a result of whether solutions are portrayed as possible, and the extent to which people are made familiar with technologies and institutions required for solutions. The psychological literature suggests quite clearly that people's beliefs about the existence of a problem depend to a great extent on whether they believe that problem can be solved; where no satisfactory solutions are available, and frustration sets in, problem avoidance is a hardwired strategy.[113] In this manner, belief and concern about the existence of climate change may follow, rather than precede, a successful search for satisfactory solutions. Kellstedt et al. offer evidence in support of this idea. Examining individual level determinants of concern over climate change, they found no evidence that people's self-reported knowledge about climate change and its impacts correlated with a higher level of concern.[138] Indeed they observed that many of the people who reported that they knew the most about climate change had come to the conclusion that on their own they could do very little to solve it, and both their belief and level of concern were low. What they did find to correlate positively with concern was people's estimation of their own power to reduce or eliminate climate change.

In this light, one could imagine that the observed waning of public concern over climate change may have resulted from a sense that international negotiators will not be able to agree on a satisfactory climate policy solution, a sense growing in the months leading up to the 2009 Copenhagen climate talks and persisting ever since. Unfortunately, we can find no published study that addresses this issue head on. There is however anecdotal evidence that policy-makers and advocates have increasingly chosen to frame decisions in ways that largely omit climate change and its uncertainties as a concern. This may be a wise strategy, both because the framing raises a very different set of uncertainties as relevant to the decision, and, in countries such as the United States, because it avoids the association with a highly politicized policy domain. One example is a recent study published by the Rocky Mountain Institute on the potential to decarbonize the United States energy system.[139] They find that a near complete decarbonization is possible over the next 40 years, in a manner that would increase economic output and the quality of life during that time. Precisely because of this latter element to the finding—that decarbonization is justified on its own economic merits—any mention of climate change and its associated uncertainties is barely to be found in the text.

Below the level of international climate negotiations, policy-makers have made a great deal of progress in national and subnational jurisdictions, and while some have argued that these efforts could prove instrumental,[140] it is certainly too early to tell. Confidence in these policies, however, depends on a set of factors largely unrelated to uncertainty about the climate system: whether or not new sources of energy will prove to be reliable and cost effective; whether they will have an adverse effect on people's lifestyles; whether they will have detrimental impacts on the landscape or create perceived risks to health and safety. Unlike the threat of catastrophic climate change, which over the coming years is likely to remain a possibility several decades in the future, attitudes toward the policies to stop climate change could evolve rapidly in response to increasing direct experience with these other outcomes. The psychological literature suggests that growing familiarity with new technologies and response options will lead to growing acceptance of these policies. Moreover, as people increasingly see a solution to climate change as possible, they may become more likely to accept it as a problem in the first place.

There is a widening gap between how climate scientists versus the general public perceive the likelihood and severity of future climate change and its impacts, and the extent to which they view climate change as a societal problem. A large literature, reviewed in other articles, has documented how those perceptions have changed over time in response to both legitimate and irrelevant events and information, and has proposed improved methods for communicating climate risks in a manner as to reverse the trend. What we suggest here is that the gap may begin to erode not as a result of more (or better) communication of climate science and associated climate impact uncertainties, but rather as a result of growing experience with climate policies themselves. For people to support these policies in the first place, it is not sufficient and may not even be necessary for them to perceive climate change as a problem.

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