

Dangerous Climate Change: The Role for Risk Research

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The notion of “dangerous climate change” constitutes an important development of the 1992 United Nations Framework Convention on Climate Change. It persists, however, as an ambiguous expression, sustained by multiple definitions of danger. It also implicitly contains the question of how to respond to the complex and multi-disciplinary risk issues that climate change poses. The invaluable role of the climate science community, which relies on risk assessments to characterize system uncertainties and to identify limits beyond which changes may become dangerous, is acknowledged. But this alone will not suffice to develop long-term policy. Decisions need to include other considerations, such as value judgments about potential risks, and societal and individual perceptions of “danger,” which are often contested. This article explores links and cross-overs between the climate science and risk communication and perception approaches to defining danger. Drawing upon nine articles in this Special Issue of *Risk Analysis*, we examine a set of themes: limits of current scientific understanding; differentiated public perceptions of danger from climate change; social and cultural processes amplifying and attenuating perceptions of, and responses to, climate change; risk communication design; and new approaches to climate change decision making. The article reflects upon some of the difficulties inherent in responding to the issue in a coherent, interdisciplinary fashion, concluding nevertheless that action should be taken, while acknowledging the context-specificity of “danger.” The need for new policy tools is emphasised, while research on nested solutions should be aimed at overcoming the disjunctures apparent in interpretations of climate change risks.

KEY WORDS: Dangerous climate change; decision tools; perception; rapid climate change; risk assessment; social amplification; thresholds

1. INTRODUCTION

Danger: the possibility of suffering harm or injury. Dangerous: likely to have adverse consequences (Oxford English Dictionary, 2003)

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The question of what might constitute “dangerous climate change,” and how as a global society we should be responding to the complex and multi-faceted challenges that our current understanding of climate science raises, touches upon the entire spectrum of interests and methodological approaches represented within the risk research community. Increasingly, climate scientists are adopting the tools and techniques of risk analysis in their efforts to characterize future climate uncertainties, their impacts and outcomes as well as to identify both the limits and thresholds beyond which changes in climate systems might be deemed unacceptable (see Dessai *et al.*, 2004). There is also a range of fundamental risk perception and risk communication issues associated with the ways in which citizens might respond to

current discourses about the dangers posed by climate change.⁴ And the evaluation of different mitigation and adaptation options under climate uncertainty requires both appropriate policy instruments coupled with wide ranging economic analysis.

The issue of climate change is also, as with so many of the key environmental risk issues of the 20th and 21st centuries, a genuinely interdisciplinary one, cross-cutting the natural and social sciences. For example, the communication of risks associated with climate change, or their formal economic and policy evaluation, cannot easily proceed without a strong grounding in the basic climate science of the matter. Equally, and as we know from decades of risk research, formal risk assessments or analytic models cannot on their own determine what society or individuals will ultimately come to regard as “dangerous.” To do this we need to determine what values society will bring to bear in making a judgment of unacceptable or intolerable climate risk as part of the wider question of society deciding what to do (Fischhoff *et al.*, 1981; Pidgeon, 1998). It is no surprise, then, to find the *Third Assessment Report* of the Intergovernmental Panel on Climate Change emphasizing that, while the sciences should be the source of information and evidence on anthropogenic climate change and impacts, the danger that these may represent will be judged by sociopolitical processes, in turn influenced by development, equity, and sustainability considerations, as well as aspects of uncertainty and risk (Watson & Core Writing Team, 2001).

All of the above considerations have to operate within the understanding that “danger” is a contested term, continuously shaped by the uncertainties in climate science and by debates about the management and acceptability of risk. In such debates, it becomes imperative to ask: What climate risks are “acceptable” to whom? What changes to life supporting systems are possible, or even perceived as necessary? And how much change are individuals/societies prepared to tol-

erate? All of this means that the climate science and policy communities, in attempting to approach the topic of dangerous climate change, might derive benefit from some of the wider insights to be found within the field of risk research. Accordingly, this Special Issue of *Risk Analysis* represents an attempt to make useful connections between both of these two communities of research and policy discourse, at the same time attempting to show how some of these key conceptual questions might be approached through such a synthesis. The perspectives through which some of the proposed answers are drafted have varied implications for institutional and behavioral responses to climate change.

2. EXISTING APPROACHES TO OPERATIONALISING DANGEROUS CLIMATE CHANGE

The term danger is related to climate change in contemporary international climate policy in the 1992 UN Framework Convention on Climate Change (UNFCCC, 1992). Article 2 of that framework sets out the objective “to achieve . . . stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.” Of course, the terms “dangerous anthropogenic interference with the climate system” (as per Article 2) and “dangerous climate change” are not strict equivalents: the former relating to human-induced changes to the climate system, the latter to the wider global impacts resulting from such changes. However, in the resulting technical literature the terms are typically indeed used interchangeably (e.g., Dessai *et al.*, 2004; Mastrandrea & Schneider, 2004), and this is the convention that we adopt throughout this article.

Alongside changes in levels of greenhouse gases, and the wider impacts of those changes, the Article 2 definition of dangerous climate change also highlights the importance of the rate (and by extension the timing) of any change in climate parameters. For example, in a recent analysis O'Neill and Oppenheimer (2002) infer an upper limit for greenhouse gas concentrations and the timescales during which these can be achieved to prevent substantial

⁴ In line with scientific terminology, this editorial refers to “climate change” rather than “global warming,” which is more commonly used in the gray literature and public debates in both the United States and the United Kingdom. While the two terms denote changes resulting from increased greenhouse gas concentrations, strictly speaking they encapsulate conceptual differences. “Global warming” refers to a gradual overall warming of the Earth’s atmosphere, while “climate change” indicates alterations to the climatic system as a whole, i.e., local/regional changes in temperatures (cooling as well as warming), in rainfall, in wind patterns, etc.

change to coral reef systems, to the West Antarctic Ice Sheet (WAIS), or to the Thermohaline Circulation (THC).⁵ They estimate that a stabilization of atmospheric CO₂ concentrations at 450 parts per million (ppm) by 2100 would lead to a range of warming of the order 1.2–2.3°C, which would probably, but not certainly, prevent the THC from closing down and possibly avoid the collapse of the WAIS, but would incur damage to at least one vulnerable ecosystem (e.g., coral reefs). Timing is therefore crucial: the authors estimate that meeting the Kyoto targets 10 years later (in 2020 rather than 2010) could preclude stabilizing concentrations at 450 ppm by the end of this century.

Another important component of Article 2, and one closely related to the issue of timing, is the function of adaptive capacity. Human systems, and to a certain extent natural systems too, are not passive recipients of climatic changes. In addition to contributing to these changes through GHG emissions, they can also modify their responses to reduce negative impacts or maximize positive impacts deriving from these changes. As Mastrandrea and Schneider (2001, p. 444) point out: “The capacity to adapt is enhanced by foresight of upcoming changes and reduced when changes are abrupt, large and/or relatively unforeseen. Thus, abrupt changes are likely to be more dangerous than changes that are more slowly evolving and better foreseen . . . The ability to adapt is itself a measure of whether any particular climate stimulus is ‘dangerous’.” Similarly, if the onset of a relatively gradual change in the climate were nevertheless faster than adaptation could occur, this event would likely be more “dangerous” than if adequate responses were possible. Thus, a dangerous climatic outcome could also be considered a function of the interrelatedness and dependency of timing and adaptive capacity, a system characteristic labeled by Perrow (1984) as “tight coupling” in his theory of how catastrophic system failures and disasters can come about.

Patwardhan *et al.* (2003, p. 4) argue that a more in-depth understanding is required of what limits (i.e., levels and/or rates) of climate parameters are associated with critical impacts on key areas for human

well-being, taking the WEHAB⁶ components as basic reference points. These can be conceptualized, according to the authors, by using the notion of critical thresholds, of which the authors define two types.

1. *Thresholds of type I:* These entail smooth changes that could at some point result in damages that could be considered “unacceptable” by policymakers. The authors envisage that the threshold would be defined through a sociopolitical process involving consideration of relative risks and benefits to particular sectors/regions. It is clearly thresholds of this type that should be the subject of societal decision making and debate to define what constitutes dangerous climate change and impacts thereof.
2. *Thresholds of type II:* Natural bounds that, if exceeded, would lead to major potentially irreversible biogeophysical impacts. Patwardhan and co-authors argue that irreversibility coupled with sufficient scale would be “unacceptable” to virtually all policymakers and would thus qualify as dangerous change.

Some governments and organizations have indeed made policy judgments on what constitutes danger in relation to climate change thresholds, and based upon the currently available science. For instance, the German Advisory Council on Global Change (WBGU, 2003) examined the threshold beyond which the effect on the three criteria specified in Article 2 would no longer be tolerable, estimating that “the threshold from which damage to the global natural heritage is no longer acceptable . . . [is] in the range of 2°C global warming relative to pre-industrial values” (WBGU, 2003, p. 1). Similarly, the European Union Environment Council Decision of 1996 proposed that temperature increases should not be allowed to exceed 2°C and that CO₂ concentrations should be kept below 550 parts per million volume (ppmv) (EC, 1996).

There remain, however, considerable uncertainties in defining particular thresholds, exemplifying the difficulties in translating the notion of danger directly into policy-useful guidance. Accordingly, others have argued that in cases such as climate change, characterized as they are by scientific complexity,

⁵ Various model runs suggest that the Thermohaline Circulation may in theory further weaken or collapse under future climate change, resulting in substantial temperature *decreases* over the whole of Europe. Similarly, further temperature increases may result in the melting of the West Antarctic Ice Sheet, potentially raising sea levels significantly around the globe.

⁶ The WEHAB (Water, Energy, Health, Agriculture and Biodiversity) framework was introduced at the World Summit on Sustainable Development held in Johannesburg in 2002 and identifies key areas for human well-being and development.

pervasive uncertainty, value conflicts, and high decision stakes, traditional forms of science policy making alone cannot find and deploy solutions to such issues (Funtowicz & Ravetz, 1993).

3. CURRENT UNDERSTANDINGS OF PUBLIC OPINION AND PERCEPTIONS OF CLIMATE CHANGE

The risk community and other scholars have used a variety of methods to discern public opinion toward, and perceptions of, climate change. Public opinion matters not just for normative reasons, but also because of its role in the policy process. The adoption of new programs does not require that the public enthusiastically support them, but those programs calling for significant sacrifices by the general public and particular powerful interest groups are unlikely to be enacted if there is hostility from these actors (Sabatier & Jenkins-Smith, 1993). Public opinion also matters in the case of climate change because success in addressing the challenge of dangerous climate change will require voluntary actions by individuals and organizations as well as wise national and international policies. At the risk of oversimplification, we contend that the research has generated three generalizations about public opinion regarding climate change.

First, many people misunderstand aspects of the science underlying climate change and in particular are confused on the precise nature, causes, and consequences of climate change. This conclusion emerged from both ethnographic studies (see, e.g., Kempton, 1991, 1997; Henry, 2000) and research using mental modeling and a local survey by a prestigious team at Carnegie Mellon University (Bostrom *et al.*, 1994; Read *et al.*, 1994). Evidence also suggests that individuals tended to confuse the greenhouse effect with stratospheric ozone depletion, failed to differentiate between causes of climate change and other environmental pollutants (e.g., insecticides, aerosol sprays), or, conversely, to recognize that the burning of fossil fuels is linked to CO₂ emissions (Thompson & Rayner, 1998; DEFRA, 2002). Although the casual sampling and local nature of these studies called into question the generalizability of their findings, even initially nobody doubted that, at least in the United States and in the United Kingdom in the 1990s, large segments of the public were poorly informed. Subsequent studies undertaken in other nations worldwide, including surveys by Bord *et al.* (1998), Brechin (2003), and work by Böhm and Pfister (2001), replicated many of these findings.

More recently, a number of UK public opinion polls and qualitative research studies indicate that most people are somewhat ambivalent about climate change. Although a majority express high awareness and concern about the issue as an environmental problem, associating it with urgency and negativity, these evaluations are influenced by fluctuations in the social context (Kirby, 2004; Norton & Leaman, 2004) and personal circumstances, as the importance of climate change is often secondary to more pressing issues in people's lives such as health, family, safety, personal comforts, and finances (DEFRA, 2002; Poortinga & Pidgeon, 2003; Bickerstaff *et al.*, 2004). Effectively, for most people in developed nations, climate change is distant in space and time (i.e., perceived as affecting other more vulnerable parts of the world or societies in the future—a finding also common to the United States; see, e.g., Lorenzoni *et al.*, forthcoming). Thus, while most people recognize the potential risks associated with climate change, they also underline the benefits of current lifestyles. For many, “danger” is associated with more immediate (but also potential) loss of present comforts as a result of mitigation measures, and with disruption to ways of life in the longer term, resulting from the unmitigated impacts of climate change.

A second longstanding observation is that most people are not opposed to government efforts to reduce greenhouse gas emissions, so long as the policies are fair and effective. Even if they are not felt to be so, most individuals will tolerate those of minimal inconvenience to them. National surveys followed up on the ethnographic and mental modeling studies to examine support for climate change policies (see, e.g., O'Connor *et al.*, 1999a, 1999b). This work reported that the mass “public” could be separated into three groups: a minority who supported strong immediate efforts to reduce greenhouse gas emissions; an even smaller minority who judged almost any actions to be premature; and a majority who expressed a willingness to make reasonable sacrifices to begin to address the problem. This research also found that recognizing the causes of climate change was a powerful predictor of behavioral intentions both in terms of voluntary actions and support for government policies. Studies in the United Kingdom have also shown that individuals generally accept that the threat of climate change should be addressed collectively, although they question their personal agency in resolving the problem, thus transferring at least part of the onus for the solution onto others, especially governments and powerful institutions (Bickerstaff *et al.*, 2004; Nicholson-Cole, 2004).

Third, at least in the United States, public opinion on climate change has taken on a partisan aura, as Democrats are disproportionately likely to favor actions and Republicans are somewhat less inclined to support proposed government policies. This difference is not simply a reflection of differing general philosophies toward the role of government. Partisan differences were negligible before the fall of 1997 when the Clinton administration launched a campaign to build public support for the Kyoto Treaty. After the barrage of media coverage in the fall of 1997, partisan differences increased significantly (Krosnick *et al.*, 2000). At a global level differences also exist (e.g., between the United States, the United Kingdom, and other nations). At the time of writing this editorial, the 2005 G8 Summit had just concluded, with relatively little movement to bridge this gap.

4. ORIGINS OF THIS SPECIAL ISSUE

This Special Issue of *Risk Analysis* stems from invited paper presentations to an international workshop on “Perspectives on Dangerous Climate Change” held at the University of East Anglia (Norwich, UK) on 28 and 29 June 2004, jointly sponsored by the UK’s Tyndall Centre for Climate Change Research and the Leverhulme Trust supported program on *Understanding Risk*. The two days brought together climate scientists, risk perception and communication specialists, economists, and representatives of the insurance industry and decisionmakers to discuss (1) interpretations of and perspectives on danger in relation to climate change from their own area of expertise, (2) similarities and differences among these, and (3) implications for policy making.

The workshop event sought to explore the few existing links and cross-overs between the climate and risk communication and perception communities, and to forge a deeper understanding of what constitutes “dangerous” climate change from the climate science and risk communication and perception research perspectives, respectively. Whereas the former community has focused on definitions of “dangerous” climate change by experts, which tend to be “externally” described through formal risk assessment procedures, little attention has been dedicated within the policy process to how “nonexperts” view climate change, which lies more within the sphere of risk research. One of the rationales underlying this meeting therefore was that climate change responses cannot be adequately organized and managed if discrepancies exist between formal working definitions of danger by climate communities and nonexperts’ informal

perceptions and definitions of what they understand by dangerous climate change. Both have a role in shaping policy (see also Dessai *et al.*, 2004).

Prompted by a scoping paper prepared by two of the editors (Lorenzoni & Pidgeon, 2004), the articles presented at the workshop covered a range of themes, including the role and ability of science in defining “danger” given the uncertainties and complexities inherent in climate, natural, and social systems; the cultural and social representations of climate change and their influence on climate change communications; public and expert perceptions of climate change; the psychological drivers of behavior in relation to climate change; social amplification and attenuation of climate risk perceptions; the impacts of climate change on human health; and the role of value judgments and equity considerations in policy making.

As a result of the workshop, authors were invited to develop revised versions of their articles for potential inclusion in this Special Issue of *Risk Analysis*. The objective of the issue is to explore understandings and complex interpretations of “danger” and risk in the context of climate change, with a view to promoting a wider debate on policy and research options for addressing this issue in effective, fair, and equitable ways. A total of nine articles were accepted, all being subject to the normal peer-review process for the journal. The selection is supplemented by one additional article not presented at the conference.

By design, the Special Issue was to include a variety of interdisciplinary perspectives on danger, some of which are based on methodological approaches not usually represented in *Risk Analysis*. As editors we believe that this has resulted in a Special Issue that, taken as a whole, is both conceptually and methodologically innovative, and one likely to stimulate significant research and policy debate.

5. THE INDIVIDUAL ARTICLES

In very broad terms, the nine articles each represent different stages in the climate change risk characterization and communication cycle, with contributions from Europe, North America, and Australia.⁷

The first three articles address some of the contrasting issues involved when attempting to define danger from the perspective of expert analysis. The

⁷ As conference organizers we actively attempted to solicit perspectives and research contributions on this issue from other than European and North-America-based authors, but without significant success.

first of these, by Michael Oppenheimer, sets the scene by providing an overview of the capacity, and limits, of the natural sciences in defining danger. One particular perspective, conceptualizing danger as the impacts derived from an extreme event with irreversible consequences, is described. In the second article, Sari Kovats, Diarmid Campbell-Lendrum, and Franziska Matthies discuss the limited use of current risk assessments of potential impacts from climate change on health. Finally, Nigel Arnell, Emma Tompkins, and Neil Adger describe an expert uncertainty elicitation study for rapid onset climate-related events.

Then follow two articles, from the United States and Europe, respectively, which explore the complexity and variety of public perceptions of danger in relation to climate change. Anthony Leiserowitz reports a study of perceptions of climate changes and their affective evaluation among the American publics. Simon Niemeyer, Judith Petts, and Kersty Hobson explore UK citizens' perceptions of, and potential responses to, projected rapid changes in the climate using the technique of Q-analysis. These two articles address the degree to which some of the early research findings on perceptions of climate change (e.g., regarding public knowledge and support for climate change actions and policies) still hold.

The subsequent three articles deal with the socially defined process of interpretation and translation of climate change information and knowledge, with a particular focus on the role of the media in the social amplification of risk, something which has been acknowledged in the United States (see Krosnick *et al.*, 2000). In an analysis of UK broadsheet reporting of climate change over the period 1985 to 2003, Anabela Carvalho and Jacquelin Burgess discuss the interactive and evolutionary nature of this process, strongly bound as it is by external cultural and political factors. Joe Smith illustrates some of the constraints under which environmental and other journalists have to operate in his analysis of how the BBC, one of the best-known world broadcasting services, approaches the issue of climate change. And Marc Poumadère, Claire Mays, Sophie Le Mer, and Russell Blong analyze how the 2003 European heat wave became constructed as a national disaster in France.

In the final article of the Special Issue, Rachael Dempsey and Ann Fisher provide a methodological account of the Consortium for Atlantic Regional Assessment (CARA) project. This seeks to provide a platform for presenting integrated scientific findings about climate change and land-use patterns on the East Coast of the United States, and for communi-

cating this information to decisionmakers and other stakeholders. They point out that a comprehensive approach to climate change risk should accommodate the complex impacts upon ecosystems, equally alongside those on humans and the built environment.

6. SALIENT THEMES

Taken as a whole, the articles describe the scientific, psychological, social, and cultural processes through which climate change is defined and characterized, also drawing implications for decision making. Within this subject matter, the articles explore several interrelated themes.

The first theme relates to *the limits of current scientific understanding*. Oppenheimer acknowledges that the natural sciences approach to modeling climate uncertainty holds a range of limitations, while still being useful for policy, especially if this is defined by a precautionary approach (see also new approaches to decision making, below). In addition, by focusing on identifying global and potentially irreversible threats that could cause major disruptions to ecological and human systems overall, science continues to pursue its attempt to reduce the uncertainty in knowledge and therefore in future projections (e.g., models that suggest the WAIS could collapse, and therefore be a dangerous outcome, but with current high uncertainty). Similarly, Kovats and colleagues point out the impossibility of identifying clear thresholds of health effects from climate change via current scientific methods (i.e., health risk assessments). Difficulties of adequately dealing with these are compounded by the inability of current socio-economic systems to respond to climatic variability. Thus, they argue, it is futile to contemplate "safe limits" for health impacts from climate change. This then raises the question of whether "tolerable" levels should even be considered and what the contribution of science may be in defining these, given the uncertainty inherent in its assessments.

Uncertainties in modeling the climate system also mean that estimating the likelihood of occurrence of such events is fraught with difficulty; expert judgments on the onset of rapid climate change vary significantly and have wide ranges of implied values, as Arnell and colleagues discuss. Interestingly, they also report a marked reluctance of their respondents (all holding a climate science or policy background) to put faith in simple "subjective" judgment for estimating such uncertainties. There is obviously a considerable way to go before decision-analytic and Bayesian-based

methods for uncertainty estimation are fully accepted within the climate community. By complete contrast, not all climate impacts are uncertain. Some are only too well understood, as illustrated by the article of Poumadère *et al.* The authors observe that the dangers to vulnerable people (the old and/or poor) attendant upon heat waves are well known, based upon long-standing experience from countries such as Australia and the United States. Their article also raises the question of how societies are capable of learning and transferring appropriate lessons from the past that might be relevant to dealing with future dangerous climate fluctuations.

The second major theme concerns *the differentiated nature of public discourses and perceptions of the danger from climate change*. Leiserowitz reports that, among the U.S. public, individuals perceive climate change as a moderate risk, affecting other populations or places removed in space and time, a pattern similar to that found in other studies (for a review, see Lorenzoni & Pidgeon, in press). Furthermore, very few Americans linked climate change to direct health impacts, indicating a clear gap between lay models and expert assessments such as those discussed in the article by Kovats *et al.* However, a more in-depth analysis allows Leiserowitz to further distinguish views into “interpretive communities”: that is, groups of individuals who share mutually compatible risk perceptions, affective imagery, cultural worldviews, and sociodemographic characteristics. In particular, he finds three such groupings: (1) individuals who think of climate change as a low or non-existent risk, (2) individuals who perceive climate change as a real and high threat, and (3) people who conflate global climate change with stratospheric ozone depletion. Niemeyer *et al.* take a different methodological approach to denote individuals according to their views of rapid climate change in their Q-analysis study. While this methodology dates back to the 1960s, it has been applied relatively rarely within the risk perceptions domain, and is specifically designed to differentiate between the subjective positions people endorse. Niemeyer and colleagues suggest that there may be thresholds of rapid climate change (e.g., with respect to extreme heating and cooling) that instigate different individual responses, related to how other societal actors are perceived. Taken together these two articles suggest that public perceptions of, and responses to, climate change risk are not a unitary whole, with considerable differences both between individuals and across aspects of the issue. This diversity in lay perceptions may even be greater than that present

among the scientific community itself (as underlined also in the final article by Dempsey and Fisher).

The third theme concerns *the social and cultural processes that shape amplification and attenuation of climate risk perceptions and responses*. Various case studies have shown that events related to hazards dynamically interact with psychological, social, cultural, and institutional factors, resulting in amplification or attenuation of individual and social representations of risk and danger (see Kasperson *et al.*, 1988; Pidgeon *et al.*, 2003). Until very recently climate change has, in lay perceptions, been an attenuated or “hidden hazard” (Kasperson & Kasperson, 1991). In the Kaspersons’ words, climate change became attenuated because it was both a *value-threatening* and an *ideological hazard*. However, hidden hazards may not remain so forever, and a key element of social attenuation and amplification processes is their dynamic nature, coupled with the way in which different institutions, such as the mass media, constantly seek to transform both scientific information and policy debates about risks. Carvalho and Burgess’s analysis of three UK broadsheets over 18 years illustrates how communication about climate change is a multi-directional process delineated and shaped by the social learning of the producers and receivers of the information. The authors identify two main influences on the newspapers’ discourses: the ideological stance of the reporting media themselves, and the political positions encapsulated by top government officials’ pronouncements on this topic. In contrast, Smith’s investigation into the internal operations of BBC reporting on climate change underlines the struggles among various perspectives and interests that hamper a consistent and meaningful understanding, let alone portrayal, of such a complex issue. In particular, a tension exists between the prescribed practices and norms inherent in professional news journalism and the characteristics of trans-disciplinary issues such as climate change, which some (e.g., Gee, 2000; Harrabin, 2000) have argued require long-term, consistent, and cross-cutting coverage rather than reporting in the blazing and eye-catching form of a news story. While media reporting, then, is often forced into a common register to represent different risks, Smith’s article highlights the need for the media to recognize the messy edges around climate science, issues of scale, and the importance of making adequate comparisons that reflect the dominant scientific perspective on the issue rather than merely presenting competing arguments in the search for a “balanced” presentation.

Marc Poumadère and colleagues directly apply the social amplification of risk framework as a way of conceptualizing how changes in the construction of the dangers of a heat wave occurred within French society during the summer of 2003. The initial difficulty of recognizing the severity of the situation, in addition to active denial, effectively swept the problem under the carpet until it was too late. There were indeed a few cases of rapid and effective adaptation to the new circumstances. In general, however, reactive one-off coping responses were enacted, such as allowing nuclear power stations to discharge their cooling water into rivers at a higher temperature than normally permitted. Eventually, it was officially recognized that the threat had translated from a remote possibility to “here and now.” This article also makes the point that small incremental changes in the parameters that represent “the norm” may quickly become dangerous, resulting in social discontinuity if local adaptive capacity is not structurally or culturally available—even in some relatively wealthy societies.

Consideration of social amplification leads on to the fourth underlying theme: the need for *systematically designed risk communication* about dangerous climate change. As noted above, despite a range of surface similarities among lay perceptions of climate change risk in both the United States and Europe, there also exists considerable diversity in such beliefs. While this observation, as a comment about perceptions of environmental or technological hazards in general, is not a new one (see Pidgeon *et al.*, 1992) it does hold important implications for risk communication, suggesting the need for carefully targeted rather than universal messages. Smith's article also engages with this theme as it digs into the tension of translating and communicating danger in relation to climate change. News and reporting focus on shocking images and personal distress, playing to individuals' interest in personal experience and familiarity. The media also tend to present the issue through stories that make an event immediately apparent and perhaps more directly relevant to people's lives in ways that have the drama and passion of personal events. This clearly differs from the type of communication some scientists would prefer and also raises the question of how the dangers of gradual changes from the norm may be represented in popular discourse—here there is clearly a potential for rupture in the fidelity of translation. Dempsey and Fisher pick up on this point in their CARA methodology, which aims to make threats of climate change and potential dangers more relevant to stakeholders in order to

promote a shared knowledge base and encourage engagement about the issues involved. The authors acknowledge both the importance of scientifically validated information being made available in a usable form for stakeholders, and the transparency and inclusivity of any stakeholder-based decision-making process. As a more general comment on communication, it may well be the case that a crisis narrative of climate danger may neither foster engagement nor encourage proactive responses. Rather, it may result in fatalism and withdrawal. One line of action is to situate global climate change in local realities (e.g. Kates & Wilbanks, 2003). Indeed, the article by Dempsey and Fisher explores the perceived misfit between global problems and local realities, proposing new tools that can address this gap and allow information to be better communicated in a relevant form, and for the trade-offs in decision making to be more transparent.

A fifth theme is *the need for new approaches to climate decision making*. Over the years the issue of environmental protection has been viewed as a key test case for the operationalization of precautionary approaches to decision making (O'Riordan & Jaeger, 1996), and not surprisingly precaution figures prominently in the UN Framework Convention on Climate Change (UNFCCC, 1992). While there have been a range of conceptual critiques leveled at the principle over the years, some unfairly (see, e.g., Sandin *et al.*, 2002), the articles in this issue do point to the possible need for a new synthesis. Oppenheimer opens up his article with the question of whether the precautionary principle is indeed being operationalized in climate policy, as uncertainty currently is being both reduced and better characterized. These advances suggest a more circumscribed role for precautionary approaches, giving way, as climate science progresses further, to risk assessments under uncertainty. Of course, science may narrow—but can never eliminate—uncertainty, so decisions to act will be required regardless. Accordingly, both Oppenheimer's and Smith's articles make reference to “postnormal science” (Funtowicz & Ravetz, 1993; Rosa, 1998), as an acknowledgement of the very complex nature of the climate change problem, requiring coherent, cohesive, and concerted action based on the guidance of scientific knowledge and shaped by a multitude of societal perspectives elicited through various methods and techniques already tried and tested by researchers of different disciplinary backgrounds. This approach broadens the knowledge base in the climate risk policy process by moving away from traditional notions of risk characterization and one-way communication,

toward embracing the understanding that there are multiple stakeholders and publics, with different response patterns and views. Such diversity may need to be taken into account if policy making on such a complex issue is to address the roots of the problem successfully, as advocated in the article by Dempsey and Fisher. This approach also closely reflects the more dynamic definition of danger that Dessai *et al.* (2004) call for, possibly based upon elicitation and mediation of values with a view to integrating technical analysis by experts and values- or perceptions-based perspectives on dangerous climate change. One can nevertheless question the postnormal model as a practical approach. Oppenheimer argues that in fact the wording of Article 2, designed to address the varied views and stakeholder perspectives as advocated by postnormal science, might have encouraged the definition and management of climate change risks through “scientific search for thresholds.” Viewed through this lens, the difficulties in operationalizing a postnormal approach become more evident. Smith also draws our attention to the limits of some communication media in brokering scientific output to the stakeholders who should have, according to the postnormal model, an active involvement in addressing the issue.

These considerations lead us to one final overarching theme: *interpretations of danger are context-specific*. All the articles in this Special Issue have shown that there are multiple (sometimes competing) interpretations of danger, and that these invariably become meaningful only in relation to their context of use. At a broad conceptual level, the word “danger” encapsulates a rich tension between what humanity as a whole should avoid and what is perceived as unacceptable by different socioeconomic groups and societies: for some, climate change is a removed risk, for others the manifestations of climate change are already immediate threats. Disciplines also, due to the varied nature of their foci, encapsulate different perspectives. Such diversity adds richness, and complexity to decision making. However, such considerations lead to practical questions on how to successfully manage climate change. For instance, how can scientific concerns be adequately addressed given this diversity in opinion? Are we any nearer to addressing climate change in fair, equitable, and sustainable ways?

7. CONCLUDING COMMENTS AND RESEARCH OPPORTUNITIES

The articles in this Special Issue also provide some preliminary answers in the form of suggested

directions for possible future research. Among the prospects that may be more closely discipline-bound, several of the articles identify the need for longitudinal national and cross-national studies of media responses to climate change issues to enable a comparative analysis of changes in reporting as scientific and public understanding evolves over time. As the Smith, Carvalho and Burgess, and up to a certain extent Poumadère *et al.* articles suggest, the media fulfils a fundamental role as a means of communication as well as an actor in the communication process. Subject to external and internal factors that constrain in-depth and cross-cutting reporting, the media’s adaptation to change in the climate change discourse and its facilitation of that process deserve long-term attention and study. Additional research would also be warranted on the notion of “interpretive communities,” to refer to the term used by Leiserowitz. Segmentation of a nation’s population based on their beliefs on climate change related to their social and demographic characteristics, as well as the worldviews and value positions they hold to, is likely to be of great interest to communicators as well as to educators and forecasters. Issues to be further studied could include the “permanence” of such communities over time, their susceptibility to external (e.g., media coverage as mentioned earlier) and internal (e.g., personal circumstances) influences, and their cross-cultural validity. Staying within the sociopsychological realm, studies could also be undertaken on the influence of affect on individual beliefs and imagery, and the implications of this for future climate change risk communication and behavioral change. We tend to assume that the most important component of media communication is its discursive context (both verbal and textual), yet images are likely to play a central role in the way affect-laden beliefs about environmental risks are formed (see, e.g., Boholm, 1998).

As described above, initial research on public opinion and perceptions of climate change stressed the importance of lay *mis*understandings of climate science. A key future research requirement would seem to be the extent to which the gathering global policy debate, and with this the possibility of rising public awareness, is influencing the qualitative structure of such beliefs among the general population, and in different countries of the world. While for many of the issues traditionally studied by risk perception researchers (e.g., nuclear power, chemicals) one would forecast little radical modification of public representations in the near term, climate change stands out

as entirely different in this regard. Radical disjunctions from the understandings gained from the past are a very real possibility. Such research on public beliefs might also make fruitful connections with the wider debates within science and technology studies (e.g., Irwin & Wynne, 1996), which suggest that the “deficit” models of the lay public are in need of revision. One part of the critique of such models is that by stressing misunderstandings of science, they often unintentionally imply that providing accurate information about risk, or the underlying science of the matter, will resolve every policy controversy or behavioral issue. As risk communication literature also points out (e.g., Fischhoff, 1995; Morgan *et al.*, 2002), things in practice are rarely that simple. While it would be entirely wrong to overlook the misunderstandings that really will matter for people and society in responding to climate change risks, equally, public attitudes may be driven by wider factors such as concern that the issue is still highly uncertain, trust in decisionmakers, or skepticism about the wider ideological representations that the many various actors are bringing to the climate change debate. Under such circumstances, policy or risk communication responses that stress solely education, to the neglect of these other issues, are unlikely to be fully successful. It is clear also that various disciplines may also want to address a critical gap in our current knowledge of perceptions of climate change; specifically, with respect to peoples in developing nations, some of whom are likely to be the very first to suffer serious impacts of dangerous climate change.

In broader terms, most of the articles in this Special Issue touch upon, to varying degrees, the vast debate on the theoretical and methodological underpinnings of a successful transition toward sustainable societies, where the dangers of climate change (however defined) are circumscribed. Several of the articles highlight the tensions in managing such a transition, including issues related to the endorsement of responsibility for action and for enactment of that action. Clearly, such considerations raise questions regarding the most effective drivers of change (e.g., the motivation for governmental action under uncertainty vs. lay perceptions of such action) and how these, if identified, could be implemented. In other words, these reflections lead us to the intensely debated merits of representative democracy vs. more participatory approaches, in terms of social learning and implementation of responses to risk issues (see various contributions to Okrent & Pidgeon, 1998). Greater attention could thus be dedicated to the investigation of new policy tools that could foster change and “measure”

whether such a transition is conceptually and practically occurring. Various means of decision support are being developed to deal with value judgments (e.g., Pidgeon & Gregory, 2004). For instance, hybrid approaches to decision making (see DeKay *et al.*, 2002) may be useful in operationalizing risk assessments and decision analyses in contexts of uncertainty and where precaution may be advocated. Similarly, Ralph Keeney and Tim McDaniels (2001) have proposed a framework that stresses learning over time to address climate change policy options.

Research into how well actual climate change research is responding to the needs identified for learning over time would be both timely and significant. Again, this type of work would seem most usefully organized through comparative studies across nations, taking account also of the potential contribution here of economic or insurance-based analyses. Another more specific focus, which may perhaps fall within the sphere of risk research as a whole, would be on the infrequently analyzed linkages among studies of the media, public opinion, national advocacy coalitions, national policies, and the international climate change regime in policy processes (a notable exception is Fisher, 2004). Not only does mitigation deserve attention; adaptation is another major research issue. Although climate change is a global problem, the effects from both climate change itself and from mitigation and adaptation decisions are local as well as international. Increasingly, local communities are demanding a role in determining how the policies of any international climate change regime are to be implemented in local places (see Jasanoff & Long Martello, 2004). The risk community has much to contribute toward understanding how successful adaptive management might be brought about.

Despite the breadth of the articles in this Special Issue, they appear to be suggesting a two-pronged approach:

1. Pursue nested solutions to this global problem with additional research to reduce uncertainties and assess risks where possible, informed also by some form of precautionary approach (see, e.g., Wiener & Rogers, 2002).
2. Take action, recognizing the diversity of local impacts and cultures, which in themselves shape perceptions of, and responses to, climate change.

Taken as a whole, the articles underline the importance of, at the very least, acknowledging the existence and nature of these varied perspectives on dangerous climate change.

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