an "evangelical science" (see footnote 1). In fact, there is a cultural and political history of climate science that originates in the science wars of the eighties, in the cultural wars mainly in the US and with the rise of the Tea Party and finally in the symbolic equation made by Jerry Ravetz, who compared the "war on carbon" to the "war on terror" (in Krauß, Schäfer & von Storch 2012). There are deep implications in this drastic analogy: the war on carbon might be as wrong as the war on terror was, rendering climate politics fruitless and ineffective.

« 6 » After the failure of the COP15 climate summit in Copenhagen, "the dangerous relationship between climate research and politics" (von Storch & Krauß 2013) became an even more widely addressed topic in the social and political sciences. Second-order science perspectives at least occasionally entered climate discourse; there were reflexive, critical and constructivist analyses of the IPCC reports (Beck 2012), of its documented errors (van der Sluijs 2012) and of the hacked emails from climategate (Grundmann 2012; Ryghaug & Skjølsvold 2010). These contributions from science and technology studies and social sciences have already left a significant impact on the recently published new IPCC report.

« 7 » Bruno Latour (2004) also provides an interesting discussion of the prospects and consequences of analyzing the production of climate knowledge in terms of constructivism. Climate skeptics easily adopted the constructivist approach and the notion of uncertainty and turned it into an argument against climate politics. In his recent book, Latour (2013) reconsidered his position and stated that a statement such as "the sea-level is rising" is already political, as it changes the conditions for politics fundamentally. From this perspective, he adopted Carl Schmitt's metaphor of war for himself and argued for "climate wars" against those who deny climate change or consider it as a minor problem. He did not abandon constructivism, but he added politics, with diplomacy as its practice and war as its ultimate rationale.

« 8 » Finally, Aufenvenne, Egner and von Elverfeldt suggest that climate services provide a good example of a new approach to improving science-public communication. Again, I suggest that there is a history to be considered. Climate services are forms of governance that originate in top-down approaches and a linear understanding from science to politics; more often than not, they simply extend first-order knowledge into the practice of climate politics (Krauß & von Storch 2012). This often results in new forms of green colonialism, replacing indigenous knowledge systems with "Western" climate science and values (Mahony & Hulme 2012). As a result of this critique, the chapter on climate services in the new IPCC report includes a reflexive approach and argues for the dialogue between different kinds of knowledge, for knowledge exchange and the identification of pathways instead of top-down solutions.[2]

« 9 » Aufenvenne, Egner and von Elverfeldt link the problem of uncertainty in climate science with problems in science-public communication. In doing so, they convincingly suggest that second-order science is better suited to communicating climate research. Their approach is far from utopian, as current examples from science and technology studies as well as from social science and ethnographic studies demonstrate. They also tentatively make a first and important step towards laying bare the implicit authoritative approach and even evangelical mission inherent in the policies of climate research. The more radical implications of this approach are only randomly mentioned in the article; it would be great to see them fully developed in subsequent articles. Nonetheless, the article provides a useful epistemological first aid kit for climate research in crisis.

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The Social and Political Context of Science

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> Upshot • Second-order science primarily focuses on perception and cognition. However, social contexts, including political interpretations of science, are also included because they are part of the interpretations of the observer. To understand a scientific theory, it is helpful to understand neurophysiology, the history of the individual and the social and political context in which the scientist was operating.

« 1 » In their target article, Philipp Aufenvenne et al. hope that second-order science will ameliorate the stridency of the climate change debate. In my opinion, second-order science, by pointing out the limitations and biases of an observer, can help people to be more tolerant of and more patient with the views of others. However, the importance of the debate and the strong interests of actors involved in the discussion will sustain debating methods that go beyond a normal scientific conversation.

The debate over climate change

« 2 » Just as conceptions of scientific conversations have been changing, conceptions of public conversations have also changed. Consider the fields of advertising, propaganda and political campaigns. Advertising resulted from the combination of a market economy and mass media – newspapers and magazines, radio, television and now the internet. In advertising, the criterion for success is not truth or objectivity but rather whether customers buy the product. It was not long before the methods of advertising were applied not just to selling soap or cars but also to electing political candidates (McGinniss 1969).

« 3 » World War II and the Cold War led to numerous innovations in propaganda. (Brown 1975) Propaganda during wartime is different from advertising in that the reputation of the source (e.g., a company advertising a product or a candidate running for office)

		Message		
		white	gray	black
Source	white	Truthful message	Mixed message	False message
		Source is given	Source is given	Source is given
	gray	Truthful message	Mixed message	False message
		Unclear source	Unclear source	Unclear source
	black	Truthful message	Mixed message	False message
		False source	False source	False source

Table 1 • Types of propaganda.

need not be protected. Complete hostility is already assumed. Methods of propaganda can be classified as white, gray or black on two dimensions – the message and the source (see Table 1). The message can be truthful (as perceived by the source), a mixture of truth and falsehood, or a deliberate lie. The source can be truthfully given, obscured, or attributed to an incorrect source. Just as advertising has made the transition from selling products and services to political campaigns, so too have the methods of propaganda sometimes entered the political arena when some stakeholders feel very strongly about the consequences of the debate.

« 4 » Restrictions on the burning of fossil fuels threaten the profits of large industries, and not offering flood insurance for homes and businesses in some areas threatens property values. Furthermore, relocating cities and farms, even if done over a period of decades, is psychologically disruptive and can lead to denial. Hence, human caused climate change is not a normal scientific debate and we should not be surprised if methods of discussion go beyond what is common in the scientific community. Table 1 shows that the possibilities for styles of communication are larger than just the top left square.

« 5 » The opinions of scientists have been politically important for hundreds of years. Gallileo was placed under house arrest. Copernicus decided to publish his conclusions posthumously. Some geneticists in the Soviet Union who resisted the views of Stalin were murdered (Medvedev 1969). In the United States, scientists who disagree with the policies of the administration not infrequently become whistle-blowers. When scientists engage in policy relevant research, they are not only thinking about theory, methods and data. They are also estimating the consequences for their careers of reaching "politically incorrect" conclusions. Hence, second-order science can encompass issues that go beyond scientific uncertainty and humility about what scientists can know. When vital interests are involved, the issue for stakeholders becomes how to shape the information environment so that political decisions will favor the interests of particular groups – for example, coal producers, or those who live near power plants, or the general public.

« 6 » These remarks were stimulated by the example of climate change. If we turn our attention to the possibility of a second-order science, we are dealing primarily with academic traditions, egos and preferences.

The discussion of second-order science

« 7 » Second-order science assumes that science is an instrument in the regulation of social systems and that human beings are purposeful systems. Claiming that science operates outside of social systems or that the purposes of scientific observers will not affect their observations is not believable in cases where strong commercial or political interests are concerned. Second-order science suggests that we should recognize the personal and social context of observations and research, acknowledge these and, when appropriate, discuss them in research reports. We already do this to some degree. Including brief biographies is a step in this direction. Also, a common practice is to acknowledge the funding source for a study. Usually this is done to give credit to the funding organization rather than to indicate the bias or perspective underlying the research. But the latter purpose is served as well. Such disclosures may become more common (Morgan 1983). In the case of climate change, or the earlier debate over the safety of cigarettes, knowing who funded a study can be a better indicator of the conclusions of a report than knowing the theory, method or data used.

« 8 » Advocates for a realist philosophy often argue that any move away from objective science opens the door not just to emotions but to political or self-serving arguments, apparent or disguised. However, if scientists do not acknowledge political interpretations and uses of science, these interpretations will be discussed in a forum separate from science, usually by journalists or "watchdogs" such as the Union of Concerned Scientists. Second-order science suggests that the social and political context is relevant to the science itself, that interpretations and their policy implications are not separate from science (see Figure 1).

« 9 » One hears two arguments against second-order science. One claim is that second-order science would weaken the objectivity and authority of science and hence undermine the effort to create reliable knowledge. A second claim is that by pointing out the perspectives, including interests, of observers and institutions, one legitimizes a no-holds-barred contest over scientific results, at least as perceived by the public. A reply is that the interests of stakeholders need to be known and discussed. Second-order science would acknowledge and comment on the psychological, social and political context of scientific research, when needed, in order to explain the implications of a report.

« 10 » There are several audiences for scientific research. First, the scientific community shares an understanding of research methods and understands the various sources of uncertainty in results, but scientists from one field may have little understanding of the methods in another field (Umpleby 1990). Second, decision-makers, who commonly have a background in law, may know little about a specific scientific issue. Usually they will listen to the judgment of scientists but will also be influenced by lobbyists and campaign supporters. Third, science journalists will listen closely to what scientists say and try to communicate results and un-

certainty to the general public. Fourth, the public will be influenced by many messages about a scientific issue from scientists, journalists, political leaders and affected interest groups.

« 11 » It is important to understand that for several of the actors in a social system, the criterion of success is not truth, certainty or reliable results but rather whether public decisions are consistent with one's interests. Any means of communication that furthers that goal will be favored and considered legitimate by some people. An expanded conception of science would give scientists a larger regulator (in terms of requisite variety) for contributing to the wise management of society.

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Figure 1 • A cartoonist's view of science in the social and political context. With kind permission of the Union of Concerned Scientists, http://go.ucsusa.org, and the artist, Kevin Cannon. Each year the Union of Concerned Scientists sponsors a contest for the best cartoons depicting the interaction between science and politics.

Authors' Response:
Communicating Second-Order Science

Philipp Aufenvenne,
Heike Egner
& Kirsten von Elverfeldt

> Upshot • For communicating second-order science, von Foerster's ethical imperative provides a viable starting point. Proceeding from this, we plead in favour of emphasising the common grounds of diverging scientific opinions and of various approaches in second-order science instead of focussing on the differences. This will provide a basis for communication and stimulate scientific self-reflection.

« 1 » We owe thanks to our commentators as they illuminate aspects of our argumentation in a specific and especially insightful manner. Our response will be organized around the topics of:

a | maximising choices (Ison §5),
b | the transformation of scientific findings as soon as they enter the public agenda (von Storch §9), and
c | the notions of "history matters" and "personal and social context matters" (paraphrasing Krauß §§3ff and Umpleby §7 and §9).

« 2 » We will start with a response to Ray Ison's legitimate plea to "not become stuck in a discursive trap about what second-order science is or is not" (Ison §5). This is why we focussed on a current scientific-public debate and left the history of second-order science and a tracing of the full range and domains of its praxis (Ison §4) to other authors and other papers. We completely agree with his conclusion. To quote Heinz von Foerster's ethical imperative, "Act always so as to increase the number of choices" (Foerster 2003: 227), the question is indeed: "How can we move forward in ways that maximise our choices?" (Ison §5).

« 3 » One strong possibility for maximising our choices in scientific debate would be to overcome the tendency to mark differences and delve into dichotomies and dualities (as it is still common in scientific practice). Emphasising common ground instead of focussing only on the differences opens the doors to communication and fruitful debate. As soon as scientists of different disciplines and backgrounds find ways to exchange and discuss their assumptions and findings in a constructive manner (in the sense of being based on a shared ground), space for self-reflexivity unfolds. In