Advanced Review

Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world

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Public understandings and perceptions of, as well as engagement with, climate change have garnered the interest of research and policy for almost three decades. A portion of this growing body of literature examines such perceptions in-depth, using largely qualitative methodologies, such as personal interviews, limited sample size surveys, focus groups, and case studies. This area of research has been conducted on different continents, with individuals of different cultural backgrounds and ethnic groups, and a variety of demographic characteristics. It has examined various aspects of the communication process, such as audience differences, influence of framing, messages and messengers, information processing, etc.). This paper focuses on this subset of the climate change literature, highlighting similarities and differences across cultural, social, and geographical landscapes. Apart from demographic and regional differences, this literature also offers more detailed insights into the effectiveness of different communication strategies and into the cognitive and psychological processes that underlie public opinions. These insights are generally not obtained through large-scale opinion surveys. Our review highlights great variation and sometimes direct contradiction between these pieces of research. This not only points to a need for further refinement in our knowledge of public understanding and engagement, but also simply to accept that no one theory will explain the variation in human experience of climate change and action in response to it. *WIREs Clim Change* 2011 DOI: 10.1002/wcc.120

INTRODUCTION

Individuals play an important role in responding to climate change. Whether they are leaders in government, business, or a neighborhood association, or members of the public at large, individuals are ultimately the actors who initiate, inspire, guide, and enact the necessary cuts in greenhouse gas (GHG) emissions to slow down global warming and who develop and implement the sustained and sustainable adaptive responses to minimize its impacts. Recognizing these roles does not imply a disregard for the larger (enabling or constraining) contexts in which individuals act, nor do we mean to place inappropriate responsibility on individuals. There is forever a tension between structure and agency, which can only be acknowledged, but not resolved one way or the other. To the extent we recognize the critical role of individuals, however, in responding to climate change, what matters is their level of cognitive and emotional engagement as well as how that engagement leads to, or is affected by, behavioral changes and civic and political activities.

The Backdrop: Insights from Large-Scale Opinion Surveys

A significant body of literature comprised of large-scale public opinion surveys is available, especially from highly developed nations such as the United States, the United Kingdom, other European countries,

Additional Supporting Information may be found in the online version of this article.

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Canada, and Australia. This literature helps to recognize widespread patterns of opinions, attitudes, levels of understanding, and concern among different publics. In instances where such surveys have been taken repeatedly over time, we also have some understanding of long-term trends in these indicators, as public communication of climate change has made information available and shaped these opinions and beliefs.[1,2] In recent years, studies into individual understandings of climate change have emerged using other methodologies and focusing on specific audiences, yet the fine-scaled insights from these studies have not yet been reviewed and synthesized. It is the primary goal of this paper to fill this gap. In synthesizing existing insights about individuals' role in climate change, we distinguish between *understanding* (acquiring and employing factually correct knowledge of climate change), *perception* (views and interpretations based on beliefs and understanding), and *engagement* (a state of personal connection that encompasses cognitive, affective, and/or behavioral dimensions, see below). We recognize that there is an inherent and unavoidable tension between our dual attempt to synthesize the insights gained from this body of work—inherently a matter of generalization—and to illustrate the detailed insights that can be gleaned from it. We try to balance generalization and detail through overarching findings and examples in the text, but also a table listing a subset of studies and much longer, detailed supporting information with the specific insights from the pertinent studies cited in this article.[a]

Evidence for the importance of individuals' understandings and perceptions is demonstrated by the significant volume of literature that examines people's views on and knowledge of the climate problem.[3–8] These scholars argue that how individuals understand climate change is important in shaping their responses, including their understanding of and support for policies that aim to address the problem and their willingness to change behavior.[9] Some policy responses indeed count on the active, behavioral involvement of individuals for their success. For example, to meet the ambitious UK emissions target of 34% reduction below 1990 emissions by 2020, which lists 'homes and communities' as one area where efficiencies are thought to help meet the goals, engagement of individuals is absolutely essential.[10] Similarly, Dietz et al.[11] illustrate that a nontrivial 'wedge' of US emissions reductions could be achieved through individual and household actions, if behavior change programs were designed and delivered effectively. In order to mitigate effectively, future regulation, incentive programs, taxation schemes, and other policies may enlist individuals to change energy-consuming habits, travel modes, leisure activities, and could conceivably include calls for adjustments to individuals' food, lifestyle, and reproductive choices.

The majority of studies to date have examined collective, public perceptions of climate change using primarily quantitative data drawn from large, often nationally representative samples. The results of these studies suggest the following generalized findings: climate change is as yet perceived by most people in developed countries as a distant threat that is removed from their lives both spatially and temporally. More specifically, climate change risks are perceived as nonpersonal, concerning the future, other places and people, and other species (plants and animals).[6,12,13] While many risks share this pattern—whereby individuals view themselves as less at-risk than they perceive others to be—the implication of such a pattern is that mitigative action is simply not perceived as particularly compelling or urgent. Previous studies have also found that the public commonly confuses or conflates climate change with other environmental issues, especially stratospheric ozone depletion, air pollution, and weather.[3–8,14–20] This still holds true after 30 years of communicating climate change.[1,2,21,22]

The implication of these predominant yet incorrect mental models is that they set people up to believe in the wrong (or largely irrelevant) solutions (ozone-depleting substances in spray cans have long been banned), or to feel disempowered (if extreme weather events are acts of God, then there is nothing we can do about them except cope). High levels of awareness and varying levels of concern about climate change coincide with still very limited knowledge in many developed countries.[2,4,23–26]

Belief in the reality of climate change is waxing and waning, depending on concurrent events such as particularly cold winters and other weather extremes, or nonclimatic events like terrorist threats, economic recessions, or major public controversies like that following the illegal retrieval and publication of personal emails from the University of East Anglia or discoveries of mistakes in the 2007 report of the Intergovernmental Panel on Climate Change.[24,27,28] Still, generally more than half the population in surveyed developed countries 'believe' in the science.[27–30] At the same time, perceptions of the prevailing level of consensus among scientists vary considerably from year to year, but generally have not fundamentally changed since surveys started asking questions about it more than 20 years ago.[23,31]

While evidence is not uniform, gender, age, and ethnicity seem to affect the levels of understanding,

perception of reality and urgency of climate change, the sense of responsibility to act, concern for the future, and—importantly—the roles different demographic groups hold with regard to climate-relevant behaviors (e.g., making decisions about consumption levels, food choices, the number of children, or impactful choices such as car purchases).[32–36] For example, McCright[37] found in a longitudinal review of Gallup Poll data between 2001 and 2008 for the United States that—contrary to expectations from scientific literacy research—American women actually have greater scientific knowledge of climate change than men do, yet they underestimate their climate change knowledge compared to men. Women express slightly greater concern about climate change than do men, and this gender divide is not accounted for by differences in key values and beliefs or in the social roles that men and women differentially perform in society.

There is emerging evidence from large-scale studies suggesting that recent direct experience with weather-related disasters increases concern about climate change,[38] yet willingness to take adaptive or mitigative behavior following such experiences is inconsistent, probably because of the many physical, psychological, social, and political influences on risk perception.[38–41] Concern about climate change in comparison to other problems varies over time within and among countries and by proposed policy solution. Often, climate change falls short, and sometimes by a considerable margin, when compared to other, more directly experienced environmental problems (such as water or air pollution) or when listed against broader concerns such as the economy, health care, national security, and other pertinent issues of public policy.[42] Both the information the public receives and hears about climate change, and the appraisal of the risks from climate change lead to an overall low level of concern.[43]

The Added Value of In-Depth Studies of Individual Understandings

On the basis of this work, it has been suggested that current levels of awareness of and knowledge about climate change are insufficient in leading to effective behavioral change. Support for climate mitigation policies varies significantly over time and from country to country, with the major emitting economies showing limited but not insignificant support for (hypothetical) climate policies.[32,44–46] What is more difficult to discern from these studies is how individuals explain the causes and impacts of climate change, how they process information, form their views and come to change their climate-relevant behavior (rather than just expressing willingness to do so), and what the deeper motivations for, and barriers to, actual behavioral changes and other forms of engagement are.

A small but growing number of studies have examined perceptions of climate change using small samples and mainly qualitative, in-depth methodologies such as focus groups, personal semi-structured interviews, small-sized surveys using experimental study designs, processes with participant observation (e.g., scenario discussions with visualization), expert elicitation, or case studies. This research offers several categories of insights into individuals' understanding, perception and engagement with climate change that cannot be obtained from large-scale surveys.

Deep insights into understandings, perceptions and engagement among particular population segments: Small-scale studies, by virtue of focusing on a small and particular subset of larger audience segments or populations, provide insights into the particular understandings, perceptions, and levels of engagement of the group studied, as well as into the audience-specific barriers to more active engagement. For example, such studies reveal differences in individual understandings, perceptions and levels of engagement among very young or older students; youth versus older individuals; particular professional groups; particular urban or rural populations, value/attitude-based segments (e.g., high/low environmental values, ideologies or party affiliation) or a set of influentials considered critical to reach for larger campaigns. Some studies also focus on, or allow insights into, the ways regional populations differ from national averages, allowing for more tailored outreach campaigns. Cultural differences may be as significant as those among different demographic groupings but may be glossed over (by averaging) in national samples. Studies of this sort can reveal culturally resonant framings and reveal regional 'hooks' that are of interest and meaning only to the regional population. In sum, such differentiated insights provide essential information when trying to design communication that is meant to resonate with a particular audience segment.

Testing of the impact of different communication strategies and campaigns or policies designed to change behavior: Some studies involve testing differences in receptivity to different communication channels, messengers, framings, or the use of different communication vehicles (graphic, iconic, spoken, written communications). Typically it is only possible in very careful experimental, comparative studies to understand what aspects have what particular impact on the audience. It is also more economical to test

a particular strategy at smaller scale, make necessary adjustments after the testing phase and only then scale up to a large-scale, national test or campaign. Research that examines behavioral responses to policies also benefits from in-depth approaches to help explain motivations for behavioral change and whether/how these connect with relevant policies.

Deeper insights into the cognitive and emotional processes underlying responses to climate change information: In-depth studies, such as interviews and focus groups, or some experimental study designs allow researchers to more fully understand why individuals react the way they do to a particular type of information or communication. They may reveal underlying mental models, misunderstandings, belief systems, affective, and behavioral responses to climate change information that offer greater leverage for designing effective outreach and engagement campaigns. Large-scale surveys, by virtue of the nature of standardized, often automated and fixed questions and, in some cases, responses, do not allow for following up to better understand the responses given.

Our synthesis of the existing in-depth qualitative studies aims to provide an integrative review of the work conducted on individuals' attitudes toward and opinions of climate change, focussing on studies linked to understanding of climate change (science) and (to a lesser extent) GHG mitigation, but not adaptation (which will be the subject of a separate paper).

In the next section, we review in more detail why individuals' views on climate change matter *vis-à-vis* societal responses to climate change. Section '*Selected Findings from In-Depth Studies on Public Understanding*' reviews the findings from small and largely qualitative studies that examine understanding, traditional knowledge, perceived responsibility, faith, and behavior in relation to climate change. Section '*Synthesis: Individuals' Understandings, Perceptions, and Engagement*' synthesizes the research findings focussing on the three aspects, understanding, perception, and engagement, and the final section offers some suggestions for further research.

THE IMPORTANCE OF THE INDIVIDUAL IN CLIMATE CHANGE

Individual and Household Emissions

GHG emissions attributable to household and personal consumption as a percentage of total national emissions are highly significant in those western societies that have contributed the majority of emissions to date.[47] Direct energy use by US households, for example, accounted for 38% of overall US carbon dioxide emissions in 2005, or 626 million metric tons of carbon, though differences from state to state make generalizations as to their sources within household use difficult.[48–50] By comparison, this amount is larger than the emissions of any entire country except China.[11] A recent study of both direct and indirect energy consumption by Chinese households suggests that residents' lifestyles and related economic activities contribute 30% of total carbon dioxide emissions.[51] Of course, there are significant urban-rural differences in China that play a role for emissions;[52] indirect emissions exceed direct emissions for urban residents while direct emissions are more significant in rural settings.[51,52] Energy consumption and income are strongly correlated in China; higher income brackets emit significantly more than low income brackets.[52] Western development pathways, lifestyles and notions of progress have set emerging economies on a path similar to that of already industrialized countries and this will increasingly translate into significant personal and household emissions there unless rapid steps are taken to decarbonize the economy.[53] It is clear therefore that individual and household emissions are significant contributors to climate change.

The Engaged Individual

Having established the importance of the individual in terms of contributing to climate change, it is also important to define what we mean by 'engagement'. If we assume that individuals are actors who contribute to climate change, need to deal with its impacts, and identify, develop, support, and implement climate solutions, then involving them is not an option but an imperative. Engagement has been defined as 'a personal state of connection with the issue of climate change, in contrast to engagement solely as a process of public participation in policy making'.[54] Individuals can be engaged on three levels: with their minds, hearts, and hands. By implication, these ways of engagement can be achieved through rational-cognitive and affective means and practical actions. While much research remains to be undertaken in how to increase, balance, and effectively motivate and sustainably engage on all of these levels, it is quite well established that one-way communication tends not to foster deep cognitive engagement or systematic information processing and typically is insufficient to lead to sustained behavioral or political engagement.[45] Deeper affective engagement with an issue is difficult to achieve through one-way communication, and even harder to sustain, much less to control from the outside.[55] Dialogic processes can make up for some of

these deficits.[56–58] Cultural narratives (stories) and the construction of meaning in social interaction tend to touch people more deeply, even if they are not deeply knowledgeable about climate change, and can better motivate interest and sustain engagement.[59–61]

Knowledge of One's Contribution to GHG Emissions

What then if individuals were aware of and knew how their energy use and the products they consume contributed to GHG emissions and thus to climate change? Would they change their climate-significant behaviors? Knowledge of climate change alone is commonly considered a desirable but insufficient condition for mitigating GHG. More specifically, knowledge of the *causes* of anthropogenic climate change is generally considered useful as it lays an initial foundation for directing people to the right kinds of mitigative actions. However, research has shown repeatedly that knowledge, even of the causes of climate change, alone is not enough to motivate and shape effective mitigation outcomes due to cognitive, social, practical, and institutional barriers.[54] Despite the continued reliance on information campaigns to mobilize action, communication research has largely dispelled the knowledge- or information-deficit model of environmental education and communication.[62–65] More knowledge of a problem does not necessarily, directly, and by itself lead to change in behavior, and sometimes it can actually hinder behavior change.[66,67] At the very least, more concrete guidance and pragmatic help with how to realize changes in energy consumption are necessary. Typically, however, a range of enabling and supporting conditions must also be met, including social and institutional support, policy and infrastructure changes, and often clear signals from the market.[32]

The Role of Individuals in the Political System

More generally, whether and what depth of understanding is necessary for effective mitigation action on climate change depends on what type of action is sought and how we understand the political system. Of course, it could be argued that in governance systems other than democracies, and in situations where exclusive top-down policy making of the authoritarian style is considered favorable and feasible, only individuals in leadership positions would be influential actors on climate change. Action by individuals (and the masses) then could—theoretically—result simply from their enactment of the rules set in place by those in power. Public understanding of climate change or affective engagement would then be largely unnecessary to motivate implementation of GHG mitigation measures. In practice, however, this type of dictatorial action on climate change is extremely unlikely for at least three reasons. First, top-down policy making has been found to be less than effective without public buy-in given the unstable realities of party politics of most democracies.[68,69] Political support for and public engagement in climate change policies are needed for political leaders to realize emissions reductions. Second, in light of the now almost 20-year history of largely unsuccessful international negotiations on emissions reductions under the UN Framework Convention on Climate Change, and the lack of effective action by many national leaders to produce and implement meaningful solutions, a 'leaders-at-the-top-only' solution is already not being realized and seems very unlikely in the consensus-based system of the UN Framework Convention on Climate Change. And finally, current discourses about bottom-up and informed decision making, participation, and deliberation suggest that (overtly) authoritarian governance has largely, with some notable exceptions, gone out of fashion.[70] Given further that most major GHG emitting countries are in fact nominal democracies, at least some degree of electoral and political support for mitigation policies is a required (but probably insufficient) prerequisite for effective GHG reduction. These arguments do not preclude that a more strategic approach to communication may be needed to reach large-scale policy goals, and that it would be wise to employ the power of social relations to target primarily influential elites who in turn reach wider audiences.[71,72] However, the political reality and both normative and strategic arguments suggest that individuals at all levels play important roles in achieving the radical reductions in GHG emissions that many now view as necessary (see also Ref 73).

SELECTED FINDINGS FROM IN-DEPTH STUDIES ON PUBLIC UNDERSTANDING

We now turn to the results of in-depth, typically small-scale studies on public understanding of climate change from around the world, concentrating on contextualisation of understanding, the importance of direct and vicarious experience, traditional ways of knowing, perceived responsibility, and the role of faith in determining climate-relevant behavior. Details of the studies reviewed, including geographical location, studied population, objectives, methods used, and key findings are included in Table 1, just a sample of the

types of studies we draw on in our discussion, and in the supporting information.

Individual Understandings of Climate Change Vary but Are Always Contextualized Within Broader Considerations

There is strong evidence that individuals contextualize the issue of climate change within much broader, though not necessarily environmental, perspectives. Focus group research conducted in Frankfurt, Germany and Manchester, United Kingdom, and other studies in Newcastle, Australia, as well as in Roxbury, Massachusetts and rural southern Oregon (United States), for example, suggest that participants' thinking about climate change transcends strictly environmental issues and includes consideration of global inequalities, fairness, and health or livelihood concerns in addressing the issue.[75,85,86] Further evidence for this contextualisation is that Australian participants draw on scientific and local knowledge and on moral and value-based considerations in their responses to questions about climate change.[75] This contextualization of climate change among other issues also exists in developing countries. For example, among biosphere reserve managers climate change threats were found to be less than illegal activities such as poaching.[87] These studies highlight how individuals' perceptions about climate change are linked to equity, development, and perceived economic power, where socio-political context and the connection between management and science play an important role in risk perception.

Recent experimental research combining cultural theory and psychometric risk perception research in the United States puts these findings into a broader context: People are not 'blank slates' receiving information about risks (such as climate change) and interpreting them at face value. Rather, such information is always and inevitably filtered through pre-existing cultural worldviews (beliefs about how nature works, what constitutes a 'good' and fair society, what roles governments and individuals play respectively in bringing about such a society and how humans should interact with nature, etc.). These worldviews influence people's uptake, understanding, interpretation of and response to climate change information.[88–92] These findings are confirmed in in-depth cross-national studies,[81] within-nation, cross-cultural subgroup studies[12,93,94] as well as within-nation studies exploring alternative explanatory drivers of attitudes and behaviors[95,96] clearly reveal the influence of deep-seated values and beliefs about the workings of the world—partly also reflective of differences in individual personalities (e.g., more pessimistic or optimistic individuals)[97]—on interpretations of climate change. Weber[98] therefore concludes that social and moral framings of climate change may be more effective than purely cognitive-rational or affective appeals to get through to people.

In fact, research examining personal responses to climate change highlights that there are some common attitude types among publics around the world. Early work on cultural theory[99] suggested that the four (or five) generalized types of cultural worldviews held by an individual (the solidarist, hierarchist, individualist, and egalitarian (as well as fatalist) predispositions)[b] have an effect on how climate change is viewed.[94,96,100,101] Increasingly, this is shown in empirical work. For example, Norwegian focus group research suggests four typical response types (the acceptors, the tempered acceptors, the uncertain, and the skeptics).[83] Some aspects of these types correspond to the egalitarian (acceptors and tempered acceptors) while the uncertain and the skeptics do not correspond well to cultural theory types. A study of Australian responses to climate change also suggests that there are four types of basic attitudes; concern, skepticism, apprehension, and action.[102] In this case, the concern and action groups resonate with the egalitarian and the apprehensive resonate with fatalist views, but the skeptics as well as aspects of the apprehensive do not easily correspond to cultural theory typology. Research conducted in Canada also found four typical responses, the individualist (resonant with the egalitarian), the systemist (also resonant with the egalitarian), the skeptic (resonant with the individualists of cultural theory), and the economist (a version of the egalitarian).[84] These results converge on several findings: they show systematically varying levels of concern, the presence of skeptical views in all societies studied, and some degree of acceptance, ranging from solid to tempered. Most importantly, however, the cultural worldviews of individuals fundamentally determine their attitudes toward climate change.

Direct and Vicarious Experience of Climate Change Shapes Individuals' Views

The imagery (as part of the larger set of elements that make up the framing of an issue) can play an important role in shaping how climate change is perceived by individuals. In a UK study using a survey and focus groups, participants who had seen the film '*The Day After Tomorrow*' felt more concerned about climate change than those who had not seen it.[103] However,

TABLE 1 | Selected In-Depth Studies on Individuals' Climate Change Understandings, Perceptions, and Engagement (For Additional Studies, See the Supporting Information)

Study (author, year)	Country/location	Study participants	Study aims	Method	Key findings
BBC World Service Trust, 2009[74]	Ethiopia (rural and urban)	Citizens, policy-makers, religious leaders, business people, journalists and civil society representatives	Understand Ethiopians' thinking and understanding about climate change, and identify effective communication strategies	16 focus group discussions with citizens and 18 in-depth interviews	—Knowledge of climate change and global warming is very low in Ethiopia. Most recognize neither the terms nor the concepts —Most Ethiopians, regardless of their religion, feel that God alone has the power to change the weather. Very few believe that human activity has a role to play —Traditional community and religious leaders are the least knowledgeable about climate change, while concern is rising among urban opinion leaders
Bostrom et al., 1994[14]	US/Pittsburgh, PA	Staff and students at Carnegie Mellon University ($n = 7$), teenagers ($n = 20$) and adults ($n = 31$); Participants at the annual Pittsburgh automobile show ($n = 34$)	Understand people's mental models of climate change	Interviews and questionnaire	—Lay individuals and even highly educated individuals hold misconceptions about climate change, for example, —Explanations of the physical mechanisms causing global climate change were inconsistent and incomplete —Literal interpretation of the greenhouse effect —Misperceptions about the relative importance of various causes of global warming —Misconceptions coexist with correct beliefs —Flawed mental models restricted respondents' ability to distinguish between effective and ineffective response strategies

TABLE 1 | Continued

Study (author, year)	Country/location	Study participants	Study aims	Method	Key findings
Bulkeley, 2000[75]	Australia	High school and university students and their parents ($n = 242$)	Assessment of public understandings of climate change	Survey (56 questions)	—Public understanding of global environmental issues incorporates scientific and local knowledge, values, and moral responsibilities —Climate change connected by participants to their local communities —Concern about efficacy of individual action —Strong evidence against the 'information-deficit model'; providing information to improve knowledge among the public is insufficient alone to effect behavioral change
Byg and Salick, 2009[76]	Tibet, China	15 villagers in each of six villages in Deqin County ($n = 90$)	To examine Tibetan villagers' perceptions of climate change	Semi-structured interviews, statistical analysis of the results	—Participants noticed a variety of changes related to climate change in significant detail —Villagers had not heard of climate change and attributed the changes they perceived to local phenomena —There were significant divergences between some of the perceived changes between villages —Varied explanations for the perceived changes include cosmology, modern life, environment, policy, and both local and outsiders' religious misconduct —Weather is considered a local phenomenon determined largely by local deities. Adverse conditions are therefore seen as a result of neglect of religious duties or a breach of taboos —Tibetan villagers seem concerned about the same issues as scientists with respect to climate change effects on glaciers, forests, but also tourism, energy use and transportation

TABLE 1 | Continued

Study (author, year)	Country/location	Study participants	Study aims	Method	Key findings
					—Anxiety and psychological stress because these concerns are real and influence what actions are considered appropriate by people in the area
Ferguson et al., in press[77]	US Midwest	University population ($n = 79$)	Examine whether collective guilt for the in group's collective GHG emissions mediates the effects of beliefs about the causes and effects of global warming on willingness to engage in mitigation behavior	Survey in experimental design varying causes and effects of CC	—Guilt is higher when respondents believe that CC is human-caused and will have minor effects. —Collective anxiety does not mediate such beliefs in the causes and effects of CC nor the willingness to engage in mitigative behavior
Green et al., 2010[78]	Torres Strait, Australia	Indigenous Australians	To document local observations of environmental change relevant for developing a better understanding of climate impacts in the Torres Strait	Workshops, interviews with elders	Torres Strait indigenous understanding of environmental change is supported by sophisticated knowledge that covers flora–fauna–climate interactions, seasonal weather patterns and climate, and indicators of seasonal change.
Joireman et al., 2010[79]	United States/ Northwest	Psychology students at a state university in the NW US (Study 1 $n = 93$; Study 2 $n = 42$); marketing undergraduate students at state university in NW ($n = 159$)	Explore the importance and effect of experience and heuristics on belief of global warming	Word search puzzles followed by brief survey (index)	—Significant positive correlation between the outdoor temperature and beliefs in global warming —People were more likely to believe in global warming when they had first been primed with heat-related cognitions. —People were more likely to believe in global warming and more willing to pay to reduce global warming when they had first been exposed to a high vs. a low anchor for future increases in temperature

TABLE 1 | Continued

Study (author, year)	Country/location	Study participants	Study aims	Method	Key findings
Leduc, 2007[80]	Polar regions	Inuit elders (n = unknown)	Gain a deeper understanding of the Inuit notion of 'Sila' and its relationship to Western notions of weather and climate	Dialogue between Inuit and scientists	The Inuit concept of Sila refers to more than 'weather changes' but alludes to cultural and spiritual dimensions that interpret climate change as the world's ethical response to improper human actions
Lorenzoni and Hulme, 2007[81]	Rome (Italy), Norwich (United Kingdom)	Adults and high school students, n = 135 (Norwich) and n = 206 (Rome); Discussion groups (n = 10, Rome and n = 19, Norwich)	Cross-cultural exploration of environmental attitudes, personal views on climate change, and options and responsibilities for managing climate change	Survey and discussion group with subset of survey respondents	—Participants fell into four segments, based on their beliefs about CC: denying, doubtful, uninterested, and engaged —Participants exhibited strong awareness of climate change and most, albeit with some hesitation and skepticism, acknowledged a human contribution —Most considered climate change an intractable problem due to scientific uncertainty and ineffective solutions —CC was perceived to be distant —Imagining long-term futures (using scenarios) proved difficult; two decades is feasible —Myopia was recognized and denounced, but viewed as inevitable —Regardless of attitudes toward climate change, discussants shared the hope that the future would be a ''better place'' (more fair, equitable, less environment disruption) —Aspirations were tempered by personal experiences and views —Participants believed a major crisis was necessary to radically alter societal trajectories —Inconsistency between scientific projections and personal views lead to questioning of science

TABLE 1 | Continued

Study (author, year)	Country/location	Study participants	Study aims	Method	Key findings
Morton et al., 2011[82]	United Kingdom	Study 1, adult participants, fairly well educated ($n = 88$); Study 2, university students ($n = 120$)	Examine how framing climate change predictions differently might moderate the tendency for uncertainty to undermine individual action	Question-naire, experimental design, verbal debrief	—Higher uncertainty combined with a negative frame (highlighting possible losses) decreased individual intentions to behave environmentally —Higher uncertainty combined with a positive frame (highlighting the possibility of losses not materializing) produced stronger intentions to act —Effects of uncertainty were mediated through feelings of efficacy
Ryghaug et al., 2010[83]	Norway	Members of various social networks (4–8 individuals per group, $n = 62$, 24 men and 38 women)	Analyze how people reason about and make sense of human-made global warming	10 focus groups	—The domestication of climate science knowledge is shaped by five sense-making devices: news media coverage of changes in nature, particularly the weather, the coverage of presumed experts' disagreement about global warming, critical attitudes toward media, observations of political inaction, and considerations of everyday life —Sense-making allows for ambiguity, resulting in four audience segments: the acceptors, the tempered acceptors, the uncertain and the skeptics
Wolf et al., 2009[84]	Canada	Residents of Victoria, BC and Salt Spring Island, BC (Interviews: $n = 86$; Q sort : $n = 38$)	To examine how individuals conceive of responding to climate change	Q-Methodology including interviews, Q-sort and focus groups	—Participants view a civic, non-reciprocal and non-territorial responsibility that includes the private sphere in its remit for responding to climate change —Four factors were identified; the individualist, the systemist, the skeptic and the economist —Even these engaged and knowledgeable participants struggled with making changes in their lives that would translate into effective emissions reductions

participants viewed extreme events as less likely after having seen the movie.[103] Research on visualization tools and experimental interventions using icons and imagery suggest that such tools can help increase knowledge and concern if the information embedded does not overly appeal to negative emotions such as fear.[104–106] While offering significant potential to attract individuals' interest, representations of climate change that promote fear are generally ineffective in motivating personal engagement because they are often perceived as manipulative.[106] The two separate studies examined in the paper both find that nonthreatening visual representations that link to individuals' everyday emotions and concerns engaged more effectively.[106]

Level of concern about climate change, however, cannot be solely explained with individuals having been affected by impacts but rather from engagement with the issue through cognitive, affective, behavioral, and moral means. Evidence from the United Kingdom suggests that exposure to floods, as one type of climate change impact, does not necessarily affect concern about climate change.[107] Therefore, even direct experience with impacts may not motivate behavioral responses to mitigate emissions. Rather, the study finds that individuals with pro-environmental values are significantly more likely to address climate change than those with other value orientations. Moreover, the direct experience with impacts may orient individuals more toward taking adaptive actions, rather than focus on the root causes, as a study of communities in Alaska showed where energy use and income generated from energy production is so deeply woven into people's daily lives that they do not easily see a way out.[108]

Traditional Ways of Knowing Shape Perceptions of Climate Change

Individuals in modern, heavily urbanized society live largely disconnected from their natural environment. A 'Human Activity Pattern' survey conducted of the American public in the late 1990s illustrated that 51% of the population spent no time outside in a normal day at all (except maybe for the short walk from the house to the car to the office and back), and another 30% spent under one hour per day outside.[109,110] Such modern lifestyles essentially disconnect individuals from directly experiencing changes in the environment and instead make them completely dependent on mediated information about nature and climate change (e.g., the news, TV documentaries, or stories others tell). By contrast, those working directly on the land (or sea) and with natural resources, and particularly many traditional societies, are still immersed in their natural surroundings and in fact dependent on subsistence from the land and its resources. Thus, their direct experience and knowledge of the environment can be expected to be quite different from that of urban dwellers.

Traditional ecological knowledge has been defined as a 'cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment'[111] (p. 1252). Traditional knowledge about peoples' environment including weather and climate suggests not only that knowledge passed down through generations is still used today but that it can complement scientific knowledge and potentially help to adapt to faster changes than would be associated with variability alone. Research in Uganda, for example, points to a differentiated and dynamic system of local climate knowledge that is open to new information[112] and similar results emerge from indigenous Australians[78] and traditional peoples in the high Arctic.[113] The authors argue that the system could be used to inform climate science because of its spatial scale and practicality.[112] Also, Samoan classification of clouds and winds are consistent with western scientific classifications, which could be integrated into scientific knowledge.[114] Kenyan pastoralists rely on indigenous knowledge about rainfall variability and use this knowledge as a framework within which they interpret scientific information such as meteorological forecasts.[115] Various scholars working with traditional peoples have thus argued that indigenous knowledge, their ways of life, with their differing value, governance and belief systems must be better reflected in scientific assessments of climate change and that indigenous people need to be more closely involved in responding to the challenges of climate change.[116]

In climate change research, traditional knowledge and observation of weather are often used to substantiate and extend scientific evidence, for example, in data-scarce regions such as the Arctic.[113,117–119] There is much less evidence on discrepancies between traditional knowledge and scientific understandings or competing knowledge claims than there are attempts to substantiate scientific with traditional knowledge.[120] One example of such work explores alternate ways of perceiving, explaining, and responding to climate change. For example, in South Pacific small island developing states perceived risk from coastal flooding does not result in any increased migration away from the islands.[121] Islanders do not

see climate change as a reason for concern, let alone to move away, and those with intentions to migrate do not cite climate change as a reason.[121] Similarly, perceived causes of climate change diverge from scientific knowledge among Senegalese smallholders and agricultural extension agents.[122] Subjective perception can also influence what farmers, for example, feel they need. Meze-Hausken[123] has suggested that rainfall needs among Ethiopian farmers in part determine perceptions of changes in rainfall that diverge from observed changes (see also Ref 124). Grothmann and Patt[125] found farmers in Zimbabwe hesitant or even resistant to change crops when a drought was projected, in part because they did not know how to correctly interpret climate-related probabilities. Thus, while disconnects are reconciled, there remains a gap in understanding how the discrepancies between scientific and traditional knowledge can be reconciled, and how alternate ways of understanding change can be respected, while acknowledging the potential for a very different world as a result of climate change.

Ranging Views on Personal and Collective Responsibility

A number of small studies have examined how responsibility for acting on climate change is perceived by individuals. This research demonstrates that publics around the globe have formed diverse attitudes about responsibility that are strongly influenced by local cultural dynamics, religious dimensions, and ethics.

In the mid-1990s, Hinchliffe[126]—based on interviews with individuals in the United Kingdom about an energy saving campaign—argued that appealing to individuals as the primary site of action is ineffective. More recent evidence suggests that some individuals openly acknowledge a moral[75] or civic[84] responsibility for acting on climate change. In neither case is this responsibility necessarily viewed as contingent on action from political actors or governments. In fact, a study of Canadian individuals suggests that those who act on climate change do so because they feel let down by their government which is not committing to meaningful emission reductions.[84] A comparative study of British and Swedish students, however, showed distinctly different assignments of responsibility for causing climate change (individual consumer behavior, policies, market structures, lifestyles) and resulting differing expectations of individual versus government actions to solve the problem.[127] Thus, while a higher percentage of British students than Swedish students saw individuals as the main cause of global warming and government lagging far behind, youth from both countries put their hopes in the government to solve the problem.[127] Interestingly, a focus group-based study from New Zealand found that when discussing individual responsibility for GHG emissions, tourists distinguished between their travel and their everyday life, with greater responsibility for mitigation perceived in everyday life.[128] The value of freedom to travel is firmly established in the minds of many tourists and limiting travel is considered unacceptable.[128] While these may seem like contradictory results, context-specific cognitive dissonance and its resolution could explain why there are situations in which individuals admit and act on a perceived responsibility and others in which they do not.[129]

Framing is critical in its function to allocate responsibility for taking action. For example, if climate change is framed as a scientific matter, many lay people do not feel directly included or addressed (since science falls under the purview of 'experts', i.e., others). Similarly, if it is framed as a matter of technological innovation, researchers and engineers are perceived as the primary actors. In frames that rely on the notion of environmental stewardship (as in many religious communications on this topic), individuals and communities feel more directly implicated.[130] The imagery, language, messengers, and stories used in different frames can thus underscore or detract from an individual's sense of responsibility. For example, among the participants in the aforementioned UK focus group study that examined the effects of the movie '*The Day After Tomorrow*', viewers experienced an increased motivation and sense of responsibility to act personally on climate change.[103] While participants generally felt that public concern could not lead to action without the aid of political support, they articulated a collective human responsibility for the causes of climate change.[103]

The discourse surrounding certain behaviors also affects how individuals negotiate responsibility. As argued by Butler,[131] evidence from focus group discussions in the United Kingdom suggests a moralization of certain individual behaviors that have come to be associated with climate change, and thereby creating an individualized responsibility. In participants, this discourse produced feelings of guilt but not a change in behavior.[131] This is not surprising in light of studies on guilt appeals, which typically find that 'Responses to guilt [. . . , ranging from resentment to rationalization to a search for self-affirmation] aim primarily at maintaining one's sense of a moral self,

and may or may not also motivate behavior that ends or rectifies the guilt-invoking action'[55] (p. 71).

Religious Beliefs Shift Perceived Agency on Climate Change

Belief in a higher spiritual being plays an important role in determining whether people believe that human action can influence the climate or the weather. This insight has emerged from research in Tibet, Fiji, parts of Africa, Central America, Polar regions, and the United States. Donner in fact, traces these deeply held beliefs about the skies as the 'domain of the Gods' back throughout the ages and many cultures.[132] The implication of beliefs in a higher power being responsible for weather extremes (and any possible changes therein) is that people or governments are not perceived as having any control, influence or responsibility for that which is in God's hands. Particularly, if climatic change is interpreted as God teaching people a lesson or punishing sinners, public acceptance of climate policy may be undermined.

For example, among Tibetans there is a belief that the mountain deities have been angered causing the climate to change[76] (see also Ref. 133). Donner[132] showed, that the perceived role of God in affecting the weather is common also among Fijian peoples. Even in western(ized) societies, extreme weather events are still often viewed as 'acts of God'.[134] Similarly, participants of the results from the Tuvaluan study explain their findings with the "special relationship Tuvalu shares with God and due to the promises of God made to Noah in the bible[121] (p. 109). Leduc[80] found through a carefully facilitated dialog between Inuit and scientists that the Inuit concept of 'Sila'—inadequately translated as 'weather changes'—actually alluded to a cultural and spiritual dimension of the observed changes in weather and climate, namely nature's response to improper human action.[80]

In Africa similarly strong beliefs in the hand of God in changing the climate are apparent. Research conducted by the BBC World Service Trust in 10 Sub-Saharan countries (DR Congo, Ethiopia, Ghana, Kenya, Nigeria, Senegal, South Africa, Sudan, Tanzania, and Uganda) illustrates that most rural populations in these developing countries have little awareness and understanding of the concept of climate change (and only slightly more so of 'global warming') even though they are already contending with its impacts. While specific findings vary from country to country, key insights gained from interviews with individuals in rural Ethiopia are illustrative.[74] Generally, knowledge of climate change and global warming is very low in Ethiopia with very few recognising the terms or the concepts. Most Ethiopians interpret the term 'climate change' to literally mean 'weather change', largely because the term 'climate' is little used or understood. Instead of linking climate change or global warming to the warming of the Earth as a result of the emission of GHG, the majority of Ethiopians connect it to localized increases in temperature caused by local activities that produce visible pollution or smoke, such as the burning of firewood for fuel. For the few Ethiopians in urban areas even aware of human-caused climate change, global warming is inaccurately associated with their prior knowledge of ozone depletion.[74]

Regardless of people's awareness and understanding of climate change, Ethiopians recognize that their weather is changing and that these changes (such as erratic and insufficient rainfall, dwindling water sources, failed harvests and dying livestock) are profoundly affecting their lives. They explain that the land simply cannot support them anymore. Moreover, most Ethiopians, regardless of their religion, feel that God alone has the power to change the weather. This 'God frame' leaves little if any room for human activity as a cause, and therefore for a role for humans in mitigating emissions. While such differing explanations of change need to be respected, they raise questions about whether and how to help prepare strongly belief-based societies for adaptation or convince them of 'green' development pathways.

The pervasiveness of some version of the 'God frame' across cultures and time has important implications for public engagement and policy development: (1) the impacts of a changing climate can be viewed as punishment for people's climate-irrelevant actions, and (2) there is nothing one can do but cope. In terms of mitigation (including low-carbon development) and adaptation, this has serious implications for those countries where such beliefs are pervasive.

Questions of faith, it is important to note, are not only relevant in less-developed, less-Westernized nations. Even in highly developed nations like the United States, faith-based beliefs play an important role in problem understanding, raising concern, and motivating practical engagement.[130,135–138] Most interesting for the purposes of understanding the relevance of religious beliefs for individuals' understandings, perceptions, and engagement here is that studies of religious discourses in the United States illustrate how climate change is framed as a direct and severe threat to God's creation and to notions of social justice, that is, a violation of the dictum to 'love thy neighbor', and, in turn, acting on these threats is

promoted as 'God's work'.[136] Thus, climate change as framed in not just conservative-evangelical, but also more progressive-religious terms—regardless of the relative lack of a direct experience with climate change impacts—has become a salient and immediate issue with morally motivated, personal responsibility. The discussion here of the various ways in which climate is being associated with God, however, illustrates that faith can help or hinder active engagement with the issue.

The (Missing) Link Between Understanding and Behavior

There is now much evidence on the gap between knowing about climate change and changing behavior to help mitigate.[139,140] Qualitative research has explored this disconnect and provides valuable insights into how it can be addressed. Lack of a sense of urgency *vis-à-vis* other, more immediate and pressing issues certainly play a role. But denial is also important in remediating the cognitive dissonance that climate change can induce.[141] Recognizing one's contributions to the problem, and thus acknowledging feelings of complicity and guilt, may or may not lead to remedial action regarding climate change.[55,142] As suggested by Whitmarsh,[143] there is an asymmetry of behavioral intentions and the actual effects of behavior in terms of emission reductions. Behavior in response to climate change consists largely of token actions that can broadly be described as environmental (e.g., recycling) but that do little to reduce GHG emissions.[143] This has been attributed to a lack of knowledge about how to reduce emissions effectively[143] (see also Ref 103). Further, there are significant social, institutional and practical barriers to public engagement.[44,45,54] Thus, even people who want to mitigate are faced with obstacles or change their behavior in ways that are unlikely to yield effective emission reductions.[84]

An area of growing interest to researchers is the affective dimension of climate change, as it is believed to provide a critical link between knowledge and attitude on the one hand, and action on the other.[40,98,144–147] In Canada, evidence from research into ecological citizenship suggests that ecologically minded individuals are not only cognitively and behaviorally but also affectively more engaged.[148] Similar findings emerged for some, but not other studies of pro-environmental behaviors in Britain.[149,150] Even those most motivated to act struggle with making their actions meaningful in terms of emission reductions.[84] Individuals tend to be more effectively engaged emotionally by positive messages, while appealing to fear has been found to be largely counterproductive.[106] But in order to overcome obstacles and barriers to action and change, path-dependent institutional structures, market signals, organizational cultures, and policy-making procedures need to be adjusted or reinvented.[151]

SYNTHESIS: INDIVIDUALS' UNDERSTANDINGS, PERCEPTIONS, AND ENGAGEMENT

The in-depth studies cited above provide considerable explanatory power in understanding people's thought processes, barriers, and what might serve to motivate people to act on climate change.

Understanding

Acquiring and employing factually correct knowledge of climate change was defined above as *understanding* climate change. Individuals' understanding of climate change is still limited according to the small-scale studies reviewed here. Part of the reason may be lack of focused education on climate change, powerful cultural, and perceptual filters that screen out new and challenging information while selectively letting other bits in, peripheral information uptake through the media, and lack of direct immersion in natural environments among people in industrialized countries. Evidence on traditional knowledge systems suggests that they often complement western scientific knowledge and have been used to substantiate scientific evidence, for example, in the rapidly changing Arctic. However, some ways of understanding diverge from scientific evidence and there is much less research on this than on convergent or complementary ways of knowing, and on the consequences of divergent knowledge systems and beliefs. In some places knowledge of climate change or the concept it represents is very limited. Yet, where this lack of knowledge coincides with a climatically exposed livelihood, individuals recognize that the weather or other aspects of nature is changing and that these changes are affecting their lives. What the review of numerous in-depth studies also reveals is an inconclusive relationship between the level of education and the level of understanding of climate change; the relative role of understanding in raising concern and in motivating action. Clearly, individuals enact climate-relevant behavior without or with an incomplete and sometimes misguided understanding of climate change, while others understand the problem full well and do or do not act to reduce their emissions.

Perceptions

In terms of perception, that is, the views and interpretations of the climate issue based on beliefs, experiences, and understanding, the evidence from in-depth studies reviewed here suggests that individuals' perceptions of climate change are strongly contextualized and encompasses other, not necessarily environmental, issues. Positionality in society (as indicated by gender, age, socioeconomic status, and other social variables) may play an important role in these differentiated judgments of climate change by various groups, but evidence about how much of a difference it makes in different contexts is not uniform. The observed perceptions also explicitly accounts for ethical and moral dimensions, such as those relating to equity, development, and economic power. Climate change is perceived through the lenses of pre-existing cultural worldviews. This means that perception of the issue is strongly determined by beliefs held by individuals about the functioning of nature and what would constitute a 'good life', fairness, and the appropriate role of individuals versus markets and the government. Accordingly, evidence from developed countries on differences in individuals' perceptions converges on systematically varying levels of concern, the presence of skeptical views in all societies studied, and some degree of acceptance, ranging from solid to tempered.

Perception of climate change is also shaped by the framing used in climate change communications, particularly the imagery and stories employed, which can help increase knowledge and concern if the embedded emotions do not overly emphasize (i.e., manipulate) negative feelings such as fear, guilt or hopelessness. Negative affective appeals seem largely counterproductive, especially when unaccompanied by messages that build listeners' sense of efficacy, hope, and optimism about the future. How climate change is framed can fundamentally affect how the issue is perceived. For example, appeals to parenthood and hero's stories, such as that found in the film '*The Day After Tomorrow*', can shape perception, but such demographic variables, including parenthood, do not show consistent evidence for people's concern and intentions to reduce personal emissions. Moreover, concern about climate change does not necessarily stem from having been affected by the effects of climate change directly; in fact, evidence is inconclusive as to whether those directly impacted by events such as floods are as or more likely than others to attempt mitigation of GHG. Some limited evidence suggests that individuals openly acknowledge a responsibility, either moral or civic, for addressing climate change. While one may hypothesize that notions of responsibility and motivation to act are similarly shaped by the deeply held cultural worldviews, further research is needed to discern the reasons.

Engagement

In this article, we defined engagement as a state of personal connection that encompasses cognitive, affective and/or behavioral dimensions. The studies reviewed here suggest that denial as well as distancing and an active disconnect between recognizing causes and assigning responsibility for action play important roles in mitigating the cognitive dissonance climate change causes in individuals. There is evidence for an asymmetry of intentions and actions in part due to insufficient practical knowledge about how to reduce emissions effectively. Incorrect mental models (such as global warming being the result of the ozone hole) or the cross-culturally common 'God frame' can effectively hinder or, as seen in evidence from US progressive Christian beliefs, promote individual engagement; this has significant implications for mitigation and adaptation. On the other hand, there is no direct or uncontested linkage between a correct understanding of climate change and active engagement either, and a wide variety of framings can motivate action without deep, scientifically correct understanding. Even where individuals perceive a sense of personal responsibility and show a willingness to act, many experience a sense of futility in light of the barriers they face, the lack of government leadership and facilitative policies, and the immensity of this 'global' problem versus individual actions. Affective engagement with climate change requires further research; clear is, however, that negative emotions such as fear—unmitigated by communication on how to translate worry and concern into effective remedial action—are more likely to disengage individuals, while positive emotions help inspire and motivate people. Limited evidence suggests that ecologically minded individuals feel and are more actively engaged—pointing to the importance of identity in pro-environmental behavior—but still struggle to make changes in their lives that would reduce their emissions effectively.

FUTURE RESEARCH OPPORTUNITIES

Suggesting broad-stroke research directions for small-scale studies is hampered by the same dilemma as underlies this synthetic review: the juice is in the details. As the studies reviewed here, future research in this area will continue to be highly contextual,

focus on specific audiences and employ a wide variety of approaches, framings, and participants, in diverse settings. Specific questions are virtually endless due to these differences. Nevertheless, we attempt to provide some categorical suggestions.

First, in-depth studies focused on understanding allow us to learn how people process information, how they make sense of it in a very contextualized fashion, how they do or don't learn, and thus—pragmatically—how stubbornly hindered climate change communication and education is *vis-à-vis* pre-existing mental structures, and in turn, what possibilities there are to tap into people's prior understandings. Future research should be more explicitly interdisciplinary, joining forces between learning and communications experts, and examine how understanding differs not just by socio-demographic or cultural groups, but by learning contexts. For example, what settings allow for better uptake, systematic processing, and improved assimilation of new information? What sequence of information is most conducive to improving people's understanding without overwhelming them cognitively or affectively? How can selective information uptake in highly polarized contexts be circumvented?

Second, in-depth perception studies lead us into the inner workings of people's beliefs and emotions. Evidence cited above is inconclusive as to what experiences and mental processes lead to what perceptions, and how they do or do not motivate more active engagement. Future research should examine how and what could stabilize or change individuals' perceptions. While more seems to be understood about how people maintain certain beliefs, what internal processes and/or outside events can change them? Again, interdisciplinary research might yield interesting insights, for example, on how stages in human/personal development (not just chronological age), life experiences, levels of maturity, social roles, or personality types affect beliefs and perceptions of climate change. What psychological capacities are needed for people to confront the 'inconvenient truths' of climate change?

Third, with regard to engagement, past research has established how difficult it is to actively engage with climate change. While much has been said about the value-attitude-action gap, and the lack of direct linkages between understanding, perceptions and behavior, more needs to be understood about those who do make changes in their lives. In fact, cutting across these three focus areas of research, we found that much of the research we report on here is focused on what is lacking and what does not work. One of the great advantages of small-scale studies is the relatively low cost for testing out alternative approaches to public communication and engagement. We believe, therefore, that more such smaller, in-depth studies are particularly well suited to examine what does work in terms of cognitively, affectively, and behaviorally engaging individuals. Already, many campaigns are underway, but often they lack pre-intervention establishment of baselines, monitoring, and post-intervention evaluation. These campaigns offer ready-made opportunities to further our understanding on effective communication. More importantly, maybe, the fact that we find such significant differences, and sometimes opposite findings from studies of different populations, suggests that one-size-fits-all campaigns are doomed, if not to fail, at least to only reach limited goals with far smaller audiences than intended. 'Retail' communication approaches on the basis of better understanding of particular target groups may thus be more promising.

Such subgroups may be selected on the basis of strategic considerations, that is, with an eye to bigger impact. For example, experts increasingly recommend that campaigns should target opinion leaders—individuals considered particularly trustworthy by specific segments of the population (e.g., local political leaders, civic leaders, business, or religious leaders). Thus an area of valuable research would be to focus attention on the understandings, perceptions and the barriers and motivations of elites, policy-makers, business leaders, and other influentials. This would help set in motion much wider public support for climate action. Effectively reaching such policy elites may also help in facilitating high-level action that can remove some of the barriers the wider public faces.

On the basis of the insights reported here, we hypothesize that many publics seem ready to act if their leaders were to take some bold action at the policy level. It is possible, and worth examining more specifically, that people feel paralyzed not just or maybe not as much by the magnitude and complexity of the climate change threat (i.e., the threat appraisal), but by not being able to do much about the ossified structures that constrain their actions (election systems, energy systems, transportation infrastructure, markets, etc.), and not because they do not want to help address climate change. In other words, they may disengage because of their negative (but not at all irrational) appraisal of capacity and efficacy. Specifically investigating such questions might produce helpful results to bring to the attention of leaders who claim they do not have enough backing in the electorate.

Finally, while it is quite common in many western societies that only small percentages of

populations are civically active and that participation in elections in many democracies is lessening, more research on engagement is necessary to better understand what would (again) or already does motivate people to engage in civic or political actions on climate change.

It has been our own experience in reviewing this literature of in-depth studies that a deeper understanding of individuals' responses to climate change has resulted in a more compassionate understanding of people's reaction to this daunting challenge. It is from there, maybe, that a more civil conversation can be had.

NOTES

[a] The supporting information table lists 68 in-depth, often small-scale studies reviewed for this paper. The three principal criteria for inclusion are: (1) a substantive focus on understanding, perception, or engagement with climate change; (2) an emphasis on mitigation behavior or generic issues related to understanding of climate change, rather than on adaptation behavior; and (3) the study does *not* report on a large-scale survey of nationally representative populations. While we do not claim this to be an all-encompassing review, the reader will find detailed insights in these studies that helps us better understand human cognitive, affective, and behavioral responses to climate change. In the 'Findings' column of the supporting information we briefly summarize what if anything is different from the large-scale, quantitative studies/surveys, what is surprising, and/ or what offers deeper insights.

[b] Cultural theorists distinguish cultural subgroups within a 2 × 2 matrix, clustered by people's adherence to two fundamental dimensions of what is perceived as a 'good' and just society, for example, a highly stratified society with strong emphasis on loyalty to one's peer group would be a high grid/high group or 'hierarchist' society. A minimally stratified society with strong emphasis on individuals standing out from the group would be an 'individualist' society. Some researchers see little evidence for fatalism as a cultural type and thus drop that category; others add solidarism as an alternative, resulting in inconsistent numbers of groupings.

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