Overview

Behavioral dimensions of climate change: drivers, responses, barriers, and interventions

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This overview describes the anthropogenic drivers of global climate change, reviews the behavioral and psychological responses to its impacts (including barriers to behavior change), considers behavior-focused intervention strategies, and suggests future directions for research. In doing so, it demonstrates why and how behavioral science is crucial for confronting the complex challenges posed by global climate change. The human dimensions of climate change are discussed, followed by descriptions of key theoretical models for explaining and predicting climate-relevant behavior, issues and distinctions in studying human behavior in response to global climate change, an account of psychological (as opposed to structural) adaptation and its behavioral sequelae, the many psychological barriers to behavior change in this context, and behavior-focused intervention strategies. The overview concludes with suggestions for researchers interested in advancing knowledge about behavior change and psychological responses to climate change. When knowledge about human behavior, cognitions, and psychological adaptation is integrated with that produced by researchers in related social and natural science disciplines, the result will facilitate solutions to this massive shared challenge.

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INTRODUCTION

Climate change is not a new phenomenon. The Earth's temperature and climate have changed considerably over the past millions of years. However, the current changes and those projected for the future differ in that they are largely driven by human behavior.[1] Given that the human contribution to the problem is intimately related to sustainability behavior, climate change is a central concern of psychology, especially environmental psychology, and other behavioral sciences.[2]

Climate change is primarily driven by greenhouse gas (GHG) emitting human behaviors, such as the burning of fossil fuels, and therefore may be largely mitigated by changes to those behaviors. However, human behavior is the least-understood aspect of the climate change system[3]; unfortunately, the main cause of the problem is the very aspect of it that is least understood. Worldwide GHG emissions resulting largely from human causes continue to rise despite official efforts to promote mitigation and reports from many citizens that they are taking steps to overcome the problem.

We have a considerable opportunity and an enormous responsibility to effect change through increased understanding of the factors that underlie the anthropogenic causes of climate change and the ways in which GHG-mitigating behaviors may be effectively encouraged. Although a dire need for more research remains, a body of knowledge already exists in behavioral science which elucidates some of the key mechanisms that underlie climate change-relevant behavior and points to some promising avenues for human responses to the climate crisis through behavioral interventions.

Therefore, a primary goal of this article is to offer an overview of research and theory related to the behavioral drivers of climate change, psychological

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barriers to behavior change, and key intervention strategies for encouraging behavior change. If the more extreme adverse projections of climate change are to be avoided, the collective efforts of many individuals making major changes to their GHG-relevant behaviors will be required, and these can be achieved through effective intervention strategies.

Human behavior is changing the climate, and humans are, in turn, impacted by climate change. IPCC Working Group II concluded that climate change is highly likely to result in more frequent temperatures, floods, drought, extreme storms, heat-related deaths, infectious disease epidemics, and decreases in crop yields and water quality. Although some uncertainty exists about the rate and intensity of these changes—because they are contingent in part on the success of mitigation efforts—many of these changes are irreversible.[1,4] Thus, these impacts not only pose a considerable threat to human health and well-being, but they will also require much adaptation. Thus, a secondary goal of this article is to provide an overview of behavioral and psychological adaptation to climate change.

The article concludes with suggestions for researchers interested in advancing knowledge in this area. We demonstrate the utility of behavioral science insights in the dialog about climate change solutions, as well as the usefulness of integrating this knowledge into climate change models in related disciplines to promote multidisciplinary collaboration among the natural and social sciences. In sum, this overview aims to demonstrate that a behavioral science perspective is indispensible for increasing understanding of the anthropogenic drivers of climate change, how to mitigate them, and how to promote effective adaptation to our changing world.

HUMAN BEHAVIOR AS A DRIVER OF CLIMATE CHANGE

In the past century, human behavior has caused the Earth's temperature to rise higher than it has been since civilization developed about 10,000 years ago.[1] This is largely the result of changes in GHG-emitting human activities that increased substantially following the Industrial Revolution. Several key GHGs that are directly the result of human activity are carbon dioxide (e.g., from the burning of fossil fuels), methane (e.g., from the decomposition of organic waste in landfills and the production of animals for food), and nitrous oxide (e.g., from industrial processes).[5] As shown in Figure 1, environmental systems and human systems are inextricably interconnected.

In the United States, for example, individuals and households account for about 40% of the direct energy consumed, through home energy use and transport, and this does not take into account their indirect energy use through the purchase of other consumer goods and services.[7] Thus, climate-relevant individual decisions are at the heart of climate change. Given that people often have difficulty identifying the causes of their behavior,[8] the task falls to researchers to reveal the factors that most influence their decisions.

Of course, climate change-relevant behavior is not solely dependent on individuals. Collective psychological processes also come into play. Collective guilt, for example, is experienced when people perceive that their in-group is responsible for doing harm.[9] In terms of the present issue, collective guilt about GHG emissions mediates the effect of climate change beliefs on willingness to engage in mitigation behaviors.[10] Collective or group decision making is also important that groups have a voice in the decision can affect, for example, which mitigation strategy is supported.[11] These findings suggest that collective emotions and collective decision-making must be considered in order to fully encourage mitigative behavior.

KEY THEORIES OF ENVIRONMENTAL BEHAVIOR

Since the 1970s, environmental psychologists have worked to identify which factors predict environment-related behavior, a line of research which is closely linked to that on climate change.[12] This research has suggested that behavior is predicted by the interplay of three general influences: intrapersonal, such as personality states, values, and motivations; interpersonal, such as social comparison and social norms; and external, such as rewards and punishment. An early model of proenvironmental behavior, the knowledge deficit model,[13] assumed a causal progression from environmental knowledge to environmental concern to proenvironmental behavior, but it has now been largely discredited. Research shows an important gap between proenvironmental attitudes and proenvironmental behavior,[14–16] and more recently several suggestions[17] and theoretical frameworks have been advanced to explain this weak association. That many barriers may separate intention from action has also been recently documented.[18]

No current model seems solely sufficient to account for the complexity of behavior, but some are more widely used. One of those is the theory of planned behavior (TPB; Figure 2),[19,20] an extension of Fishbein and Ajzen's[21] theory of reasoned action. Both endeavor to explain how attitudes and

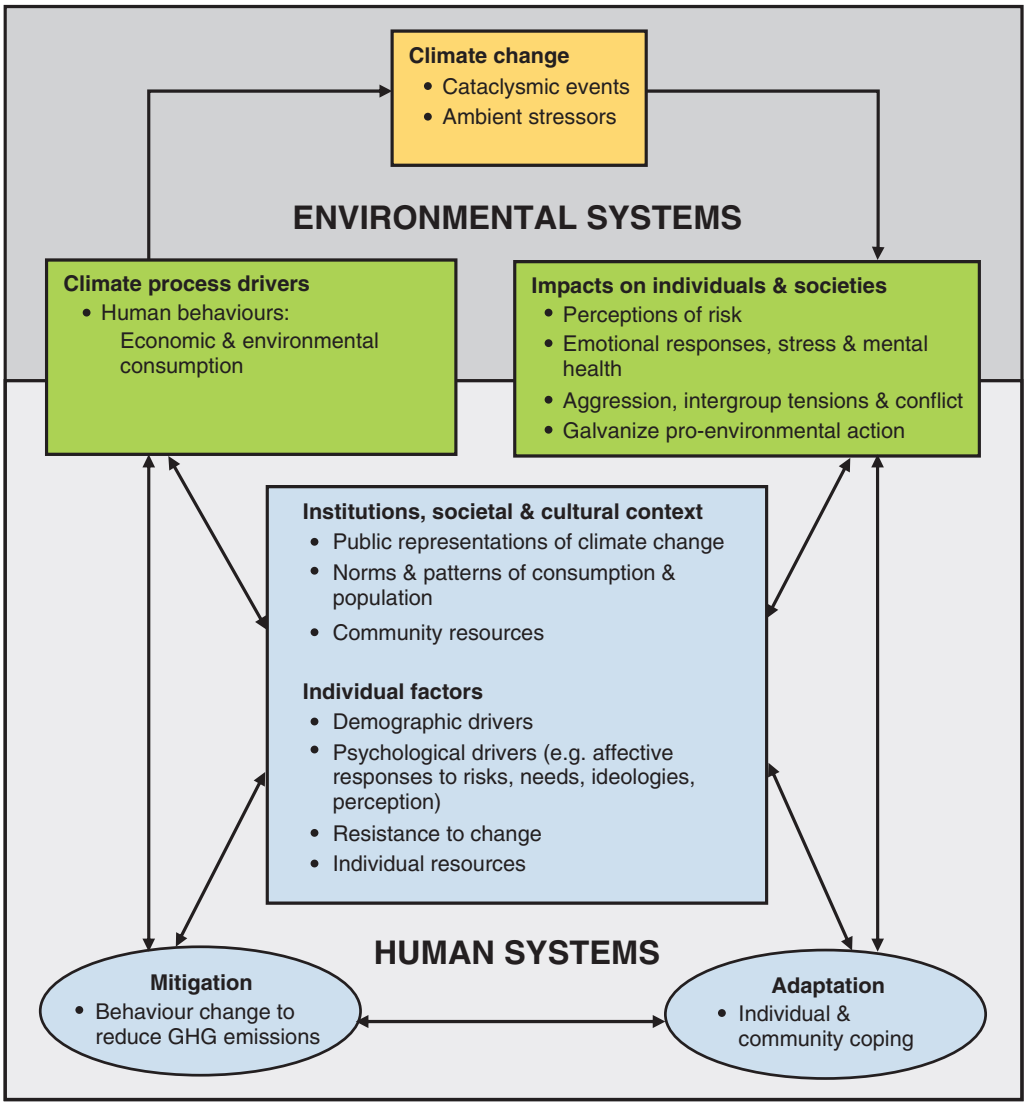

FIGURE 1 | Human–environmental climate systems.[6]

behaviors are connected. Ajzen and Fishbein noted that behavior-specific attitudes are more predictive of intent, and thus of proenvironmental behavior, than are generic environmental attitudes. The TPB assumes that behavioral intention (i.e., to behave proenvironmentally) is the most proximal psychological determinant of behavior. It posits that intention is, in turn, causally determined by three factors. First, individuals must have a positive attitude about the climate-relevant behavior (as determined by their values and beliefs). Second, individuals must believe that social norms support the behavior,[19] that is that the behavior is normal and congruent with the expectations of important reference individuals or groups. Finally, individuals must believe that they have sufficient control over the action. The TPB posits that the more that these three factors are aligned in the proenvironmental direction, the more likely the person will intend to engage, and will actually engage, in proenvironmental behavior. The TPB has been successfully applied to explain a range of environmental behaviors, such as recycling[22,23] and public transport use,[24] although its explanatory power can be increased when the model is supplemented with additional variables, such as habits[25] and descriptive norms,[24] as well as self-identity and past behavior.[26]

Two other commonly used theoretical frameworks to predict and explain proenvironmental behavior are the norm activation model (NAM)[27] and its spin-off, the value-belief-norm (VBN) theory[28,29] (Figure 3). The NAM proposes that an individual perceives a problem (e.g., potential negative consequences

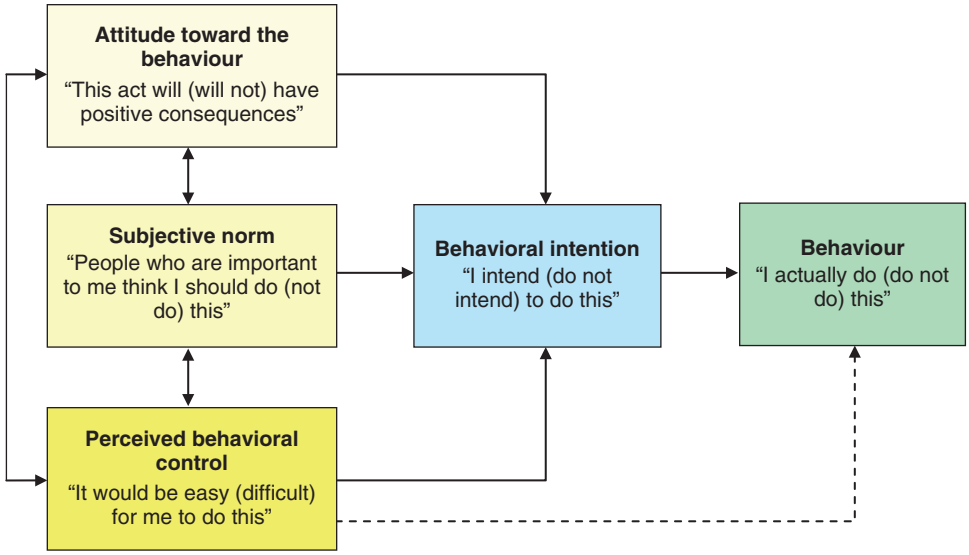

FIGURE 2 | The theory of planned behavior.[19,20]

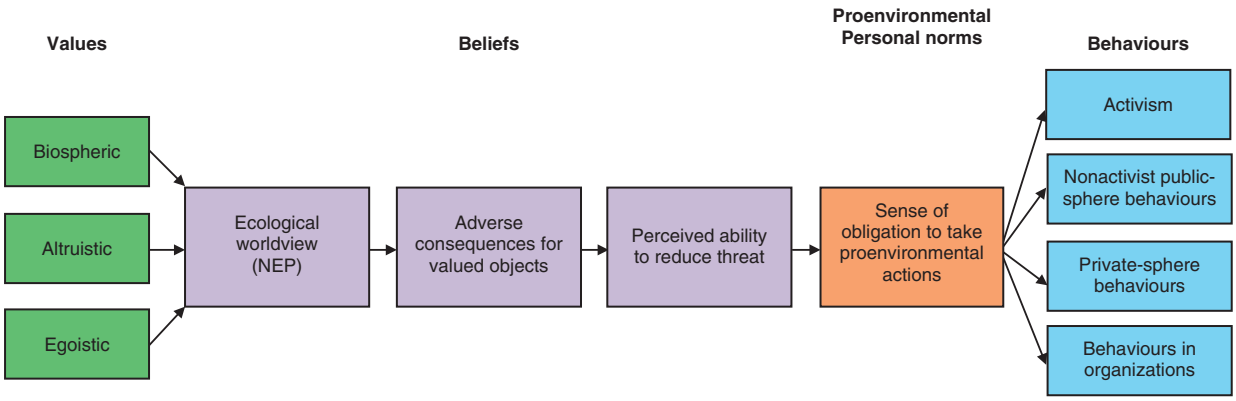

FIGURE 3 | The value-belief-norm theory.[28,29]

to the environment), understands the consequences of action or inaction, and then weighs the benefits or costs of acting or failing to act.[30] Stern and his colleagues modified the NAM to develop their VBN theory specifically to explain environmental behavior.[28,29] The VBN theory adds to the TPB's causal chain by suggesting that personal values precede environmental beliefs. It asserts that behavior follows from personal norms, which are activated by a belief that environmental conditions will threaten something valued by the individual (e.g., nature) and the belief that the individual is able to act to reduce this threat. The VBN theory further suggests that these two beliefs stem from one's general conception of human–environment interactions in that it combines the NAM with the New Ecological Paradigm.[31,32] The VBN theory has been successfully applied to explain various climate-relevant behaviors, such as the acceptability of household energy-saving policies[33] and willingness to reduce car use.[34]

Other, more sophisticated, models have also been proposed, such as Hines, Hungerford, and Tomera's[35] model of responsible environmental behavior, among others.[36–38] However, as noted by Kollmuss and Agyeman,[15] none of these models overcome the fact that associations between knowledge and attitudes, attitudes and intentions, and proenvironmental behavior are weak. This suggests that behavior is also determined by external, or situational, factors, such as economic constraints, available options, and other psychological barriers.[18,35] When attempts are made to include a broader or even complete set of influences on proenvironmental choices made by people, the model becomes very complex.

The most comprehensive model, which links psychological influences with those from other social

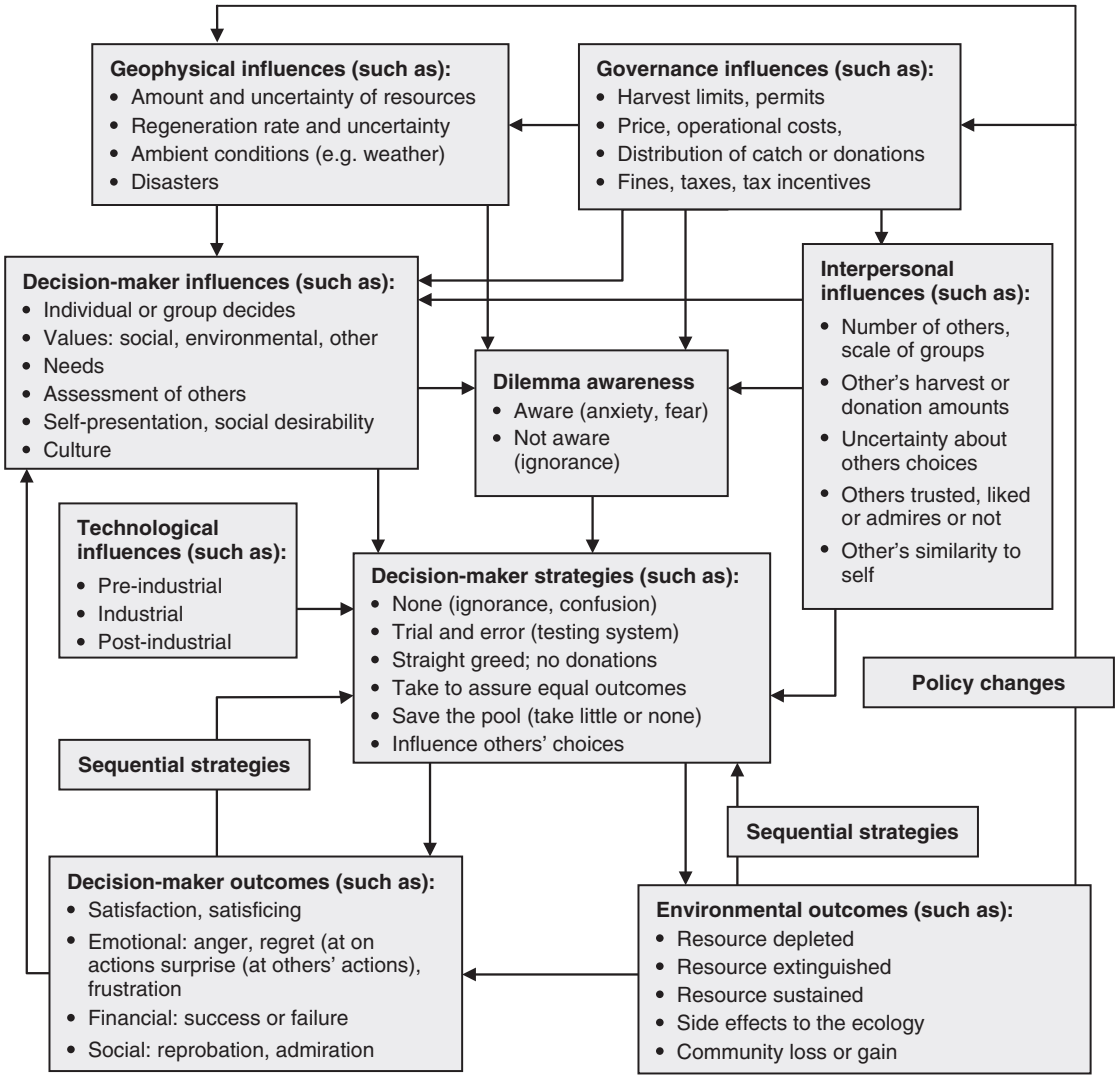

FIGURE 4 | The general model of social dilemmas.[39]

and natural sciences, is the General Model of Social Dilemmas (GMSD; Figure 4).[39] The GMSD recognizes that choices which affect the environment often have a geophysical element (e.g., weather, and the accessibility of the resource), a regulatory context (e.g., policies, rules, and pricing), and technological elements (e.g., gas vs. electric engines), in addition to psychological elements (e.g., motivation, cognition, norms, interpersonal influences, and decision-making strategies). It also acknowledges that environmental decisions affect not only the individual decision-maker (and significant others), but also the community and the environment. Finally, it recognizes that these outcomes feed back their consequences so that the regulatory context (in particular), but even the geophysical and technological factors, are affected in a continuing dynamic cycle of influence.

SELF-REPORTED PROENVIRONMENTAL BEHAVIOR VERSUS OBJECTIVE ENVIRONMENTAL IMPACT

In most social science studies, proenvironmental behavior is assessed by self-report. Although environmental impact generally is lower for those who report behaving more proenvironmentally, and some research suggests that self-reports are adequate predictors of actual behavior (e.g., see Refs 40 and 41), self-report measures of proenvironmental behavior are generally only weakly associated with environmental impact.[34,42,43] Consider the difference between a low-income person who lives downtown and cares little about the environment and a middle-class person who lives in the suburbs and cares deeply about the

environment. The poorer person does not drive, lives in a small apartment that uses little heat, and buys little. The middle-class person purchases a hybrid vehicle, organic vegetables, and lives in a 'comfortable' single-family house full of Energy Star appliances. The middle-class person appears 'greener' based on environmental concern measures, but the poor person actually has a smaller environmental impact[34] and, therefore, can be thought of an 'inadvertent environmentalist.'

Several factors help to account for the discrepancies between self-reported behavior and actual environmental impact.[43] First, individuals may not provide accurate reports of their behavior because of social desirability or other response biases. Second, these discrepancies may result from a lack of awareness about the environmental consequences of their behaviors; individuals may unintentionally or 'unavoidably' engage in anti-environmental behaviors, as evidenced in the example above. Third, some measures bias responses toward falsely strong proenvironmental scores because respondents are often asked about a series of environment-related behaviors which, as individual actions, have a low impact. Clearly, these measures should weight each item according to its actual impact, rather than merely sum them as equals. This mismatch between self-reports and objective environmental impact is problematic because studies that fail to recognize the mismatch may produce flawed conclusions about how to facilitate proclimate behavior.

HIGH- AND LOW-IMPACT BEHAVIORS

Distinguishing among subclasses of proenvironmental behaviors is important in part not only because each can have different psychological and contextual determinants (see Refs 44 and 28), but also because these behaviors vary widely in terms of their objective environmental impact (Table 1). Unfortunately, many existing studies have focused on actions which have relatively small environmental impacts, such as refusing plastic bags in retail stores.[45] Such studies provide knowledge about the factors identified as important predictors of low-impact behaviors, but whether the same factors might also be useful for reducing high-impact behaviors is questionable.

Evidence suggests that environmental attitudes, personal norms, and values tend to be related more to low-impact behaviors than to high-impact behaviors,[46–48] whereas high-impact behaviors, which tend to be psychologically important and entrenched in habit, are often primarily explained by contextual factors and are typically more difficult to change.[49] Perhaps understandably, but regrettably, behaviors that are easiest to measure often receive the most research attention, and thus more impactful behaviors have not been studied in proportion to their importance.[7] This is problematic given that the ultimate goal of research on proenvironmental behavior is to reduce environmental impact.[43]

Some policymakers hope that low-impact 'catalyst behaviors' (e.g., recycling) will lead to the adoption of higher-impact behaviors through spill-over effects. Some evidence suggests that such effects occur[26,50] but other evidence suggests that action in one behavioral domain sometimes leads to inaction in others, resulting in no net positive effect on consumption.[51] Thus, presently, the main utility of psychological constructs appears to lie in their ability to explain low-GHG impact behaviors, although the relative lack of research on high-impact behaviors leaves the answer to this question incomplete. Attempts have been made to combine attitudinal and contextual theoretical perspectives (e.g., Refs 52 and 39), but drawing conclusions about the relative predictive power of different variables or theories would be premature because high-impact behaviors have yet to be widely studied.

IMPACT- VERSUS INTENT-ORIENTED BEHAVIOR

The distinction between impact- and intent-oriented proenvironmental behaviors is important, but, until recently, had not received much attention. It may partly account for the often observed weak association between environmental attitudes and proenvironmental behavior. For example, environment-friendly actions sometimes are undertaken for nonenvironment-related motives (e.g., a person who cycles for health, not for climate reasons).[53] Intent-oriented behavior, which focuses on the actor's intention, and impact-oriented behavior, which focuses on the behavior's environmental impact,[28] do not always overlap. In a large-scale survey, for example, a marked discrepancy was observed between the percentage of respondents who stated that they engage in proenvironmental action specifically out of concern about climate change (31%) and the percentage of respondents who stated that they perform what are considered to be 'energy conservation behaviors' (96%).[53] These findings suggest that a great deal of GHG-mitigating behaviors may not necessarily, or consciously, be performed for the sake of the environment *per se*. Furthermore, intent-oriented environmental actions typically are determined by attitudes, whereas impact-oriented behaviors tend to be

TABLE 1 | Energy Conservation Behaviors, Ranked According to Their Energy Conservation Potential[7]

The Short List: Percent of Current Total US Individual/Household Energy Consumption Potentially Saved, by Action Effectiveness	
Action	Energy Saved (%)
For all Individuals and Households *Immediate Low-Cost/No-Cost Actions*	
Transportation	
1. Carpool to work with one other person	Up to 4.2
2. Get frequent tune-ups, including air filter changes	3.9
3. Alter driving (avoid sudden acceleration and stops)	Up to 3.2
4. Combine errand trips to one-half current mileage	Up to 2.7
5. Cut highway speed from 70 to 60 mph	Up to 2.4
6. Maintain correct tire pressure	1.2
Potential savings subtotal	Up to 17.6
Inside the Home	
1. Lighting: Replace 85% of all incandescent bulbs with compact fluorescent bulbs	4.0
2. Space conditioning: Heat: Turn down thermostat from 72°F to 68°F during the day and to 65°F at night A/C: Turn up thermostat from 73°F to 78°F	3.4
3. Clothes washing: Use only warm (or cold) was, cod rinse setting	1.2
Potential savings subtotal	8.6
Potential savings subtotal for nine actions listed	Up to 26.2
For all individuals and households *Long-term, higher-cost actions*	
Transportation	
1. Buying low-rolling resistance tires	1.5
2. Buy a more fuel-efficient automobile (30.7 vs 20 mpg EPA average-adjusted composite)	13.5
Potential savings subtotal for two actions listed	15.0
For homeowners: Inside the home *Immediate low-cost action*	
1. Space conditions: Caulk/weather-strip home	Up to 2.5
Immediate higher-cost action	
1. Space conditioning: Install/upgrade attic insulation and ventilation[1]	Up to 7.0
Potential savings subtotal for two actions listed	Up to 9.5
Longer-term, higher cost actions	
1. Space conditioning: install a more efficient heating unit (92% efficiency)	2.9
2. Space conditioning: install a more efficient A/C unit (SEER 13 or EER 12 units)	2.2
3. Refrigeration/freezing: install a more efficient unit (replace a 19–21.4 cubic foot top-freezer unit bought between 1993 and 2000 with a new Energy Star unit)	1.9
4. Water heating: Install a more efficient water heater (EFS 0.7 unit)	1.5
Potential savings subtotal for four actions listed	8.5
Total potential savings subtotal for six homeowner actions listed[2]	Up to 18.0

The potential savings listed in this table apply only to individuals and households that have not already taken the action. Adding up savings across actions can overestimate aggregate savings because of interactions between some actions. For example, the energy saved by caulking/weather-stripping a home will be less if a more fuel-efficient furnace is also installed. The estimates in the 'Increased Efficiency' column assume that consumers replace old equipment when it wears out rather than discarding functioning equipment. If consumers replace equipment before the end of its useful life, part of the energy they save by using the more efficient equipment is cancelled out by the energy used to manufacture the new equipment.
Please see *Environment*'s Web site, www.environmentmagazine.org, Notes for Table 3, for data entry sources.
[1]Roughly 80% of older homes are underinsulated, according to the US Department of Energy. 'Save Hundreds on Energy Costs,' *Consumer Reports*, October 2007, 27.
[2]Approximately 67% US households owned their homes in 2005.

determined more by many motivations, contextual influences, and demographic variables. Household energy use, as an example of an impact-oriented behavior, is most strongly related to nonattitude factors, such as income, household size, age, health, weather, and convenience.[42,53]

CURTAILMENT VERSUS EFFICIENCY BEHAVIORS

Distinguishing between two types of climate-relevant behaviors, curtailment and efficiency, is important.[33,54] C*urtailment behaviors* are repetitive efforts that reduce consumption (e.g., turning off a light switch). *Efficiency behaviors* are one-time choices that involve the adoption of an efficient technology (e.g., purchasing energy efficient light bulbs). The former are over-represented among reported intervention studies, yet the latter have greater energy-saving potential[47] (Table 2), although they are prone to the rebound effect.[55] An advantage of efficiency behaviors is that they do not require behavioral maintenance[56]; therefore, interventions that increase the adoption of efficiency behaviors are preferable. Nevertheless, curtailment actions are also helpful.

BEHAVIORAL AND PSYCHOLOGICAL RESPONSES TO CLIMATE CHANGE IMPACTS

Although mitigation efforts are *proactive* responses made to reduce future climate change, people also engage in *reactive* responses to climate change impacts (i.e., adaptation).[57] Some responses are both reactive and proactive (e.g., a flooded community might not only rebuild in response to the natural disaster, but also make structural improvements in anticipation of future flooding). Responses may be automatic or planned, include single, multiple or repeated actions, be carried out at the individual, community, or global level, and may take multiple forms (e.g., technological or behavioral).[6,58,59]

For climate scientists, *adaptation* usually refers to structural adaptations made to address current and impending physical impacts of climate change, such as building a sea wall in anticipation of rising sea levels. However, psychological adaptation also occurs. Adaptation has been defined in a task force report by the American Psychological Association (APA)[6] as 'a wide range of responses individuals can make to difficult circumstances including initial understandings, affective responses to situations, behavioral responses to situations, the process of selecting responses, and the reciprocating impacts of responses on individuals, communities, and the physical environment'[6] (p. 98). Psychological adaptation may also be maladaptive, as when the threat is artificially reduced by choosing one or more of the barriers described below,[18] thereby seeming to solve the problem by distancing oneself from it, by blaming others, or through unrealistic optimism.[60] Psychological adaptation can also be effective, when people mindfully attend to their negative emotions, adopt a problem-solving attitude, or shift their values.[60] This is similar to the notion of perceived adaptive capacity,[61] in which persons positively evaluate their efficacy to act in relation to their perceived costs of acting. Interventions designed to promote psychological adaptation follow from these considerations. These might involve sensitively pointing out a person's maladaptive tendencies, encouraging the expression of fear or other negative emotions so as to deal with them better, and to promote problem-focused strategies.[62] Ecopsychology explores emotional responses to global environmental crises and endeavors to provide therapeutic interventions to aid individuals in coping with climate change impacts, in part through developing each person's connection to the natural world.[6,63] Individuals who experience these therapeutic processes may be better able to adapt to climate change. However, so far, little published work reports investigations of psychological adaptation to climate change.

Nevertheless, climate change adaptation (in the psychological sense) and mitigation probably are intimately intertwined.[6] A person's psychological connection (or the lack of one) to climate change would seem to be strongly related to engagement (or not) in mitigative behavior. The structural dimension of adaptation has obvious value, but on its own does not speak to human motivation, meaning, and psychological outcomes. Fortunately, calls for research that engages the intertwined nature of mitigation and psychological adaptation have begun to appear.[64]

As the threat of climate change becomes urgent, a focus on psychological adaptation is needed. Social scientists and policy makers can draw on the results research on disaster preparedness, response, and recovery,[65] or the environmental stress perspective, which emphasizes stress and coping at the individual and community levels.[66–68] Relatively little work on climate change-related adaptation has been completed to date, partly because few communities have so far had to respond to the direct physical impacts of climate change; these include some in Alaska, northern Canada, and northern Europe.[69]

However, the APA report includes an organizational framework (Figure 5) that incorporates models

TABLE 2 | Potential Individual/Household Energy Savings Through Various Curtailment and Efficiency Behaviors.[7]

Estimated Percentage of Total US Individual/Household Energy Consumption That Can Be Saved by 27 Actions, by Action Type, 2005			
Curtailment	Energy Saved (%)	Increased Efficiency	Energy Saved (%)
Transportation			
Motor vehicle use			
Carpool to work with one other Person	Up to 4.2	Buy a more fuel-efficient automobile (30.7 vs 20 mpg EPA average-adjusted composite)	13.5
Alter driving (avoid sudden acceleration and stops)	Up to 3.2	Get frequent tune-ups, including air filter changes	3.9
Combine errand trips to one-half of current mileage	Up to 2.7	Buy low-rolling resistance tires	1.5
Cut highway speed from 70 to 60 mph	Up to 2.4	Maintain correct tire pressure	1.2
Inside the Home			
Heating and Air Conditioning			
Heat: Turn down thermostat from 72°F to 68°F during the day and to 65°F during the night	2.8	Heat: Install/upgrade attic insulation and ventilation[1]	Up to 5.0
A/C: Turn up thermostat from 73°F to 78°F	0.6	A/C: Install/upgrade attic insulation and ventilation[1]	Up to 2.0
Subtotal	3.4		Up to 7
		Heat: Install a more efficient heating unit (92 percent efficient)	2.9
		A/C: Install a more efficient A/C unit (SEER 13 or EER 12)	2.2
Subtotal			5.1
		Heat: Replace poor windows with high-efficiency windows	Up to 2.8
		A/C: Replace poor windows with high-efficiency windows	Up to 0.9
Subtotal			Up to 3.7
		Heat: Caulk/weather-strip home	Up to 1.9
		A/C: Caulk/weather-strip home	Up to 0.6
Subtotal			Up to 2.5
Space conditioning subtotal			Up to 18.3
Water Heating			
Turn down water heater thermostat from 140°F to 120°F	0.7	Install a more efficient water heater (EFS 0.7 unit)	1.5
Lighting			
Do not leave one 60 W bulb on all night	0.5	Replace 85% of all incandescent bulbs with equally bright compact fluorescent bulbs	4.0
Replace two 100 W kitchen bulbs with 75 W bulbs	0.3		
Refrigeration/Freezing			
Turn up the refrigerator thermostat from 33°F to 38°F and the freezer thermostat from −5°F to 0°F	0.5	Install a more efficient unit (replace a 19–21.4 cubic feet top-freezer unit bought between 1993 and 2000 with a new Energy Star unit)	1.9

TABLE 2 | Continued

Estimated Percentage of Total US Individual/Household Energy Consumption That Can Be Saved by 27 Actions, by Action Type, 2005			
Curtailment	Energy Saved (%)	Increased Efficiency	Energy Saved (%)
Clothes Washing and Drying			
Change washer temperature settings from hot wash, warm rinse to warm wash, cold rinse	1.2	Install a more efficient washer (replace a 2001 or older non–Energy Star washer with a new Energy Star unit)	1.1
Line-dry clothing (do not use dryer) 5 months of the year	1.1		
Color TV			
Watch 25% fewer hours of TV each day	0.6	Purchase (or trade in) 52′ Projection HD TV instead of a 48′ Plasma HD TV	1.3

The potential savings listed in this table apply only to individuals and households that have not already taken the action. Adding up savings across actions can overestimate aggregate savings because of interactions between some actions. For example, the energy saved by caulking/weather-stripping a home will be less if a more fuel-efficient furnace is also installed. The estimates in the 'Increased Efficiency' column assume that consumers replace old equipment when it wears out rather than discarding functioning equipment. If consumers replace equipment before the end of its useful life, part of the energy they save by using the more efficient equipment is cancelled out by the energy used to manufacture the new equipment. Data for electric heating elements, small appliances, and small motors could not be disaggregated for further analysis.
Please see *Environment*'s Web site, www.environmentmagazine.org, for a description of calculation strategies and methods and a complete list of sources.
[1] Roughly 80% of older homes are underinsulated, according to the US Department of Energy. 'Save Hundreds on Energy Costs,' *Consumer Reports*, October 2007, 27.

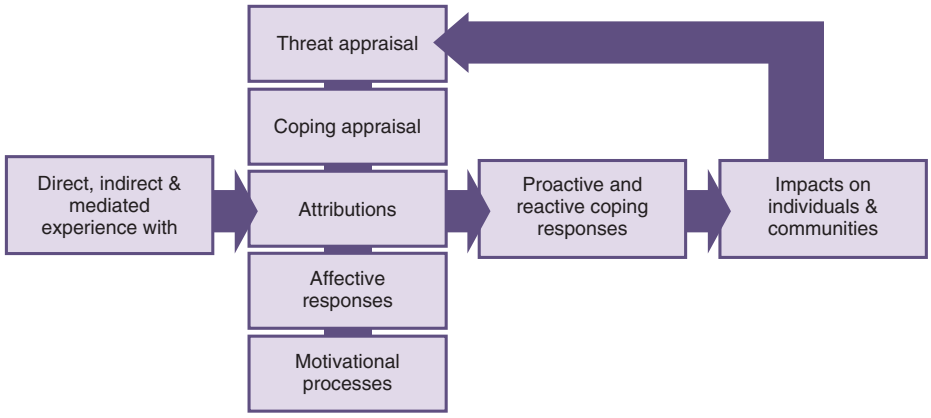

FIGURE 5 | A framework for coping as related to climate change.[6]

of environmental stress, coping, protection motivation, and health beliefs.[70–73] The framework proposes that the adaptation process is initiated by stressors, such as experiencing the impacts of climate change in the form of cataclysmic events or chronic environmental stressors. A variety of initial cognitive and affective responses to the stressors then mediate behavioral responses.

According to the framework, an initial appraisal of threatening information or events will occur, followed by coping appraisals that occur in response to stressors. These appraisals focus on evaluating how one might cope with and respond to the impact. In particular, these appraisals include assessments of one's ability to engage in a particular behavior, the likelihood that the behavior will lead to a particular outcome, and constraints on response options (such as a lack of resources and social support), and the relative costs and benefits of any feasible preventative action. Individual responses are also influenced by attributions about climate change, such as its causes or who is responsible for solving the problem, and these influence coping responses.[74,75] Affective responses are also part of adaptation: fear, anxiety, and hope influence coping responses and appraisals of threatening situations.[71,74,76–78] Finally, the framework includes motivational processes, because existing models of coping and stress propose that motivation is necessary for selecting coping responses.

These cognitive, affective, and motivational responses influence both intrapsychic and behavioral responses, which can occur at the individual and the community levels. Several intra-psychic coping responses to climate change are recognized (e.g., denial, environmental numbness, cognitive reappraisals, and emotion regulation), which may limit additional behavioral responses in some instances.[79] However, some individual behavioral responses to climate change are adaptive in a positive way, including seeking information or social support, or changing habits to adjust to a changing climate.[6] Another response that may be relevant for future research is the rejection of consumer-driven lifestyles (e.g., voluntary simplicity or the more radical 'freeganism').[80] At the community level, behavioral responses to environmental stressors include the emergence of volunteerism and other community-helping behaviors.[6,81] Many of these responses are in part related to the positive psychology approach to explaining human coping and adaptation to climate change,[82] which focuses on factors that influence individual well-being, happiness, and life satisfaction rather than on distress. Research from this perspective might focus on salutogenic actions and outcomes in the face of climate change, rather than inaction or distress.

Aspects of this general framework have been applied to real situations. For example, Grothmann and Patt[83] developed a sociocognitive model of private proactive adaptation (MPPACC) and applied it to decisions made by Germans who live on the flood-prone banks of the Rhine. Examination of their adaptive responses to future flooding (after prior flooding) found that sociocognitive factors explained the adaptive behavior better than did objective socioeconomic factors (e.g., home ownership and income levels).

Prevention and preparedness are also explored in the disaster and public health literature as potential coping responses. Both physical and psychological preparedness occur; physical preparedness includes preparations and actions made at the household level to protect self and family and to prevent damage and loss. Psychological preparedness refers to intra-individual awareness, anticipation, and readiness, reflected in one's capacity to psychologically respond in an emergency.[84]

Two other adaptation concepts are resilience and vulnerability.[85–87] The APA report refers to resilience as the 'inner strengths and coping resources for necessary adaptation to situational demands'[6] (p. 117). At the community level, resilience refers to the resources the group can draw upon, including knowledge, support systems, and social capital.[88–93] Vulnerability is the extent to which individuals and communities are at risk and are unable to cope with the adverse impacts of climate change. The differential resilience and vulnerability of individuals and groups influence their adaptive capacity.

Various models and frameworks in the existing literature that can help to explain individual and group responses to current and future climate change impacts. Although mitigation is an important way to reduce climate change, many individuals and communities will be forced to adapt to changes in climate. Psychologists and allied professionals must continue to investigate, understand, and reduce the impact of these adaptations that will inevitably occur.

PSYCHOLOGICAL BARRIERS TO MITIGATION

Despite widespread concern about climate change, many people fail to engage in behaviors necessary to mitigate climate change. Why are we not doing what is needed? As discussed above, the problem is the well-known gap between environmental attitudes and behavior.[14–16] This gap is caused by various barriers. For some, structural barriers (e.g., poverty and climate-averse infrastructure) hinder behavior change, but for others the barriers are psychological. Structural barriers may be lowered with social programs and infrastructure improvements, but psychological barriers are, arguably, more difficult to overcome. Collaboration between psychologists and other scientists, technical experts, and policymakers will be necessary to help citizens overcome these barriers.[94–97]

OVERVIEW OF PSYCHOLOGICAL BARRIERS

Researchers have begun to identify and categorize these proposed psychological barriers. Several category systems exist (e.g., Refs 15, 18, and 98), and the specific hypothesized barriers vary slightly among researchers. Lorenzoni et al.[98] suggest two levels at which barriers are perceived. At the individual level, they include uncertainty, lack of knowledge, reluctance to lifestyle change, etc., and at the social level they include lack of political action, social norms and expectation, and lack of enabling initiatives. Kollmuss and Agyeman[15] suggest that some barriers are internal (i.e., psychological) and others are external (i.e., structural). Gifford's exhaustive account of proposed psychological barriers organizes them into seven categories: limited cognition, ideologies, other people, sunk costs, discredence, perceived risks, and limited behavior.[18]

LIMITED COGNITION

The first category contains several barriers characterized by *limited cognition*. Humans are less rational than once believed (cf. Ref 99), and this applies to climate change as with other issues.

Ancient Brain

The human brain has not evolved much in thousands of years. Therefore, our brain remains much like that of our early ancestors: mainly concerned with exploitable resources and our immediate group, risks, and needs. For the most part, these concerns are incompatible with solving climate-related problems, which often concern many people, more distant risks, and delayed impacts.[100] Our ancient brain is *capable* of dealing with global climate change, but it does not come naturally.

Ignorance

Many people remain simply unaware of the realities of climate change,[101] and therefore are unlikely to act. Others, who are more aware, are paralyzed by their lack of knowledge about which specific mitigative behaviors to engage in, how to undertake those behaviors, and the relative benefits of various mitigation behaviors.

Environmental Numbness

Because environments offer more cues than we can monitor, we adapt by attending only to selected cues.[102] Thus, subtle changes in the climate or gradually increasing air pollution can go unnoticed. Behavior change is unlikely when people are unaware of problematic elements in the environment.

Uncertainty

Perceived or real uncertainty reduces the frequency of proenvironmental behavior.[103,104] People tend to interpret any uncertainty as a weakening of evidence for the argument being made and to interpret uncertainty in ways that serve their self interest. Therefore, when individuals believe that global warming *may not* be occurring, they are less likely to engage in climate mitigation.

Judgmental Discounting

Discounting leads individuals to undervalue spatially distant risks. A recent 18-nation study found that individuals believe that environmental conditions are worse in places other than their own.[105] When conditions are presumed to be worse elsewhere, people everywhere are less motivated to improve their local environments.

Optimism Bias

Optimism generally is a healthy outlook, but it can be overdone. For example, optimism can lead people to underestimate their likelihood of suffering from environmental risks.[106–108] Underestimation of risk can hinder one's action to ameliorate climate change.

Lack of Perceived Behavioral Control

Individuals may fail to act if they feel that they personally have little behavioral control over the outcome.[109,110] For instance, perceived lack of control predicts the choice between public transportation and driving.[24,111] Thus, when individuals perceive little control over the problem of climate change, they may fail to act.

IDEOLOGIES

The second category contains several barriers based on individuals' *ideologies*. Political or religious ideologies can be so encompassing that they determine a wide range of one's beliefs. When they clash with mitigation, they can be very strong barriers to behavior change.[32,112]

Worldviews

One predictor of disbelief in global warming is belief in the free-enterprise capitalism.[113] In general, some worldviews that are ostensibly about other topics, preclude support for climate change as a side effect.

System Justification

Particularly as people age and settle into a comfortable lifestyle, they tend to become less interested in change. Climate change challenges everyone to change the way that they live. Thus, one hears from some members of the community words to the effect, 'Why are you trying to rock the boat? Everything's fine as it is'. System justification is, from the point of view of a person who understands that action on climate change is essential, the equivalent of the legendary ostrich who has his head in the sand.[114]

Suprahuman Powers

Belief in a religious or secular deity can hinder taking action to reduce one's environmental impact. For

example, residents of one low-lying Pacific Ocean atoll threatened by rising sea levels are making plans to move to higher ground elsewhere, while residents of another trust that God will not break the Biblical promise to never flood the Earth again and so have opted not to relocate.[115] On the secular side, some believe that Mother Nature will take a course that mere mortals cannot influence. Naturally, inaction may follow from these beliefs.

Technosalvation

Mechanical innovation has an admirable history of improving the standard of living. Clearly, it can help to mitigate climate change; solar panels and wind turbines are just two examples. However, some place more faith in, for example, geoengineering than even geoengineers do.[95,98,116,117] As a result, overconfident beliefs in the efficacy of technology can serve as a barrier to individuals' climate-mitigating behavior.

OTHER PEOPLE

The third category pertains to barriers based on considerations of *other people*. As social animals, humans compare their situation to that of others.[118] These comparisons take several forms which may stand in the way of climate-relevant behavior change.

Social Comparison and Norms

From comparing their actions with those of others, individuals derive subjective and descriptive norms on which to base their presumed 'proper' courses of action.[113] Norms often favor anti-mitigative behaviors.[119,120]

Perceived Inequity

Perceived inequity often serves as a basis for inaction: 'Why should I change if ___ is not changing?' Additionally, perceived victimization by free-riders serves as a barrier for those who believe that they need not behave responsibly when they fear others will not.[110,121]

INVESTMENTS

The fourth category is comprised of barriers caused by *investments* individuals have made in money, time, or behavior patterns. These investments are valued by the individual, but may also be harmful to the climate.

Sunk Costs

Once one has invested in something, dispensing with it is more difficult than it would have been had one not invested in it.[122,123] Car ownership is a perfect example; having purchased a car, leaving it in the driveway to begin bicycling or taking public transit is difficult.

Behavioral Momentum

Habit is an important barrier for the mitigation of climate change impacts.[124] Many habitual behaviors are resistant to change (e.g., eating habits, the use of seat belts).[125] Some behaviors, such as vehicle use, are both major contributions to climate change and deeply ingrained habits, and are therefore difficult, although not impossible, to change.[25,52,126–131]

Conflicting Values, Goals, and Aspirations

Many goals and values are incompatible with the mitigation of climate change.[28,132–135] People often aspire to 'get ahead' and this means engaging in anti-mitigative actions such as purchasing larger houses or flying by choice. Although many agree that climate change is an important issue, it is generally seen as subsidiary to other issues. When asked to rank climate change amelioration against other concerns, many assign climate change low importance.[136] Thus, many individuals engage in behaviors that serve higher priorities.

(Lack of) Place Attachment

Individuals may be more likely to care for a place to which they feel attached than for one they do not. Therefore, lack of attachment can act as an obstacle to climate-positive behavior. More specifically, nature-based place attachment, but not civic-based place attachment, is associated with proenvironmental behavior.[137,138]

DISCREDENCE

The fifth category of barriers is *discredence*. When people perceive others in a negative light, they are unlikely to take direction from them.

Mistrust

If trust does not exist between citizens and scientists or government officials, resistance may follow. Behavior change requires that one trusts others not to take advantage, that others are honest and are motivated by public service, and that the change proposed is

effective, valuable, and equitable.[118,139,140] Trust is easily damaged through misquoted climate information or over-optimistic claims about future outcomes. When trust shifts toward mistrust, the probability of adopting mitigative behavior diminishes.

Perceived Program Inadequacy

Many programs to encourage climate-friendly behavior choices have been implemented by policymakers. However, most programs are voluntary. Thus, citizens have a choice whether to participate, and often decide that the program is not in their interest (cf. Ref 37).

Reactance

Some people strongly react against advice or policy that seems to threaten their freedom.[141] This is based in part on a lack of trust in those who give the advice or set the policy.[142] Reactance has been encouraged by some who have an interest in the fossil fuel industry, and this has helped to develop opposition to mitigation behaviors (cf. Refs 143 and 144).

Denial

Uncertainty, mistrust, and reactance can easily slide into active denial of the problem; this may include denial that climate change is occurring, that it has any anthropogenic causes, or that one's own actions play a role in climate change.[145]

PERCEIVED RISK

The sixth category of barriers relates to *perceived risk*, which frequently is present when steps are taken to change one's behavior.[146]

Functional Risk

The question 'will it work?' exists for many who consider new technologies proposed as adaptive solutions. For example, electric vehicles may have battery problems, wind power may be inconvenient, and all new technologies face similar questions.

Physical Risk

Some adaptations may have an element of danger or physical discomfort associated with them. For instance, cycling is an environmentally sound method of transportation. However, given the lack of infrastructure (e.g., bike lanes and paths) in many urban areas, cycling can be dangerous.

Financial Risk

The financial benefits of change may be outweighed by the risk of financial loss. Many green solutions require capital outlays that may, or may not, be recouped in a reasonable amount of time. Some mitigative products become a fixed part of a residence (e.g., solar panels), and so individuals risk not accruing enough savings before moving.

Social Risk

Many green choices are clear to others in the public sphere, leaving individuals open to judgments of others that may damage their reputation.

Psychological Risk

If social risks are strongly salient—one is teased, criticized, or even rebuked by one's significant others for engaging in some form of mitigative behavior change—one risks suffering damage to self-esteem and self-confidence.

Temporal Risk

Another very real risk involves the time spent planning and adopting the new course of action; the time invested might fail to produce the desired benefits, and if so, the time spent would be wasted.

According to cultural theory (CT), the perception of risk may be constrained by one's social group or culture,[147] and according to the social amplification of risk framework (SARF), the perception of risk can be amplified (or attenuated) through communication among individuals, groups, or the media.[148] CT proposes that people hold one of four worldviews: hierarchical, individualist, egalitarian, or fatalist. These worldviews are said to strongly shape how those who hold them experience and perceive risk. SARF's main thesis is that the nature and strength of perceived risk is malleable, depending on amplifiers or filters that function as information about a threat makes it way along a chain of communication links (persons, groups, or media). Clearly, CT and SARF help predict the degree of risk perceived by an individual.

LIMITED BEHAVIOR

The seventh category is *limited behavior*. Many people engage in at least minimal action that helps to limit GHG emissions, and yet almost everyone could do more.

Tokenism

Some climate-related behaviors are easier to adopt than others, but have little impact on GHG emissions. The relative ease of adopting these behaviors means that they tend to be chosen over higher-cost but more impactful actions. This tendency has also been called the 'low-cost hypothesis.'[149,150] Tokenism is one reason that proenvironmental intent may not correspond with proenvironmental impact.[28]

The Rebound Effect

Ironically, proclimate choices may ultimately be less effective than they appear because of the rebound effect, which occurs when a mitigating choice is made, but the mitigative gains are diminished or even reversed by subsequent actions. For example, persons who buy a fuel-efficient vehicle may drive further than when they owned a less-efficient vehicle. The phenomenon has also been called the Jevons Paradox[151] and the Khazzoom–Brookes Postulate.[152,153]

THE BARRIERS AND CURRENT THEORY

Some of these barriers to behavior change are addressed in part by existing models of behavior, such as Ajzen's TPB model,[19] Stern's VBN theory,[28,29] Grob's model,[36] Pelletier et al.'s model,[37] Frantz and Mayer's[38] adaptation of Latané and Darley's 5-stage bystander intervention model,[154] Lorenzoniet al.'s[98] ideas, and those of Kollmuss and Agyeman.[15] However, none of these models is complete in terms of the barriers; being complete is difficult when one goal of models is parsimony. Nevertheless, even as a list, these barriers may be used as a useful set of constructs that will be heuristic to researchers and thought-provoking for policymakers, and perhaps they eventually will be encompassed in a larger model. Continued research and practice are needed to examine each barrier more closely, especially in the context of climate change. Measuring the extent to which individuals within different groups and contexts experience each barrier is important, so that interventions can be targeted effectively.

BEHAVIOR-FOCUSED INTERVENTION STRATEGIES

A variety of behavior-change strategies have been identified and employed.[97,155,156] Traditionally, they have focused mainly on information communication strategies. Although these are popular because of their cost-effectiveness and ease of implementation, they have not been particularly effective[7,158] (see Ref 157 for review). As a result, persuasive communications using social normative information, such as guilt appeals and responsibility appeals, have gained popularity in recent years. Other strategies, such as modeling desirable behaviors,[159,160] feedback,[158] social norms marketing, and financial incentives such as rewards and time-of-use electricity pricing[161,162] have also been tried.

The promotion of proenvironmental behavior is no simple task, given that individuals face a barrage of personal barriers and are rooted within social, institutional, and cultural contexts. Thus, the task requires creative behavior-change strategies that take these contextual complexities into account.[163] For example, community-based social marketing, a step-by-step pragmatic approach to behavior change, with demonstrated effectiveness as an alternative to information-intensive campaigns, has been devised to overcome these obstacles.[164]

However, some authors have questioned these intervention approaches. Crompton,[165] for instance, argues that current behavior change strategies typically aim at small, relatively painless behavioral changes (e.g., turning off the lights or switching to compact fluorescent light bulbs), in the hope that larger changes will follow. Some surveys suggest that spill-over effects across behaviors that are similar in nature do occur,[26] but other evidence suggests that change in one behavioral domain can lead to inaction in other domains, a so-called negative spill-over effect,[51] which is reminiscent of the rebound effect. This suggests that current intervention approaches may serve to undermine the likelihood that multiple mitigative behaviors are adopted, thus detracting from the broader systemic changes needed to affect meaningful environmental impact.[165]

Governments have been somewhat hesitant to implement stringent climate-related policies and regulations, partly fearing loss of public favor. As a result, policymakers are increasingly turning to behavioral economics as a way to 'nudge' citizens toward desired behavioral outcomes via low-cost and socially acceptable approaches.[166,167] The political benefit of this approach is that it seems to offer the potential to change behavior in a low-impact manner with little regulation and without consumers perceiving that their sovereignty has been compromised.[168] At its core, behavioral economics posits that economic models are implicitly behavioral and thus that the incorporation of psychological foundations can increase their realism which, in turn, allows for more accurate predictions and better informs policy.[169] Evidence from

laboratory and field experiments reveals systematic deviations in individual behavior that differ from behavioral predictions based on conventionally held assumptions in economic models.[170] This challenges the traditional notion that individuals are 'unboundedly rational' in their decision-making[171] and calls for the inclusion of psychological measures into economic models.

For example, economic models have long sought to predict the impact of costs and benefits when they occur at different points in time (i.e., time discounting), under the assumption that individuals weigh future utilities by an exponentially declining discount factor. However, experiments indicate that a hyperbolic time discounting function matches the experimental data much more closely than does exponential discounting.[169] The environmental relevance of this discrepancy becomes apparent when the differences between these two discounting functions are examined. Individuals who discount utilities exponentially would, for instance, make the same decision prospectively as they would at the actual time of the decision.[169] On the other hand, individuals who operate according to the hyperbolic discounting function may wish to make far-sighted decisions in the future. Despite this, when that future arrives, they are likely to act in response to immediate, rather than long-term, rewards.[169]

Consequently, evidence suggests that bounded rationality assumptions should be incorporated into environmental policies to maximize their chances of success.[172–174] Some mainstream economists have already begun to adopt this alternative, bounded rationality-based, approach to their environmental policy making.[171,173] Ways in which behavioral anomalies may impact environment-related policies based on conventional environmental economics have been described in some detail.[175]

The inclusion of psychological principles into economic theory is a welcome change, but for some behavioral scientists, the main tenets of behavioral economics rest on overly simplistic assumptions about human behavior. Unfortunately, the divide between the disciplines of economics and psychology has tended to inhibit the effective transmission of knowledge and the development of maximally sophisticated behavioral economic models.[169] For example, the behavioral economics approach has been criticized for its emphasis on extrinsic goals and motivations (e.g., financial rewards), which are less successful in promoting long-term proenvironment behavior than are intrinsically derived motivations.[62,165] Its short-term and individualistic focus also runs the risk of being overly reductionist and mechanistic. Although 'all economics rests on some sort of implicit psychology'[62,165–169] (p. 42), increased collaboration between behavioral scientists and economists is crucial for developing a more nuanced approach to behavioral economics.

This leads critics of conventional behavior change strategies to suggest that campaign resources might be better spent on approaches that do not focus on small behaviors.[165] They suggest that positive spill-over effects will be more likely when individuals commit to a new behavior for environmental, rather than financial, reasons and stress the importance of focusing on values and self-identity as the crucial factors where barriers exist. They also suggest that intrinsic motivation (e.g., personal growth or community involvement) is more likely to lead to proenvironmental behavior than extrinsic motivation (e.g., the acquisition of material goods or social recognition). Moreover, they note that this effect is particularly strong for environmental behaviors that require greater effort. Crompton believes that targeting simple behaviors in marketing approaches encourages people to engage in them for self-interest, and therefore such approaches may be insufficient to motivate people to engage in less impactful, but often more convenient and more expensive, behavioral changes. Finally, Crompton points out that governments must be lobbied for certain kinds of changes, which naturally leads to an approach based more on political strategy than on marketing.

GENERAL APPROACHES TO BEHAVIORAL INTERVENTIONS

Antecedent Versus Consequence Strategies

Two broad types of intervention strategies may be distinguished: antecedent and consequence.[158] *Antecedent strategies* (e.g., increasing knowledge or problem awareness through information campaigns, modeling, behavioral commitments, and prompting) are assumed to influence the determinants of behavior prior to its performance.[176] In contrast, *consequence strategies* (e.g., feedback, rewards, and punishment) are assumed to influence the determinants of a target behavior *after* the performance of the behavior. Consequence strategies assume that, through feedback, positive or negative consequences influence the likelihood of the behavior being performed in the future.

Informational Versus Structural Strategies

Another important distinction is between informational and structural strategies. *Informational strategies* aim to change the perceptions, norms, knowledge,

attitudes, and motivations believed to underlie the behavior. In contrast, *structural strategies* aim to alter the circumstances under which the behaviorally relevant decision is made.[177] The relative effectiveness of these two types of interventional strategies has been explored for specific environmental behaviors, such as household energy use,[56,156,157,178] and other environmental behaviors.[177]

Although informational strategies have shown limited effectiveness, some, such as prompting and eliciting an environmental commitment,[56,157,179] social marketing,[179,180] implementation intention strategies,[181–183] modeling, and the provision of descriptive norm information[56,184] have been effective for certain behaviors. In general, informational strategies are most effective for behaviors that are convenient, low-cost (in terms of time, money, effort, and social disapproval), and have few structural constraints.[177] Informational strategies may also be used to increase public acceptance of structural strategies when individuals are forced to alter their behavior.[184]

Structural strategies, such as changes in physical or technical systems, legal regulations, or pricing,[177] are most effective when external factors render the performance of the proenvironmental action difficult or costly. In such circumstances, changing the costs and benefits associated with behavioral alternatives may be necessary so that the proenvironmental behavior is easier or more appealing to perform.[29,185] These structural strategies typically employ some form of reward or punishment, but in general, rewards are more effective because they create more positive emotions and cognitions.[158,186] Unfortunately, the positive effects of rewards often persist only as long as the reward structure exists. Another limitation of rewards is that they tend to be successful only when they activate an individual's behavior-change goals and help the person to achieve those goals, which often does not happen when rewards are the sole intervention strategy.[183]

The most effective interventions are tailored to the individual (or household) and to the specific behavior, take into account the particular barriers, and employ a combination of strategies, given that proenvironmental behaviors often involve a variety of informational and structural barriers.[47]

DESIGNING, IMPLEMENTING, AND EVALUATING A BEHAVIORAL INTERVENTION

Behavioral interventions are typically most effective when they are systematically planned, implemented, and evaluated, and guidelines for designing successful interventions have been generated.[164,176,177,186] First, carefully selecting the target behavior that is to be changed (ideally a high GHG-impact behavior) is important. Second, the main factors that appear to underlie the behavior should be identified. Third, the intervention should then be employed in an attempt to alter both the target behavior and the identified behavioral antecedents. Fourth, the effects of the intervention should be evaluated, in terms of its impact on the target behavior, behavioral antecedents, environmental impact, and (optionally) quality of life. These four steps are displayed in Table 3.

TABLE 3 | Four Key Issues for Encouraging Proenvironmental Behavior[176]

Four Key Issues for Encouraging Proenvironmental Behavior
I. Which behaviors should be changed to improve environmental quality?
1. Select behaviors having significant negative environmental impacts
2. Assess the feasibility of behavior changes
3. Assess baseline levels of target behaviors
4. Identify groups to be targeted
II. Which factors determine the relevant behavior?
1. Perceived costs and benefits
2. Moral and normative concerns
3. Affect
4. Contextual factors
5. Habits
III. Which interventions could best be applied to encourage proenvironmental behavior?
1. Informational strategies (information, persuasion, social support and role models, public participation)
2. Structural strategies (availability of products and services, legal regulation, financial strategies)
IV. What are the effects of interventions?
1. Changes in behavioral determinants
2. Changes in behaviors
3. Changes in environmental quality
4. Changes in individuals' quality of life

Step 1: Select a Target Behavior

The first step in designing an intervention is to diagnose the problem, which includes choosing a target behavior.[177,183,187] Selecting behaviors that have a large impact on environmental outcomes is important because, as already mentioned, some interventions have focused on behaviors that are relatively easy to

change but have a low GHG impact, rather than ones that are more difficult to change but have a greater impact on the environment.

Step 2: Identify Behavioral Antecedents

Next, the key determinants, of the target behavior should be identified. Both psychological (e.g., attitudes, barriers, values, and goals) and contextual (e.g., technological, economic, legal, demographic, institutional, and cultural) factors should be considered when designing an intervention. Determining which of these are most influential for the specific target behavior is important, so that interventions can be designed to address the key barriers. Strategies that focus on contextual factors can importantly shape psychological factors.[188]

During this step, it is important to choose a theory upon which to base the strategy.[189] Theories not only supply potential explanations for behavior, which allows for more effective analyses and enables the researcher to make sense of the behavioral situation, but they also suggest how best to approach the problem (e.g., through rewards or a structural change). However, the complexity and variety of social problems necessitates the use of multiple theories and, as a result, the application of theories in interventional research can also present some challenges.[189]

Step 3: Choose an Intervention Strategy

The third step is to design an intervention strategy that best suits the target behavior. For example, those aimed at changing attitudes, personal norms, and values seem to be most effective for low-cost behaviors (e.g., turning off unused lights).[47,48] Financial and structural strategies seem to be more effective for changing high-cost behaviors with greater long-term impact (e.g., transport mode choices).[44,49] The effectiveness of a strategy also varies with characteristics of the target individuals; for instance, urban participants may respond differently to an intervention to promote sustainable transportation than rural participants, and other factors, such as guilt and socioeconomic status, also may influence the effectiveness of the intervention across different subsets of participants.

Step 4: Evaluate

Proper evaluation of the strategy's effectiveness, in terms of its ability to influence the target behavior and select behavioral determinants, is essential, to avoid wasted effort and funds and so that lessons learned can help to create more effective future interventions.[179] Measuring objective changes, such as whether energy use declined, is also important given the problems with self-reported behavior. Measuring changes to quality of life as a result of the intervention is also valuable[190]; sometimes people anticipate adverse changes, but find instead that their life actually improves.[113,191] Finally, wherever possible, the short- and long-term effects of the intervention should be assessed, given that target behaviors can return to baseline after the intervention.[179]

The conventional method of assessing effectiveness is to measure change as a difference from a baseline to a post-intervention rate of behavior. However, the use of difference scores to assess change has long been questioned.[192–196] An alternative procedure, the regressor-variable method, has been proposed to address these problems.[194] Other, more complicated, analyses may also be used to quantitatively measure behavioral change, such as multilevel modeling and time series analyses.[197]

These analytic approaches convey whether or not objective behavioral change has occurred, and they may include quantitative information about the role of independent variables or covariates. However, to understand other factors that may promote or hinder behavior change, a qualitative approach can be invaluable. Researchers increasingly recognize the benefit of mixed-method approaches that include both quantitative and qualitative analyses.[98] The two approaches are complementary: quantitative analyses emphasise the magnitude of an effect, and qualitative analyses emphasise the why and how of the effect. Together, these approaches comprise the best overall way of determining how and why an outcome or intervention was successful or not.

FUTURE DIRECTIONS

As the impacts of climate change are more widely experienced, the need to conduct research and interventions grows. Eight suggestions for future research on anthropogenic climate change mitigation can be advanced.[6,177] First, researchers should include, wherever possible, measures of actual (rather than self-reported) environmental behavior. If self-reports are unavoidable, then at least their reliability and validity should be examined. The distinction between impact and intent-oriented actions must be considered. Particular effort should be made to study high-GHG impact behaviors, such as travel mode choice and energy use,[177] as opposed to low-GHG impact behaviors, such as refusing plastic bags. The focus should be on the strength of effects on the environment,

and whether those are importantly influenced by psychological variables or are amenable to well-designed interventions.

Second, future research should more closely examine the impact of contextual factors on environmental behavior, and how these factors interact with psychological determinants. These investigations will result in refinements and improvements to existing models. The external validity of studies performed in specific contexts should be assessed (that is, their applicability in other contexts, such as other cultures, populations, and infrastructure situations). Claims about the generalizability of findings must be tempered by consideration of these contextual factors. The existence of 'inadvertent environmentalists' whose actions are climate-positive but not from proenvironmental motivation must be acknowledged, and research might be directed toward identifying ways to identify and harness their efforts.

Third, given the ubiquity and size of the attitude-behavior gap, efforts should be made to further understand how to close it. A large number of potential barriers and obstacles have been identified, but so far little research has examined such questions as which barriers are strongest in general or which barriers are strongest for which segments of the population. Once these questions are answered, the need is for research on ways to overcome the most significant barriers.

Fourth, research should further examine the conditions under which individuals accept or reject environmental regulations, new technologies, and interventions, as well as the ways in which they adapt to them (or not) over time. Investigating the appeal of policies or technologies will lead to improved messaging strategies for the general population and for specific population segments.[198,199]

Fifth, further evaluation of the conditions under which the different models are most useful would help to strengthen understanding of how various psychological constructs function to influence behavior. Furthermore, an examination of the extent to which models and their elements, predict environmental impact (as opposed to proenvironmental behavior), would open new avenues for mitigative strategies. Policies often are implicitly based on existing theories, but some current models (e.g., NAM[27], TPB,[19] and VBN[28]) include too few elements, and others (e.g., GMSD[39]) are so inclusive that they are difficult to test, although they can serve as the basis for discussions of policy and theory.

Sixth, more research should examine the conditions under which specific interventional strategies are most effective. Unfortunately, journal articles that focus on environmental attitudes and demographics outnumber behavioral intervention articles by about a 7:1 ratio.[56] Therefore, more research efforts that investigate which strategies are most successful for which types of behavior as well as the conditions under which rewards or penalties, or a combination of the two, are most effective.

BOX 1

GHG-EMITTING CULPRITS ARE NOT ONLY IN OUR GARAGES, THEY ARE ALSO ON OUR PLATES

The GHG contribution from the production of roughly 60 billion farm animals reared annually is often overlooked, and yet it accounts for 18% of global GHG emissions (including the particularly damaging gases of methane and nitrous oxide).[203] This contribution is even greater, for example, than the 14% of emissions accounted for by transportation behavior.[204] Thus the role of meat production should not be ignored.

According to R.K. Pachauri, Chair of the Intergovernmental Panel on Climate Change (IPCC), livestock-related emissions will continue to increase along with population growth[204] and will compromise the impact of other mitigation efforts, unless steps are taken. Therefore, we need to reduce the average global consumption of animal products and the carbon intensity from production.[204] Governments should consider policies to help curb growth in meat consumption[205]; however, mitigation strategies suggested by the IPCC probably would reduce related emissions by less than 20%.[204]

Clearly, steps must be taken to reduce demand for animal products. Consumers can reduce their carbon footprint through small changes to their diets. For instance, reducing meat consumption by 20% is equivalent to switching from a standard sedan to an efficient hybrid vehicle.[205] Some consumer groups have even proposed 'Meatless Mondays' as a way to encourage a reduction in meat consumption. As added benefits, a significant reduction in meat and dairy consumption would reduce the prevalence of cancer and cardiovascular disease,[206] and would also lead to improved animal welfare.

Seventh, intervention strategies should be evaluated according to experimental design criteria. Specifically, changes in the target behavior pre- and

post-intervention, changes in relevant behavioral determinants (i.e., psychological constructs), and changes in environmental impacts should be assessed. Effects in the intervention condition should be compared to those in a control group and, ideally, effect sizes should always be included. Future research would also benefit from evaluating quality of life before and after the intervention.

Eighth, collaboration among researchers in the social and natural sciences, as well as those within government agencies and technical experts, is vital. For their part, behavioral scientists can contribute to conceptual models that include economic, technical, and regulatory considerations as predictors of the effectiveness of policies or interventions.[200] For example, psychologists can help to explain why the gap between anticipated behavior change, based on classical economic theory, and that actually observed, is often fairly large.[201] On the other hand, the impact of psychological variables or intervention campaigns on GHG-emitting behaviors often depends on factors better-understood by scientists in other fields, such as engineers who specialize in energy-efficient technologies. In short, climate change solutions cannot be independently achieved by any one discipline[202] (Box 1).

CONCLUSION

Anthropogenic climate change involves a complicated interplay of intrapersonal, interpersonal, and contextual factors, and this interplay varies across GHG-emitting behaviors. Understanding these interconnected influences is necessary for developing effective intervention strategies. Models that attempt to account for these influences vary from simple (with the possible advantage of parsimony) to complex (with the possible advantage of completeness). The extent to which these models explain variations in high-GHG impact behaviors and actual environmental impact needs further study.

Further research is also needed on the psychological barriers to mitigation. This knowledge is necessary to design intervention strategies tailored to specific behaviors and participant populations. More intervention studies are also required; importantly, these strategies are most successful when they are systematically planned, implemented, and evaluated.[177,183,187] Although all research in this area is valuable, less emphasis probably should be placed on self-reported proenvironmental behavior and on low-GHG-impact behaviors in favor of observed, high-impact behaviors.

Despite these challenges, however, this area of research is replete with promise. By identifying and addressing these issues, future research will contribute more to understanding the mechanisms that drive anthropogenic climate change and our ability to address it. Environmental psychologists and other social scientists have an important role to play in promoting behavioral changes, but climate change is not only a behavioral problem; solutions to the problem require an interdisciplinary approach.

Climate change is not only a matter of mitigation: individuals will have to adapt to the changes. Behavioral scientists examine and predict how individuals and groups are now responding, and will later respond, to climate change impacts. These adaptive responses are subject to a number of social and psychological influences, and future research needs to examine these in the communities that are forced to adapt to climate change. Bolstering communities and giving them tools to effectively respond to climate change will ease the process of adaptation. Everyone will have to adapt, even those who think they are beyond the reach of climate change. People who are severely affected will move toward those in the less-affected parts of the world. Both globally and locally, climate change will alter the lives of people everywhere, and understanding how these billions of affected individuals help to mitigate it, or not, and adapt to it effectively, or not, is an essential part of the general task of confronting the challenges it poses.

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