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How Psychology Can Help Limit Climate Change

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The Intergovernmental Panel on Climate Change has encouraged psychologists to become part of the integrated scientific effort to support the achievement of climate change targets such as keeping within 1.5°C or 2°C of global warming. To date, the typical psychological approach has been to demonstrate that specific concepts and theories can predict behaviors that contribute to or mitigate climate change. Psychologists need to go further and, in particular, show that integrating psychological concepts into feasible interventions can reduce greenhouse gas emissions far more than would be achieved without such integration. While critiquing some aspects of current approaches, we describe psychological research that is pointing the way by distinguishing different types of behavior, acknowledging sociocultural context, and collaborating with other disciplines. Engaging this challenge offers psychologists new opportunities for promoting mitigation, advancing psychological understanding, and developing better interdisciplinary interactions.

Public Significance Statement
Addressing climate change requires unprecedented societal transformations within a short time frame. Psychological research has the potential to improve current and future initiatives to mitigate climate change; however, realizing this potential requires heightened attention to the climate impact of the behaviors we study and greater collaboration and integration across disciplines.

Keywords: climate change, climate change mitigation, interdisciplinarity

The recently published special reports by the Intergovernmental Panel on Climate Change (IPCC, 2018, 2019) provided impetus for the unprecedented societal transitions required to limit global temperature increase to 1.5°C, or even 2°C, and draw attention to options for lifestyle and behavioral changes. International attention is turning to the behavioral sciences for insights. This call for action presents the psychological community with an opportunity to make our research useful for advancing global, national, and local mitigation efforts. Psychology and the social sciences are important to addressing climate change: not only will climate change threaten human health and wellbeing (Manning & Clayton, 2018; Obradovich, Migliorini, Paulus, & Rahwan, 2018), but there is evidence that meaningful action on climate change may be beneficial to wellbeing (Jackson, 2005; Kasser, 2017). As researchers devoted to understanding human behavior and practitioners committed to human flourishing, psychologists need to be involved in addressing the challenges posed by global climate change. We focus on psychology, but the boundaries between social science disciplines are fluid so the agenda we sketch must engage other social sciences as well.

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In 2008, the American Psychological Association (APA) convened a task force on the Interface between Psychology and Global Climate Change.[1] The task force summarized a significant body of relevant psychological research, accumulated over decades (see National Research Council, 1984; Stern, 1992), addressing perceptions of climate change and its human causes and consequences, and called for further work around the topic. A rapid increase in psychological research on climate change has responded to that challenge (as documented by Clayton & Manning, 2018). Our goal here is to consider how further research can make an even greater difference in limiting climate change especially, but not exclusively, through reducing consumption of fossil fuels. Despite the growing body of research, we are concerned that psychology is falling short of its potential: the discipline has generated extensive knowledge about human behavior, but that knowledge has not been successfully deployed in programs and policies.

The Role of Individual and Household Behavior

Every day we make choices and take actions that influence our "climate footprints"—the impact of our actions on climate through emissions of carbon dioxide and other "greenhouse gases," changes in land use, and other drivers of climate change. For example, estimates suggest that behavioral interventions to curtail individuals' direct energy consumption could lead to about 10% reduction in household energy use (Capstick, Lorenzoni, Corner, & Whitmarsh, 2014), and if one includes decisions with longer term effects on direct consumption (e.g., installing insulation) the effects can be several times larger (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009). Indirect effects on emissions through changes in diet and other aspects of lifestyle can have additional and powerful effects; for example, Green et al. (2015) argue that up to 40% cuts in greenhouse gas (GHG) emissions from Western diets are reasonably achievable through individual action, primarily by substituting meat and dairy with plant-based foods (see also IPCC, 2019; and Poore & Nemecek, 2018 for even greater estimated cuts). Thus there is considerable mitigation potential in changing individuals' consumption behavior. Individuals can also affect both the supply and demand of GHG-producing goods and services through their other roles (e.g., as citizens and as members of organizations).

Part of the complexity in understanding the effects of individual action on climate change comes from the multiple time frames over which actions have effects (Stern et al., 2016). Psychologists' research efforts have predominantly focused on behaviors that can have immediate or nearly immediate effects on emissions: adjusting home thermostats, using public rather than private transportation, and so forth. These immediate actions often, however, have relatively small per-capita impacts on the emission of greenhouse gases. On a longer, decadal time scale, more substantial mitigation potential lies in infrequent or one-off behaviors that involve maintaining, upgrading, or replacing energy-using household equipment, such as motor vehicles, furnaces, and home insulation (Dietz et al., 2009) or from more fundamental lifestyle changes, such as adopting a vegetarian diet (Springmann, Godfray, Rayner, & Scarborough, 2016). Persistent changes in daily behavior, such as routinely using public transportation, have short-term effects that aggregate if the changes become habitual. On still longer time scales, individual choices, such as to initiate or join a community group to take mitigation action, or to influence public policies and organizational choices, may have even greater mitigation potential; however, this potential is hard to trace back to individual action and thus hard to quantify. Importantly, some long-term effects involve feedbacks between individuals' activities in the near term (e.g., reducing consumption of GHG-intensive food) and the larger social, political, and economic forces that set the context for individuals' consumer behavior in the longer term (e.g., by shifting social norms about food and the structure of the food system). As such, there is the possibility that changing individual behavior could contribute to a wider reshaping of social norms and practices, which could in turn influence other people's behavior. This means that the potential for individual action to effect meaningful climate change mitigation could be greater and more broad-

[1] Final report made available 2009; official version published 2010 at https://www.apa.org/science/about/publications/climate-change. The report was expanded and published as a special issue of *American Psychologist* in 2011 (see Swim, Stern, et al., 2011).

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based than is often assumed, albeit that the dynamics of such social learning are as yet little understood (Bury, Bauch, & Anand, 2019; Frank, 2020).

In contrast with the typical research focus on daily behaviors, attending to time frames highlights connections among behaviors. Actions in one time frame can affect the potential for action in other time frames. There has been a conjecture about negative spillover from short-term actions to longer term actions; for example, short-term reductions in household energy use can negatively affect longer term reductions by decreasing the motivation to make them (York, 2017). However, positive spillover is also possible, for example, if energy reductions in one area lead a person to look for additional opportunities to conserve, especially when behavior becomes tied to an underlying identity (Gillingham, Kotchen, Rapson, & Wagner, 2013; Nash et al., 2017). While research is ongoing, no strong evidence currently exists for substantial negative spillover (Maki et al., 2019).

In general, limiting climate change requires interventions at multiple levels and time scales: technology change and policy change are necessary, but do not obviate the importance of individual and household behavior, especially where these have the potential to push forward such systemic change; likewise, individual responses to climate change are necessary but must be supported and enabled by policy and structural change. Moreover, behavioral, cultural, technological, economic, and policy changes interact: None can be fully assessed without considering the others. For example, policies shifting energy supply away from fossil fuels to renewables may require changes in when and how energy is used.

This article argues for rethinking the approach to research on behavioral change to enhance its potential for limiting climate change. Distinguishing types of behavior that contribute to accelerating or mitigating climate change, detailed analyses of their predictors and more careful evaluations of the climatic effects of behavioral changes on different time scales are all part of this agenda. In the sections that follow, we describe challenges to psychologists' study of environmentally significant behavior and discuss the multiple ways in which individuals and households can act to limit climate change.

Changing Individual and Household Behavior to Limit Climate Change

Limiting global warming to below 2°C will demand profound changes in individual and household behavior, and other disciplines are increasingly looking toward experts in behavior change in recognition of this need (e.g., Cinner, 2018; IPCC, 2018). While psychological approaches already contribute to this effort, we contend that a number of important factors are currently being overlooked. In the following, we first present two important dimensions that, together with the already-mentioned dimension of time scale, have so far constrained psychological research's contributions to climate change mitigation. Next, we discuss the too-dominant tendency for psychological researchers to study and develop interventions toward behaviors with limited potential to reduce GHG emissions. Finally, we discuss research on changing frequently and infrequently performed behaviors, and offer directions for how such research may become more relevant for climate change mitigation.

Overlooked Dimensions

The current and potential contributions of psychology to limiting climate change can be usefully considered in terms of two dimensions: (a) individuals' and households' roles and (b) factors affecting the effectiveness of potential interventions.

Roles. Individuals and households, the primary actors studied using psychological concepts, can act in many roles to effect change in emissions in any time frame; however, for the most part psychological research has focused on individuals' and households' roles as consumers, neglecting their other societal roles. Individuals' actions cannot only reduce the demand for GHG-producing goods and services but also affect the supply of zero-emission technologies and help alter actions by other people and by larger social entities. An appreciation of roles can also help to bridge the gaps between psychological approaches and approaches from other disciplines that have been more attentive to people's place in society, including their level of agency and power, and to cultural mores such as consumerism and to

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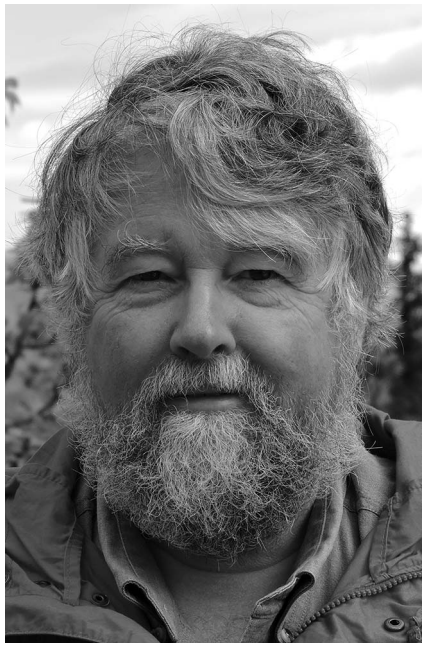
the potential to transition toward less destructive social practices (Brown & Vergragt, 2016). Building on previous work (e.g., Clayton et al., 2015; Stern, 2014; Whitmarsh, O'Neill, & Lorenzoni, 2010), we distinguish five roles: (a) consumers, who meet their material and social needs by choosing and using fuels, equipment, food products, and other consumer goods that emit GHGs or reduce emissions, either directly through their end use (e.g., automobiles, solar panels, home temperature controls), through disposal of household waste (e.g., recycling), or via "indirect" emissions across product and service life cycles; (b) investors/producers, who can reduce GHG emissions by installing low-carbon energy production systems for their own use (e.g., photovoltaic or heat pump technologies, electric vehicles that run on renewable energy supplies) or, if they have funds to invest, by investing preferentially in entities that reduce their own direct and indirect emissions or facilitate others in doing so (e.g., green investing); (c) participants in organizations that produce or can affect emissions and that may be subject to the influence of their members or employees (e.g., corporations, universities, government agencies); (d) members of communities (e.g., social, cultural, religious groups), through which they may deliberate, cocreate and disseminate information about mitigation options, and act collectively to reduce GHGs directly or indirectly (e.g., community tree planting, giving talks to schools or faith groups); and (e) citizens, who can influence policies at various levels to reduce emissions from the activities of public entities, to facilitate lower emissions choices by organizations and households in their jurisdictions, and to promote organizational investments in negative-emission technologies. Notably, some actions can fall into multiple categories or into different categories for different people. For example, food choice may be considered a simple consumer decision for some, with considerations limited to price, quality, the preferences of self and family, and so forth. For others, these factors matter but the implications of food choice for animal welfare, the environment, and social justice, make food choices a political as well as a consumer action; what has been called "political consumerism" (Boström, Micheletti, & Oosterveer, 2018).

Psychological research with respect to climate change mitigation has focused predominantly on the consumer role as defined above, treated decisions as if they happen largely in a sociocultural vacuum, and emphasized changes in frequent behaviors, such as the use of equipment or management of household waste. Such approaches typically rely upon the short time frame within which behavioral change is easiest to document. In addition, the emphasis has been on change in a target behavior, rather than on change in the impact or climate footprint of behavior, as can be seen by examining literature reviews (e.g., Osbaldiston & Schott, 2012). Studies of change in high-impact household investments are few and theoretically uncoordinated (Kastner & Stern, 2015).

Factors affecting impact (climate footprint). Stern (2011) proposed an equation to quantify impact: $I = tpn$ (see also Dietz et al., 2009; Vandenbergh & Gilligan, 2017). I represents impact on climate footprints. Technical potential (t, here called TP) represents the climate footprint of a target behavior if universally adopted. Behavioral plasticity (p, here called BP) is the degree to which a target behavior can be changed by an intervention over the time period studied. This is the aspect of effectiveness most familiar to psychologists, but we argue here that impact is in fact a function of BP $\times$ TP. As noted, the bulk of the psychological literature examines the plasticity of low-TP everyday behaviors affecting GHG emissions, although some has examined the plasticity of higher TP, longer acting behaviors such as purchases of energy-efficient or renewable energy-producing household equipment (Dietz et al., 2009; Kastner & Stern, 2015; Wolske & Stern, 2018). In the equation, *n* refers to the number of people whose behavior could possibly be changed. Impact (I), not behavioral plasticity (BP), is the key indicator for the potential practical value of psychological research. Interdisciplinary work on climate footprints has also added initiative feasibility (IF): the degree to which an intervention being considered, such as a financial incentive, a regulation, or an educational program, can actually be implemented by a change agent such as a government (Vandenbergh & Gilligan, 2017).

The implication of this analysis for behavioral scientists is the need to identify ways to achieve the greatest impact (I) established by previous research, or to find ways to go beyond previously achieved I, focusing on increasing behavioral plasticity (BP) for high-technical potential (TP)



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choices. Promising technologies and policy interventions fall short of expectations when they implicitly equate TP with impact, thus failing to consider BP. For example, research has long recognized that financial incentives for residential energy efficiency investments with high TP are far more effective, sometimes by a factor of 10, when BP is addressed, for instance, by reducing the cognitive effort required to make the investments (Stern et al., 1986). The hurdles involved in adoption, however, led to reduced effectiveness of financial incentives in the United States compared to other high-income countries during the 1980s (Stern et al., 1986). Such issues continue to be manifest today, for example, in limits to achieving high BP for adoption of photovoltaic energy production (Kastner & Stern, 2015; Stern, Wittenberg, Wolske, & Kastner, 2017).

Many analyses outside psychology primarily emphasize TP with limited consideration for BP. For example, Wynes and Nicholas (2017) estimated the TP of different actions and concluded that decisions relating to reproduction were of highest significance. But this analysis ignored issues of BP and the time scales on which emissions reductions would occur (Stern & Wolske, 2017; see also Wynes, Nicholas, Zhao, & Donner, 2018). A narrow focus on TP may skew analyses away from the highest-impact actions in much the same way as a narrow focus on BP. In our view, more psychological research should focus on actions with potentially high impact (the product, tpn), while considering the feasibility of implementing behavior change initiatives (IF) on large scale. Implementation of feasible initiatives can be critical for increasing BP for actions with high TP that have not yet been widely adopted (Wolske & Stern, 2018). Understanding the psychological, social, and policy factors that shape BP and initiative feasibility (IF) is also a worthy topic of research, as individual behaviors in nonconsumer roles might increase IF, for example, by promoting changes in organizational behavior or public policies.

The Challenge of Misplaced Focus

Because of consumers' and many psychological researchers' focus on short-term actions with relatively low TP (Thøgersen & Crompton, 2009), the impact of their efforts has been limited. The overemphasis on low-impact actions can be partly explained by misperceptions about what actions effectively reduce GHG emissions, which may, in part, be explained by the limited accessibility of information about the climate footprint of behaviors, consumer products, and services. For example, research by Attari, DeKay, Davidson, and Bruine de Bruin (2010) illustrated consumers' limited understanding of TP, and the difficulty consumers have in identifying effective actions to mitigate GHG emissions (see also Camilleri, Larrick, Hossain, & Patino-Echeverri, 2019; Whitmarsh, Seyfang, & O'Neill, 2011). Attari et al. (2010) found that individuals generally overestimated energy consumption for activities that use small amounts of energy and underestimated consumption for activities that use large amounts. This means that even when people intend to engage in mitigating actions, they often do not make the most effective choices. Oftentimes, individuals select actions derived from observations of other people or from intuitive notions of what constitutes low-emission actions, based on actions that are salient in memory, considered emblematic of environmentalism, or easy to implement; these, however, are rarely the most impactful.

Although psychologists study a wide range of behaviors, it appears that they often fail to consider the TP of target actions: many of the widely studied "proenvironmental behaviors" have low TP (Capstick et al., 2014; Dietz et al., 2009; Stern, 2014). The dominant focus on frequently performed behaviors is understandable because they are easily observed or reported; also, psychological factors have explanatory value for such behaviors (Bamberg & Möser, 2007; Wolske & Stern, 2018). The broad-brush definition of proenvironmental behaviors licenses psychologists to avoid undertaking a detailed analysis of a given action's impact on environmental outcomes, such as on climate change. When psychologists interested in proenvironmental behaviors neglect looking in detail at impacts, they risk reinforcing existing popular misperceptions of TP. For example, a recent review of behavioral interventions that promote proenvironmental behavior was unable to identify any interventions aiming to reduce air travel despite it being one of the highest GHG-emitting individual behaviors and one that is rapidly increasing (Wynes et al., 2018).

There are at least three reasons for concern about this overemphasis in psychological research on a generalized concep-

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tualization of proenvironmental behaviors uninformed by careful consideration of impact (I = tpn). First, by focusing on demonstrating the fit of particular theoretical models or the viability of certain interventions, behavioral researchers may ignore behaviors that matter in terms of climate impact. Second, as discussed below, high-impact behaviors may have different determinants than low-impact behaviors. Thus, behavioral researchers may be missing opportunities for their research to have a greater practical impact, to contribute optimally to cross-disciplinary efforts to inform initiatives and policies to limit climate change, and to develop more robust theory. Third, individuals who become aware of their misplaced focus may conclude that their efforts have been wasted, leading to reduced motivation to continue performing actions to mitigate climate change (York, 2017). While this possibility has not received much empirical attention, there is suggestive evidence for such effects (Hargreaves, Nye, & Burgess, 2013). For example, failure to adhere to the goal of recycling a water bottle was found to lower commitment toward the higher order goal of sustaining the natural environment (Devezer, Sprott, Spangenberg, & Czellar, 2014). Thus, the failure of actions to have the expected impact might leave individuals discouraged, disincentivizing engagement in higher impact actions. The practical importance of such effects is still under investigation.

Changing Frequently Performed Behaviors

Psychological research on frequently performed proenvironmental behaviors, such as recycling and switching off appliances, has identified numerous psychological factors relevant for understanding households' willingness to perform such behaviors (see Stern, 2000, 2011), and shown that these psychological factors can indeed be manipulated through behavioral interventions in order to reduce the GHG emissions from household behavior. For example, inducing goal setting or providing feedback can lower electricity consumption (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Karlin, Zinger, & Ford, 2015), and injunctive normative messages can produce short-term household energy savings (Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). This research has greatly improved our understanding of certain mitigation actions, but it neglects many behaviors with high TP (Stern et al., 2016). In what follows, we identify limitations of inferences from what is known about the mitigation behaviors psychologists most commonly study and point to pathways for increasing the contribution of psychological research to climate change mitigation.

Potential impact. Although many frequently performed behaviors have a low climate impact, even in the aggregate, this is not true for all of them. For instance, dietary decisions have a high TP if they are maintained over time. There is evidence that switching from a typical meat-intensive diet to a vegan diet has the TP to cut associated GHG emissions in half (Poore & Nemecek, 2018), and were it to be adopted by the entire world population, becoming vegan has the TP to reduce global anthropogenic GHG emissions by approximately 15% of total GHG emissions (IPCC, 2019). Thus, switching to a vegetarian and particularly a vegan diet would constitute a significant reduction in the overall climate footprint of an individual, and in aggregate, of the globe (Shepon, Eshel, Noor, & Milo, 2018).

Another frequently performed and significant behavior is the choice of travel mode for work, shopping, and leisure. Approximately 30% of the direct GHG emissions allocated to the average European household stems from transportation (Ivanova et al., 2017); thus, expanding the regular use of low-carbon transportation modes also has high TP (see Möser & Bamberg, 2008, for meta-analysis of related psychological interventions).

Certain frequently performed behaviors with moderate-TP would also yield consequential reductions in emissions if they were widely adopted (Carrico, Padgett, Vandenbergh, Gilligan, & Wallston, 2009). We do not advocate ignoring such behaviors, merely that psychologists should prioritize behaviors that have high mitigation potential in terms of impact (I = tpn), rather than merely focusing on those that are easy to study. We would not discourage people from undertaking these behaviors either, because they can matter in the aggregate (Stack & Vandenbergh, 2011; Vandenbergh & Gilligan, 2017).

Impact generalizability. The TP of a behavior does not always generalize across contexts; an important source of GHG emissions in one location may be relatively insignificant in another. This can be illustrated by household electricity consumption. Many behavioral interventions have been studied for reducing households' electricity consump-

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tion (Karlin et al., 2015), yet the importance of these behaviors is integrally determined by the source(s) of the electricity (Demski et al., 2018), and can vary by very large amounts even within countries. For example, in 2014 the carbon-intensity of one kWh of electricity was almost a hundred times greater in Kentucky than in Vermont due to differences in energy sources (Kennedy, 2017). Behavior change that reduces electricity use therefore has a highly variable impact on GHG emissions depending on what sources generate the electricity. A further complication in the analysis of impact (I) or TP is that electricity is moved across the grid, so that efficiencies in a place where most electricity is from renewable sources may allow the low-impact electricity to be transmitted to places where it displaces fossil fuels. Other contextual factors, such as geography and infrastructure, should similarly be considered when determining the TP of individual and household behaviors.

The factors influencing behavioral plasticity (BP) also vary by context. In particular, what affects frequently performed behaviors, such as thermostat settings, does not always affect infrequent, higher TP behaviors, such as improving home insulation (Black, Stern, & Elworth, 1985; Stern, 2011). Thus, what has been learned about the determinants of one type of behavior may not generalize to another. Moreover, and as will be elaborated below, even the determinants and the plasticity of the same behavior may differ between individuals, contexts, and cultures. The BP of a behavior will be affected by the frequency with which it is performed and the extent to which it is habitual; by the social norms surrounding the behavior; as well as by the perceived and actual capabilities of the actor.

Individual differences. People are different and so are the lives they lead. Identifying and recognizing how individual differences influence people's capacity for successfully executing behavioral changes to reduce their climate footprint are essential for more targeted and effective behavioral interventions. This relates to assessing both people's current climate footprints and their BP for change. Although psychological research has typically tried to characterize the behavior of an "average" individual, certain researchers have argued that it is as important to consider the nature of "behavers" as it is to consider "behaviors" (Galvin, 2013). Failure to consider individual differences may lead to inaccurate estimates about the potential impact of a particular behavior change. For instance, great variation exists in households' climate footprints across countries and economic classes (Hubacek, Baiocchi, Feng, & Patwardhan, 2017), so the potential for reducing emissions will vary too (Whitmarsh, Capstick, & Nash, 2017). Among the most important predictors of households′ climate footprint are wealth and income; studies have shown that the top 10% of people are responsible for around 50% of emissions with wide disparities both between and within countries (Gore, 2015; see also Chakravarty et al., 2009).

People not only differ immensely in their climate footprints but also in the resources they command and the freedom they have to make changes that reduce GHG emissions. The economically disadvantaged have limited funds to invest in new equipment, limited access to either credit or information, and often limited time to attend to energy and other climate salient consumption (Chen, Xu, & Day, 2017). Successful behavior change is also strongly dependent on cognitive, affective, and social factors (e.g., executive functions, emotional states, and social environment; Fitzsimons, Finkel, & vanDellen, 2015; Kotabe & Hofmann, 2015) that often interact with constraints due to socioeconomic and time-related factors, as further discussed below (e.g., Farah, 2017; Shah, Mullainathan, & Shafir, 2012). These individual differences may be especially pronounced when changing behaviors integral to lifestyle, such as adopting a vegetarian/vegan diet or changing travel modes, because they demand skillful behavioral monitoring and self-regulation over an extended time period as well as substantial time invested in learning the new practices (Nielsen, 2017). More research is needed to better identify these cognitive, affective, and social factors, and estimate their effect sizes across different types of frequently performed behaviors, and also to identify strategies to overcome the time, informational, and financial barriers faced by the disadvantaged.

Changing Infrequent, High-Impact Behaviors

The consumer actions with the greatest TP and often impact potential (I; Dietz et al., 2009) for affecting climate change are relatively rare events. These actions include

choices of where to live (Brand, Goodman, Rutter, Song, & Ogilvie, 2013) and in what sort of home; of household size; and of which equipment to acquire and use for transport, heating, cooling, and other energy-dependent services. These actions have received far less attention from psychologists than frequently performed behaviors, perhaps in part because being infrequent, it can be difficult to design studies of them with adequate sample size. Reviews demonstrate both the limited number of studies of these behaviors and the lack of consensus among researchers about which determinants of these behaviors are particularly worthy of examination (Kastner & Stern, 2015; Wolske & Stern, 2018). Psychological research on environmentally significant behavior has not made strong links to the traditions of research on transportation decisions, real estate purchases, and other aspects of consumer choice (e.g., Liao, Molin, & van Wee, 2017; Pettifor, Wilson, Axsen, Abrahamse, & Anable, 2017). It is not easy to quantify TP in order to select high-TP behaviors to study in particular contexts, but work in industrial ecology and environmental engineering, involving life cycle analysis of the climate footprints of goods and services (e.g., Ivanova et al., 2016), can point behavioral researchers in promising directions. Despite the relative paucity of research, some tentative conclusions can be drawn about how psychological concepts may be useful for increasing BP, particularly for high-TP behaviors (Vandenbergh, Stern, Gardner, Dietz, & Gilligan, 2010; Wolske & Stern, 2018).

First, for some segments of most populations, costs are an absolute barrier. Properly structured financial incentives can be an important, even if not a sufficient, condition for environmentally significant choices. However, financial incentives are most effective when integrated with initiatives that address other barriers to action (see below). Some research suggests that financial incentives can backfire by undermining intrinsic motivation, or at least minimize the possibility for positive spillover (Steinhorst & Klöckner, 2018).

Second, for greatest effect, valid information from credible sources should be available at the time and place of choice, and marketing efforts should engage with the people who interact directly with consumers at those times and places (motor vehicle dealers, home improvement contractors, salespeople in appliance stores, etc.; see Zarazua de Rubens, Noel, & Sovacool, 2018). These intermediaries may need special training or incentives. Indeed, the large literature on trust and persuasion shows that information source can be at least as important as information content or format (e.g., Clayton et al., 2015). Influence through social networks is undoubtedly very important (Frank, 2020; Henry & Vollan, 2014).

Third, information about the choice should be kept simple and provide a credible description of benefits associated with different choices on outcomes such as comfort, health, and social status (whether the benefits presented speak to people's intrinsic or extrinsic goals may influence effectiveness; Sheldon, Nichols, & Kasser, 2011). The choice information should appear on well-designed, easily accessible labels (e.g., Isley, Stern, Carmichael, Joseph, & Arent, 2016) or come as advice from trusted information sources. One-stop shopping, and minimization of paperwork, and delay in delivering incentives can make a substantial difference.

Fourth, carefully framing options and using choice-architecture approaches (e.g., default setting) can simplify decisions and create decision environments that allow consumers to make choices that are consistent with their preferences while also reducing emissions (Sunstein & Reisch, 2014). Finally, programs should provide credible guarantees of the promised benefits for consumers and adopters of emission-reducing technologies, for example by offering contractual guarantees of performance improvements or savings for renewable energy systems.

Understanding Context and Constraint

The value of psychological research for mitigating climate change can be increased by considering the dimensions and factors presented in the discussion above. In the following, we discuss how appreciating and incorporating factors mostly studied outside psychology, such as power and social structure, can facilitate integration across the social sciences and ultimately improve the generalizability of our research and the impact on climate change mitigation.

Because the primary focus of psychological research tends to be on individual-level variables (e.g., values, beliefs, and norms) our theories are developed around these variables and tested with data on individuals (Steg, 2016). There is a tacit acknowledgment that individuals' behavior is influenced by social structural and cultural factors that facilitate some courses of action and constrain others. We expect that most theory and empirical work by psychologists in support of climate change mitigation will continue to focus on the individual. But a more robust science may emerge if our theories and methods are attentive to contextual effects, to behaviors in nonconsumer roles, and to methodological and theoretical frames that emphasize other units than individuals. As described above, individual and household behaviors depend on structural factors and capabilities as well as individual factors such as motivations and values (Milfont & Markowitz, 2016). Social structures, roles and norms, physical infrastructure, and other factors beyond individuals create patterns of demand for environmental resources and help shape individuals' decisions and choices (Shove, 2010). For example, renters who pay utility bills have limited control over the insulation or heating equipment in their homes. Low-income homeowners often live in energy-inefficient housing and have limited financial

resources for energy-efficiency improvements even if such investments are fiscally prudent (Chen et al., 2017). In general, the disadvantaged also have less time and resources to investigate actions that would reduce their energy consumption and GHG emissions.

More subtle social and cultural influences also matter. Although individual choices are involved in transport behavior, which have a major impact on GHG emissions (Ivanova et al., 2017; Swim, Clayton, & Howard, 2011), the historically recent trend for living in suburban detached homes—which in turn affects households' travel footprints—constrains individual travel options and relates to cultural norms around "hypermobility" (Barr, 2018). Current patterns of housing and transportation infrastructure constrain the development of further infrastructure and influence which policies are practical or cost effective. But in turn, the pattern of residence and infrastructure is the result of a series of decisions both by consumers and by those individuals who in the past had the power to allocate resources and to develop infrastructure. We need theory and methods that can incorporate both individual agency and social structure and culture, and the interplay among them.

Although some influences on decision making, such as consumerism, seem to be as widespread as capitalist market economies, there can also be considerable variation across and within regions, countries, and cultures. Without a sound understanding of the effects of context, it is not possible to understand how results of an intervention in one place can be applied somewhere else. In a sense, a theory of context and structure is a theory of what generalizes and what does not. Thus, developing a robust and cumulative understanding of what matters in reducing GHG emissions requires a sound treatment of context. We cannot resolve these problems here, but we can point to some approaches and perspectives that can complement the typical research approaches in psychology and thus help embed those results in a broader and more robust understanding. As we emphasize in the next section, this attention to structure as well as agency will require psychologists to draw on perspectives that go beyond most work in psychology.

Seeing Agency and Structure as Part of the Same Process

The conflict between approaches that emphasize individual agency and those that emphasize structure stretches back to the earliest thinking about human action. But contemporary efforts to deal with the problem emphasize the sort of interplay we mentioned above (Dietz & Burns, 1992; McLaughlin & Dietz, 2008). Social structure and culture constrain what individuals can do or even imagine they can do, both as consumers and in their other roles. Social structure and culture are influenced by individual action, though, and while change may take generations, it also can occur very rapidly (Simms & Newell, 2017; Sovacool, 2016). We suggest that those focusing on individual action, structure and culture, or the dynamics of social structure and culture should be attentive to the fact that they address only a portion of the larger puzzle. When mindful of this, we can develop truly cumulative and useful understandings by integrating across studies and fields. This requires a collaborative effort where the work of psychologists, sociologists, anthropologists, and historians inform each other.

More Attention to Social and Economic Power

We noted above that some of the most consequential individual actions may lie outside the consumer role and involve influencing organizational decision making, communities, and politics. These are actions intended to change culture and social structure, and are currently examined by organizational and political psychologists, and researchers in other disciplines. They deserve more widespread attention from psychologists working on climate change mitigation. This will require consideration of the vast differentials in power that characterize most societies. A citizen of median income and a billionaire may both decide to engage on climate change policy, but the difficulty in mobilizing sufficient resources to have political impact is far greater for the typical citizen than for the billionaire (Dietz & Whitley, 2018).

Complementing Analyses Based on Individuals

While the individual will remain the primary unit of theory and analysis for most psychological research, this perspective could be complemented by other approaches. Most notably, this includes the analyses of organizational and political actions, in which individual actions can be important (e.g., Stern et al., 2016; Vandenbergh & Gilligan, 2017). Vayda (1988, 2009) has argued that understanding anthropogenic stress on the environment is best served by a focus on actions or practices. In an action-focused approach, one identifies an environmentally consequential action and asks why it occurs. Part of the explanation may reside in variables routinely examined by psychologists. But the explanation may also reside in routines and habits, and in structural constraints.

Social practice theorists offer a view of human action in which the individual is less an independent agent and more a "carrier" of practices that reflect social relations and are tied to physical environments (Shove, 2012). A frequently used example in relation to sustainability is that of showering which, social practice theorists contend, is a function of modern infrastructure (e.g., water, electricity, dedicated space in the home), daily rituals (e.g., getting ready to go out or unwinding at the end of the day), and contemporary conventions of cleanliness and propriety (Shove & Walker,

2010). Similarly, using the car as the dominant method of transportation is embedded in interconnected patterns of social practices, including working, shopping, visiting friends and family, and going to school. Social practices are partly constituted by, and always embedded in, material arrangements. Druckman and Jackson (2008) have shown that households in prospering suburbs far exceed the climate footprints of city dwellers. This reflects a social practice that involves large single-family dwellings surrounded by lawns, and the dominance of personal cars as a mode of transportation—a social practice in which any one element is not easily separated from the others. Thus, for social practice theorists, the appropriate unit of theoretical and empirical analysis is neither the action nor the individual but the overall practice.

Some researchers view these approaches as oppositional to the typical individual-level study (Adams, 2014; Batel, Castro, Devine-Wright, & Howarth, 2016; Shove, 2010). However, a focus on higher level or emergent phenomena, such as social practices, risks reification and dismissal of agency; furthermore, this focus often does not suggest points for intervention to effect change. Progress will be most rapid if various theoretical and methodological stances are seen as complementary with each approach informing the other (Wilson & Chatterton, 2011). Of course, our goal in this article is to consider how psychology can contribute to the mitigation of climate change, and it is in that context the relative importance of individual agency, social practices, and structural constraints should be considered. Recent work has attempted such integration by examining the synergy between findings on habits and routines (Kurz, Gardner, Verplanken, & Abraham, 2015), and between notions of behavioral spillover and "bundles" of practice (Nash et al., 2017).

Method and Practice

The problem of analyzing these links is also methodological and practical. Studying actual behavior, and especially via experiments that allow strong causal inference, comes with appreciable challenges. For practical reasons, this research is typically conducted with easily accessible populations and in contrived circumstances rather than large representative and diverse samples, or in ways that accommodate and recognize the complexities of people's everyday lives. Consequently, the typical psychological study has limited variation in terms of the socioeconomic circumstances, and the class and ethnicity of those studied. Furthermore, studies tend to be restricted by geographic and cultural location especially to the United States and Europe, and to "WEIRD" (i.e., Western, educated, industrialized, rich, and democratic) samples (Henrich, Heine, & Norenzayan, 2010), which limits institutional and cultural generalizability. Of course, a strong focus on WEIRD samples could be justified on impact grounds, as WEIRD populations often have disproportionally high climate footprints. Conversely, households in energy poverty may need to increase their energy consumption, so using more diverse samples helps psychologists understand and address the range of societal needs and circumstances. In terms of generalizability, the WEIRDness bias makes it difficult to examine the influences of broader structural and sociocultural factors on individual behavior. A remedy for this may be to coordinate studies across multiple local contexts to capture and analyze structural variation, or at least to systematically accumulate studies for secondary analyses (Marquart-Pyatt, 2013; Morren & Grinstein, 2016), and to ensure these studies measure actual behavior as far as possible (e.g., using energy/water meters, weighing waste). Psychologists could also benefit from drawing on qualitative and cross-cultural methods commonly deployed in other social sciences, particularly sociology and anthropology, in order to capture more fully the contextual factors shaping behavior. Ultimately, both theoretical and empirical work at the intersection of these approaches will be needed to determine the influences of structure and agency on environmentally significant action, and those influences will of course differ across contexts.

Working Toward More Interdisciplinary Collaboration

We reiterate our theme that while psychologists can do important, indeed crucial, work to advance climate change mitigation, their success will be limited if they restrict their engagement to within the discipline. Disciplines are reservoirs of theoretical and methodological traditions, where decades of careful work have led to the evolution of well-conceptualized theories and well-established methods. However, the very traditions, methods, and theories that allow for high-quality research within a discipline can lead to ignoring factors not central to those traditions. In our discussion of impact, we argue that psychologists will make their greatest contributions to climate change mitigation by focusing analytic attention on decisions and actions that can substantially reduce emissions (high technical potential, TP), that people can be effectively encouraged to take (high behavioral plasticity, BP), and for which effective policies and programs will be encouraged rather than blocked by political, economic, and cultural forces (high initiative feasibility, IF).

It seems obvious that psychologists should engage with engineers and other applied scientists in trying to understand the TP of behavioral changes. Understanding the effects of household choices on the climate footprints of product and service life cycles is a major and challenging field of research in itself, which implies a need for greater thoughtful engagement with experts on TP. In turn, those

discussions can be fruitful for the engineers and applied scientists because insights from psychology and the other social sciences can help shape the design of technology (Steg, Shwom, & Dietz, 2018).

While BP is already a familiar domain of research for psychologists, here too engagement with other disciplines is often warranted. As we have noted, individuals often face substantial constraints in being able to carry out high-TP actions, especially if those actions require seeking information from unfamiliar sources (e.g., contractors) or require nontrivial financial investments. Psychologists can certainly contribute to understanding financial and cognitive constraints and limits of expertise and confidence (Attari et al., 2010). But cultural factors may also matter both as a barrier in access to needed information and other resources, and in patterns of energy use. Sociologists, anthropologists, and economists have substantial experience studying such structural effects (e.g., Chen et al., 2017; Kempton, 1986; Lutzenhiser, 1992; Lutzenhiser & Hackett, 1993), and can facilitate improved treatment of these issues in psychological research.

In understanding IF, insights from other disciplines, including economics, political science, law, and public administration could be of great value. For example, the literature on how public policies are shaped by networks of individuals and organizations highlights how individuals can affect such policies in their roles as citizens and members of organizations. These networks not only include government officials but also representatives of industry, nongovernmental organizations, and social movements (Frank, 2011; Henry & Vollan, 2014). Such networks can also affect nongovernmental actions that govern GHG emissions (Vandenbergh & Gilligan, 2017). As we learn from and contribute to this research, it will be important for psychologists to appreciate approaches and paradigms that recognize units of analysis at a different level than the individual; for example, in terms of cultural determinants (Stephenson et al., 2010) and through actors such as civil society organisations and corporations (Tosun & Schoenefeld, 2017).

The ability of our scholarship to make strong contributions to mitigating climate change is most likely to develop by building understandings that integrate the strengths of various disciplinary traditions. Despite the many advantages of engaging with climate change mitigation researchers from diverse disciplines, doing so requires considerable self-reflection, humility, and a willingness both to challenge psychology's assumptions and to learn the language and perspectives of other disciplines. Psychological research cannot only contribute important knowledge to interdisciplinary collaborations (e.g., IPCC), but also represent a useful source of research on such collaborations (Clayton et al., 2015). Research on organizational and collective behavior is relevant to understanding and facilitating the complex dynamics that can be found in groups or teams of differently trained individuals.

Increasing the Impact of Psychological Research

Psychologists are learning to speak about research on climate change to an audience beyond disciplinary boundaries. The incorporation of psychological research into the IPCC reports provides increased legitimacy for the field as well as an opportunity to influence national policy and international discussions, even in countries without a well-developed tradition of psychological research. However, the continued use of insights from psychology will likely depend on their applicability to behaviors with large potential for impact. Subdisciplines of psychology that have so far been relatively disengaged from issues of mitigating climate change, such as organizational, consumer, and political psychology, may have much to contribute to the consideration of BP and TP.

Earlier articles have described how psychology can contribute to the strategic selection of behavioral targets, by assessing the likelihood that a behavior can be changed through external intervention (Clayton et al., 2016; Dietz et al., 2009). This includes high-impact behaviors for which the best established BP is rarely achieved and ones for which that level of BP could be exceeded by the use of psychological concepts. In the present article, we put the selection of behavioral targets in a broader context that includes an emphasis on TP and IF in addition to BP, and considers behaviors at multiple scales, including temporal scales. We argue not only for making psychological research more accessible to other scientists and policymakers, but also for interacting with other specialists in both problem identification and problem investigation. Mitigating climate change will require attention to psychological factors; however, psychological research will be most effective when psychology is only one of the tools in the toolbox.

Organizations such as the APA could enhance the ability of psychology to contribute to addressing climate change. Previous articles in *American Psychologist* have made recommendations to encourage interdisciplinary collaborations (Clayton et al., 2016; Swim, Stern, et al., 2011), such as incorporating information about other disciplines into psychological education and training, so that psychologists know the value of, and have skills for, interdisciplinary collaborations. Psychology conferences could also feature more interdisciplinary panels. APA journals could encourage more attention to the practical impact of behavioral interventions. If we want, as a discipline, to have an impact on mitigating climate change, such considerations should be part of our future.

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