Efficacy foundations for risk communication: How people think about reducing the risks of climate change

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Authors:
Katherine M. Crosman
Ann Bostrom
Adam L. Hayes

ABSTRACT

Believing action to reduce the risks of climate change is both possible (self-efficacy) and effective (response efficacy) is essential to motivate and sustain risk mitigation efforts, according to current risk communication theory. Although the public recognizes the dangers of climate change, and is deluged with lists of possible climate mitigation actions, little is known about public efficacy beliefs in the context of climate change. Prior efficacy studies rely on conflicting constructs and measures of efficacy, and links between efficacy and risk management actions are muddled. As a result, much remains to learn about how laypersons think about the ease and effectiveness of potential mitigative actions. To bring clarity and inform risk communication and management efforts, we investigate how people think about efficacy in the context of climate change risk management by analyzing unprompted and prompted beliefs in two national surveys (N=405, N=1820). In general, respondents distinguish little between effective and ineffective climate strategies. While many respondents appreciate that reducing fossil fuel use is an effective risk mitigation strategy, overall assessments reflect persistent misconceptions about climate change causes, and uncertainties about the effectiveness of risk mitigation strategies. Our findings suggest targeting climate change risk communication and management strategies to 1) address gaps in people's existing mental models of climate action, 2) leverage existing public understanding of both potentially effective mitigation strategies and the collective action dilemma at the heart of climate change action, and 3) take into account ideologically-driven reactions to behavior change and government action framed as climate action.

KEYWORDS: Efficacy; climate change; risk communication

1. INTRODUCTION

The prima facie purpose of risk analysis is to support and enable effective risk management. How people perceive their and others' ability to manage risk—specifically, perceptions of both the ease and effectiveness of possible actions—is pivotal to public response. Recent advances and practices in environmental risk communication, and in particular risk communication concerning climate change and extreme weather risks, demonstrate this centrality (e.g., Bostrom, Hayes, & Crosman, 2018; de Boer, Botzen, & Terpstra, 2015). They also reveal the need for greater clarity with regard to concepts and measures of efficacy in risk communication and management.

Global climate is already changing, with wide-ranging effects on both human and natural systems (Masson-Delmotte, Zhai, Pörtner, Roberts, Skea, Shulka, Pirani et al., 2019). Even under best-case scenarios, whereby current levels of emissions are immediately and drastically reduced and global average temperature increase is limited, climate change is expected to result in increasingly extreme temperatures, increased uncertainty and fluctuation in rainfall and fresh water availability, challenges to food systems, increased risks to human health, and loss of key ecosystem services (Masson-Delmotte et al., 2019). Climate change risk management is thus essential—and in order for individuals to manage risk, they must know which actions are effective, and feel motivated and able to take those actions.

Indeed, advising people what they can and should do about climate change has become a popular business. Little more than a year ago, within the span of a month the New York Times published two different sets of advice, one telling individuals to *fly less, drive less, and waste less* (Gillis, 2017), the other putting *waste less food* and *eat more plants* at the top of individual behaviors, following collective strategies such as *managing refrigerants* and *onshore wind turbines* (Schlossberg, 2017). Another contemporary analysis estimated that *having one less child, living car free,* and *flying less* are the most effective ways an individual can help slow or stop climate change. That analysis assigned *eating a plant-based diet* as the fourth-most effective thing a person can do, far less effective than the first (0.8 tonnes CO_2-equivalent emission reductions per year for a *plant-based diet,* versus 58.6 for *having one less child*,

in a developed country) (Wynes & Nicholas, 2017). Criticisms of such work include lack of attention to how easy it is for people to change their behaviors ("behavioral plasticity") (Stern & Wolske, 2017).

Social and behavioral scientists agree that household behaviors can help mitigate climate change (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009; Gardner & Stern, 2008), and that progress has been made on household behavior change even as federal regulation of greenhouse gas emissions has stalled (e.g., Vandenbergh, Stern, Gardner, Dietz, & Gilligan, 2010). Dietz et. al (2009), for example, found that U.S. national emissions could be reduced by 7.4% if individuals adopted household-level behaviors such as weatherizing homes, installing energy-efficient appliances, and purchasing fuel-efficient vehicles, even in the absence of new regulatory drivers.

In other environmental domains, knowledge and perceived ability to change behavior influence both intentions and actions (Bamberg & Möser, 2007; Heath & Gifford, 2002; 2006). However, people may not know what behaviors will help slow or stop climate change (Reynolds, Bostrom, Read, & Morgan, 2010; Seyfang, ONeill, & Whitmarsh, 2011), know which actions are most effective (Attari, DeKay, Davidson, & Bruine de Bruin, 2010; Swim et al., 2009; Wynes & Nicholas, 2017), or be able to undertake them (Stern & Wolske, 2017). Even among those who can identify a variety of effective and easy energy-saving behaviors, people often underestimate the associated actual energy savings (Attari et al., 2010; Attari, DeKay, Davidson, & Bruine de Bruin, 2011a; Frederick, Meyer, & Mochon, 2011), and fewer than half report engaging in all of them (Attari, DeKay, Davidson, & de Bruin, 2011b). Worse yet, one relatively recent study demonstrated a decline in individuals' confidence that energy-saving efforts could reduce global warming (Leiserowitz, Maibach, Roser-Renouf, Feinberg, & Howe, 2013).

Close scrutiny of scholarship on efficacy beliefs (see online Supplement) reveals a key knowledge gap: what actions and actors do laypeople think will effectively reduce risk by slowing or stopping climate change? Although mental models and other risk perception papers in *Risk Analysis* have touched on both efficacy (e.g., Bubeck, Botzen, Laudan, Aerts, & Thieken, 2018; Feldman & Hart, 2018; Kellstedt, Zahran, & Vedlitz, 2008a; Milfont, 2012; Tanner & Árvai, 2018) and perceptions of climate change risk (e.g., Bostrom, Morgan, Fischhoff, & Read, 1994; Leiserowitz, 2006; Read, Bostrom,

Morgan, Fischhoff, & Smuts, 1994; Reynolds et al., 2010; Smith & Leiserowitz, 2014; Taylor, de Bruin, & Dessai, 2014), research at the intersection is scant. For instance, are actions such as family planning or carbon taxes are salient, or even within the scope of laypeople's considerations? Even those papers that have investigated efficacy in the context of climate risk have not probed fully how easy or effective people think various actions are, relative to one another, let alone whether people "in the wild" (unprompted) make any of the fine-grained distinctions on which the literature dwells.

To address this knowledge gap, we asked survey respondents open-ended questions on what they think can be done about climate change or global warming by themselves individually, by individuals acting collectively, and by the government. Respondents then assessed on a standardized scale how easy and effective the actions they listed would be. We compared these assessments to their judgments of the ease and effectiveness of each of a selected set of actions designed to represent those commonly proposed as approaches to mitigating climate change risk or identified as likely to be effective in prior research (details in section 2.1).

The analysis of open-ended responses capitalizes on a hierarchical, open-ended coding scheme derived from prior mental models research (Bostrom et al., 1994; Read et al., 1994). The hierarchical coding scheme was critical, as mental models studies have shown that laypeople conceptualize climate change in a variety of ways, including at varying levels of specificity (Bostrom et al., 2018). Differences in specificity can be obscured when respondents react only to closed-ended survey items, rather than providing their own thoughts in response to open-ended questions.

1.1. Climate change risk mitigation efficacy

1.1.1. Definitions and distinctions

We make a key distinction between laypeople's perception of how easy it is to take a climate change mitigation action (self-efficacy) and how effective they believe that action would be in mitigating climate change (response efficacy). Each has a distinct influence on risk management preferences and behaviors (Bostrom et al., 2018; Milne, Sheeran, & Orbell, 2000). As in many previous climate change

studies, these constructs originate with Bandura's (2004) concepts of *individual self-* and *response efficacy*, *collective efficacy*, and *proxy efficacy*.

While these efficacy constructs have seen wide use in the climate change literature, there has been little consistency in their application (see online Supplement). Some scholars distinguish clearly between *self-efficacy* and *response efficacy* on climate change (Doherty, 2014; Truelove, 2009), but others don't (Heath & Gifford, 2006; Kellstedt, Zahran, & Vedlitz, 2008b; Mead et al., 2012; Milfont, 2012; Morton, Rabinovich, Marshall, & Bretschneider, 2011; van Zomeren, Spears, & Leach, 2010). Among authors who specifically use the term "efficacy," individual self- and response efficacy are often conflated, as in the statement "There are simple things I can do that reduce the negative consequences of the climate crisis" (Heath & Gifford, 2006), see also Brody, Zahran, Vedlitz, & Grover, 2008; Brody, Grover, & Vedlitz, 2012; Kellstedt, Zahran, & Vedlitz, 2008b; Milfont, 2012; Morton et al., 2011; Spence, Poortinga, Butler, & Pidgeon, 2011; van Zomeren et al., 2010).

Risk mitigation activity can occur in a variety of different contexts and social scales beyond the individual level, and perception of self- and response efficacy may vary significantly depending on whether the risk mitigation action being undertaken is performed by a government or by a collective, such as a community (Bandura, 2000). Individual and collective actions are often weakly delineated across types of efficacy (Bolsen, Leeper, & Shapiro, 2013a; Brody et al., 2012; Gifford & Comeau, 2011; Kellstedt, Zahran, & Vedlitz, 2008b; Milfont, 2012; van Zomeren et al., 2010). Relationships between actors and types of efficacy beliefs are complex; individual self-efficacy predicts collective efficacy perceptions in some studies (Truelove, 2009), but self-efficacy has no relation to group efficacy perceptions in others (van Zomeren et al., 2010). In one rare study of whether respondents distinguish efficacy types by actor, confirmatory factor analyses showed that respondents did treat as distinct the three categories of efficacy the author identified and tested: individual and collective self-efficacy for political action on climate change, and government response efficacy (Stenhouse, 2015).

Bandura's original conception of collective efficacy did not distinguish collective self-efficacy from collective response efficacy. This lack of distinction persists among some authors (Lubell, Zahran,

& Vedlitz, 2007; Roser-Renouf, Maibach, Leiserowitz, & Zhao, 2014; Thaker, 2012; van Zomeren et al., 2010), and is particularly important for climate change. Strategic actors who expect that others will not reciprocate individual mitigation behaviors may be less likely to engage in those behaviors (Aitken, Chapman, & McClure, 2011; Bolsen, Leeper, & Shapiro, 2013b; Lorenzoni, Nicholson-Cole, & Whitmarsh, 2007; Lubell et al., 2007; van Zomeren et al., 2010). Given the collective nature of the climate change problem, individuals still face incentives to free ride on the actions of others even if they believe others will undertake mitigation actions (Lorenzoni et al., 2007; van Zomeren et al., 2010). However, explicit recognition of collective action issues has to date been neglected by many studies on the role of efficacy beliefs in climate change.

Some papers that claim to measure efficacy actually measure other, related constructs (e.g., ascription of responsibility (Kellstedt, Zahran, & Vedlitz, 2008b; Milfont, 2012) or some combination of efficacy and other constructs (Brody et al., 2008; 2012; Mead et al., 2012). Other measures of constructs analogous to efficacy are not designated as "efficacy" by study authors (Attari et al., 2010; Gifford & Comeau, 2011; Lorenzoni et al., 2007; Ortega-Egea, García-de-Frutos, & Antolín-López, 2014; Tobler, Visschers, & Siegrist, 2012). For example, the statement "You think that if everybody changed their behavior, it will have a real impact on climate change" (Ortega-Egea et al., 2014) is intended to measure motivations for extra mitigation behavior, but also measures collective response efficacy. Similarly, the multidimensional concept of *carbon capability* (Whitmarsh, 2009) focuses on awareness, knowledge, and actions taken, as well as motivations.

The inconsistencies within the existing literature on efficacy and the risks of climate change give rise to our two primary questions: What do people think they and others can do to slow or stop climate change, and what do they think will be effective in achieving that end? In practice, do they distinguish between the ease of taking action to reduce climate change risks, and the effect of the actions taken?

2. METHODS

To insure the robustness of findings, two studies were conducted. The first employed a U.S. national sample recruited through Amazon's Mechanical Turk (MTurk) (Mossler, Bostrom, Kelly,

Crosman, & Moy, 2017).[1] Participants in the second study were from KnowledgePanel (GfK), which is representative of the United States population of non-institutionalized adults age 18 and older.[2]

2.1 Measures

2.1.1 Efficacy Framework and Measures

As noted above, the framework for coding open-ended responses comes from prior mental models research, and reflects a decision model derived from integrated climate assessment, in addition to common concepts from lay mental models of climate change (Bostrom et al., 1994; Morgan, Fischhoff, Bostrom, & Atman, 2002; Read et al., 1994; Reynolds et al., 2010). This framework also provided a starting point for the selection and design of survey items. The closed-ended efficacy measures in this study reflect a diverse set of those climate change mitigation actions either considered most effective (e.g., Attari et al., 2010; Attari, DeKay, Davidson, & de Bruin, 2011b; Gardner & Stern, 2008)[3] or suggested by laypeople in prior mental models research (e.g., Bostrom et al., 1994; Read et al., 1994; Reynolds et al., 2010). For example, reducing use of aerosol spray cans is an action volunteered in previous studies by those who confused stratospheric ozone depletion from CFCs with global warming

[1] While MTurk is an opt-in platform, MTurk samples are more representative of the general public than student samples (Levay, Freese, & Druckman, 2016; Paolacci & Chandler, 2014). Despite persistent differences in sample characteristics, similar conclusions have been drawn from experiments and surveys in psychology, political science, economics, and sociology when using MTurk samples compared to national samples recruited using more conventional procedures (Amir & Rand, 2012; Clifford, Jewell, & Wagonner, 2015; Gosling & Mason, 2015; Horton, Rand, & Zeckhauser, 2011; Simons & Chabris, 2012; Weinberg, Freese, & McElhattan, 2014). In general, and in line with other MTurk samples (Levay et al., 2016, our MTurk respondents are younger, whiter, and more liberal than the average American. Despite these limitations, we successfully recruited a diverse MTurk sample with regard to party identifications and ideologies. See online Supplement for a full accounting of demographics across both samples.

[2] Panelists are randomly recruited by GfK through probability-based address sampling approaches, and provided with access to the Internet and hardware as needed. Panelists were randomly assigned to one of three repeated open-ended questions, each asked three times: (1) how people try to slow or stop climate change, (2) why people try to slow or stop climate change, or (3) what comes to mind when they think of climate change (control group). Treatment differences in the open-ended responses were not robust ($p>0.01$). In the closed-ended response efficacy ratings a few minor differences emerged by treatment, but too small to be meaningful for the purposes of this paper; all analyses collapsed across treatments here.

[3] See also the discussions in Stern & Wolske (2017) and Wynes & Nicholas (2017), which were published after this study was conducted.

from CO_2 and other greenhouse gas emissions, and did not realize that CFCs were banned from spray cans several decades ago (e.g., Bostrom et al., 1994; Reynolds et al., 2010).

To reflect and test the theoretical distinctions found in prior efficacy research, the MTurk survey included open-ended self- and response efficacy questions for actions at personal, collective, and government levels of action. Informed by the results of the MTurk survey, the GfK survey design included open-ended items at the personal and government levels of action only.[4] In the MTurk survey, for the open-ended efficacy items reported here, respondents were randomly assigned to either a climate change or global warming frame.[5] The MTurk survey asked: (1) "Have you taken any actions to slow or stop (global warming/climate change)?" [if yes] "Please describe an action have you taken." [if no] "Please describe an action you have thought of taking"; (2) "If the United States government decided to try to slow or stop (global warming/climate change), what action could it take?" and (3) "Aside from government actions, if all of us who are part of the U.S. public collectively decide to slow or stop (global warming/climate change), what collective, preventative action would be most effective?" The GfK survey asked: (1) "Have you taken any actions to slow or stop global warming?" [if yes] "What action comes to mind first?" (2) "If the United States government decided to try to slow or stop global warming, what is the most important action it could take?" In both surveys, for each action the respondent provided, they were then asked to rate "How easy or hard would it be for [actor] to take this action?" on a seven-point Likert scale (extremely hard to extremely easy, centered at "neither easy nor hard," randomly reversed). Respondents were then asked to rate "What effect does [actor's] taking this action have on global warming?" on a five-point Likert scale (speed global warming to slow or stop

[4] The collective-level item was omitted from the national survey based on findings from the MTurk survey, which indicated respondents did not distinguish between collective- and government-level actions.

[5] See Mossler et al., (2017) for additional details about the parent MTurk survey and data handling thereof. Our approach contrasts with that of Schuldt, Enns, & Cavaliere, (2017), who find a difference between responses to items framed as "climate change" versus those framed as "global warming." Their analysis attributes the difference they observe to a difference in how Republican respondents react to the two terms (Schuldt et al., 2017) Responses to these wordings do not differ in our MTurk results and so are combined in all analyses.

global warming, centered at no effect). Both surveys included a sixth "don't know" response option; "don't know" responses were dropped for these analyses.

In addition to open-ended items, as noted above, respondents in both samples received closed-ended efficacy-related items developed based on the same decision model as the coding scheme, and further informed by subsequent research on mental models (Reynolds et al., 2010) and on climate change mitigation efficacy beliefs (Attari et al., 2010; Attari, DeKay, Davidson, & Bruine de Bruin, 2011a; Attari, DeKay, Davidson, & de Bruin, 2011b; Leiserowitz et al., 2013). Closed-ended efficacy items asked respondents to rate "How easy or hard would it be for [actor (you personally/ everyone in the U.S. collectively/ the United States government)] to [change behavior in specific way]," followed by "What effect would [actor] taking this action have on global warming?" For one proposed individual action an eighth "do it already"[6] response option was included to the right of "extremely easy." "Do it already" responses were treated as "extremely easy" in analyses. Response scales for closed-ended items were otherwise consistent with those for open-ended items.

In both surveys, efficacy items were preceded by items measuring support for climate change mitigation policy, belief in anthropogenic climate change, concern about climate change, perceptions of harms from climate change, and climate change general knowledge. Closed-ended efficacy items immediately followed open-ended efficacy items in both surveys.

2.1.2 Demographics

Political ideology is known to predict support for climate change policy (e.g., Bolsen, Druckman, & Cook, 2015; Hornsey, Harris, Bain, & Fielding, 2016; Marquart-Pyatt, McCright, Dietz, & Dunlap, 2014; Mossler et al., 2017, see also Bolsen, Druckman, & Cook, 2014) and was measured in response to, "In general do you think of yourself as…" with a seven-point response scale: "Extremely

[6] The only item that we included this option on was "to stop all use of aerosol spray cans at home", and for that item in the GfK national sample, equal proportions (~10%) of those who selected "do it already", "extremely easy" and "extremely hard" also said stopping all use of aerosol spray cans at home would "slow or stop global warming." A greater proportion of those who said "to stop all use of aerosol spray cans at home" would be "extremely hard" (54%) said doing so would have "no effect" than of those who said it would be "extremely easy" (30%) or who said they "do it already" (25%).

liberal/ Liberal/ Slightly liberal/ Moderate, middle of the road/ Slightly conservative/ Conservative/ Extremely conservative." Each ideological category is retained and used as an ordered continuous variable in the statistical tests for differences by political ideology reported below. For clarity and brevity when reporting and summarizing the survey results in aggregate, the three liberal categories are grouped together and the three conservative categories are grouped together. We also included items to assess belief in anthropogenic climate change. In the MTurk study, we asked: "Is the global climate changing?" (Yes/No), and if they responded yes, "Have humans caused any of this change?" (Yes/No). In the GfK study we asked: How likely do you think it is that human actions have changed global climate? (Extremely likely/very likely/likely/nether likely nor unlikely/unlikely/very unlikely/extremely unlikely; randomly reversed). In addition to ideology, we included items on party identification, gender, race, and age. For a full demographic breakdown of both samples, see online Supplement.

2.2 Data handling and analysis

An incentive of $1.25 was paid to each respondent who completed the MTurk survey. We administered the MTurk survey in April, 2016. A total of 1013 respondents completed the MTurk survey and passed an attention-check question. As noted above, only those assigned to the climate change/global warming frame were included in our analysis here, for a final sample size of 405. To reduce response burden, MTurk respondents were randomly assigned to one of three sets of efficacy questions, each focused at one specific level – individual, government, or collective (135 at each level). At the individual level, 68 respondents provided complete responses to individual-level open-ended survey questions on actions they had taken to slow or stop global warming; another 23 offered actions they had thought of taking. At the government level, 134 MTurk respondents provided complete responses (omitting one "don't know" response), and at the collective level 132 MTurk respondents provided complete responses (omitting three "don't know" responses).

KnowledgePanel survey participants were incentivized by GfK for participating. Although the GfK KnowledgePanel is based on an equal probability selection method, data are weighted by gender, age, race, education, census region, household income, home ownership status and metropolitan area to

ensure that they are representative of the U.S. adult population. GfK administered the KnowledgePanel survey in February 2017; 1820 individuals completed the survey and passed attention check questions.

All GfK respondents were asked open-ended efficacy questions at both the individual and government levels. A total of 690 respondents answered yes to "Have you taken any actions to slow or stop global warming?" and provided complete responses to "What action comes to mind first?" All respondents were asked "If the United States government decided to try to slow or stop global warming, what is the most important action it could take?" Of the 1574 respondents who provided a response, 273 were some version of "I don't know" or "N/A", leaving a total of 1301 complete answers about government action. In both the MTurk and GfK samples, some respondents gave protest responses. Protest responses varied in their content but often referenced specific mitigative actions, and so were included in the response counts for proportions and mean self- and response efficacies.

In applying the mental models of climate change coding scheme (Bostrom et al., 1994; Reynolds et al., 2010), multiple codes were assigned to responses that mentioned multiple activities. A single coder coded all MTurk open-ended responses; prior to coding the entire dataset, a second coder independently coded 100 randomly ordered responses as a reliability check. The second coder also coded all government-level GfK responses. Despite the complexity and comprehensiveness of this coding scheme (see online Supplement), coding reliability was high: the average percent coder agreement for the first 100 responses was 99.4%; Cohen's kappa for the first 100 responses coded by two independent coders averaged 0.84. Individual-level GfK open-ended responses were coded in their entirety by a third coder, and coding reliability with the second coder for the MTurk data was adequate (average percent agreement 99.4%, Cohen's kappa 0.77).

Analysis of data was conducted in R version 3.3.2 (base version) and SPSS. Welch's t-tests were applied to determine if reported levels of either self- or response efficacy associated with open-ended responses differed by level of action (personal, government or collective), and tests of association (Kendall's tau) to determine whether respondents distinguished between self- and response efficacy, and

whether efficacy ratings differed by political ideology. Efficacy scales were standardized from -1 to 1 with a center at 0 for ease of interpretation.

3. RESULTS

3.1 Descriptive statistics

3.1.1 Open-ended efficacy items

Forty-one percent of the GfK sample reported having individually taken an action to slow or stop global warming, compared to 50% of the MTurk sample; an additional 17% of MTurk respondents nominated an action they had thought of taking. This varied by political ideology, as more liberal respondents were more likely to report taking action. The top five actions respondents mentioned that they individually did to slow or stop climate change from each dataset included recycling (e.g., "recycle more"), automobiles (e.g., "I have a hybrid vehicle"), consumer demand for goods and services (e.g., "purchasing more eco-friendly products"), energy conservation and efficiency (e.g., "Do what I can to lower energy consumption"), renewable energy (e.g., "Have rooftop PV panels"), and transportation more generally (e.g., "walk to places that are close enough to walk to") (percentages shown in Fig. 1). Other less frequent responses included addressing pollution, political or civic action, reducing use of aerosol spray cans, and reducing fossil fuel usage. These actions overlapped considerably with those volunteered in response to open-ended questions about collective action (in the MTurk survey); excepting that actions to reduce fossil fuel usage (20%) and pollution (13%) superseded recycling and energy conservation/efficiency (Fig. 1).

Seventy-one percent of GfK and 99% of MTurk respondents offered actions that could be taken by government. Of the GfK respondents who offered government actions, 52% mentioned one action and 30% mentioned two actions, with the remaining mentioning three or more. Renewable energy sources (e.g., "focus on solar power") and fossil fuels (e.g., "stop using coal") were most commonly offered by GfK respondents, followed by general policy strategies (e.g., "working with other countries"), regulation (e.g., "much stricter laws"), and automobiles (e.g., "keep car emissions down"). Top nominated by MTurkers were regulation, market-based instruments (e.g., "implement cap and trade,") renewable

energy sources, fossil fuels, and CO_2 emission reduction (e.g., "lower carbon emissions in the United States") (Fig. 1). Over a fifth of the GfK sample (almost a third of responses other than "don't know") mentioned some kind of policy, aggregating across policy codes, including non-specific references to government and mention of policy or law, market-based instruments such as subsidies, taxes or cap and trade, and non-market regulation such as bans, as well as references to political or civic actions, and research.

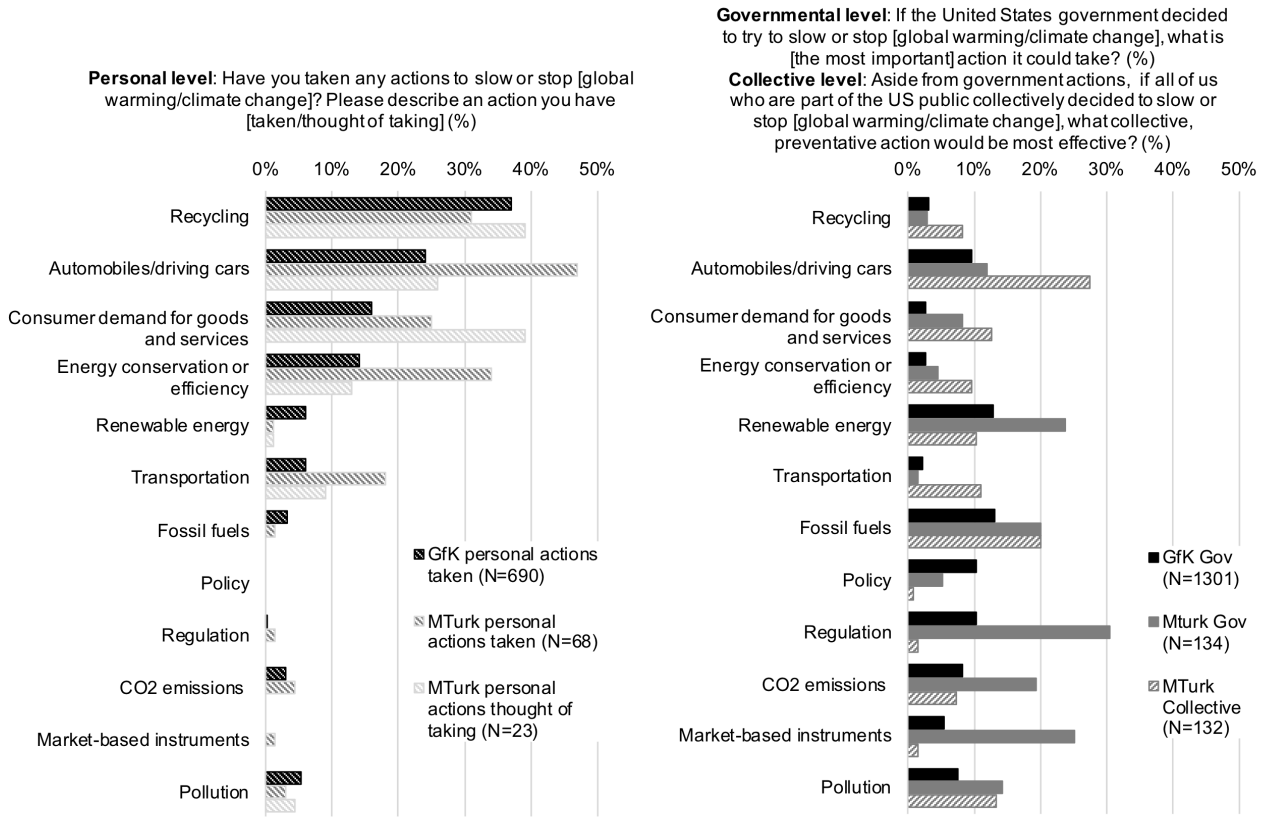

Figure 1. Top actions nominated by respondents at the personal (individual) level (top five actions from each data set at each level of action, inclusive), GfK N=738 whereof 690 meaningful, codable responses; MTurk N=91 meaningful responses. Top actions nominated by respondents at the government level, GfK N=1301 meaningful responses; MTurk N=134 meaningful responses. Proportions shown are out of the meaningful responses. Top actions nominated by MTurk respondents at the collective level, N=135, whereof 132 meaningful responses.

The highest mean self-efficacy (i.e., judged easiest to do) was for personal recycling in both the GfK (avg. 0.59, "very easy") and MTurk samples (avg. 0.60, "very easy"; inclusive of those who thought of but did not do the action they nominated) (Fig. 2; this figure focuses on MTurk data to illustrate

similarities and differences across all levels of action). Recycling was rated easier than other actions at all levels. Reducing driving or using less fossil fuel-intensive transportation were both deemed harder, but still "somewhat easy" (between 0.32 and 0.39) personally, but "somewhat hard" collectively (Fig. 2).

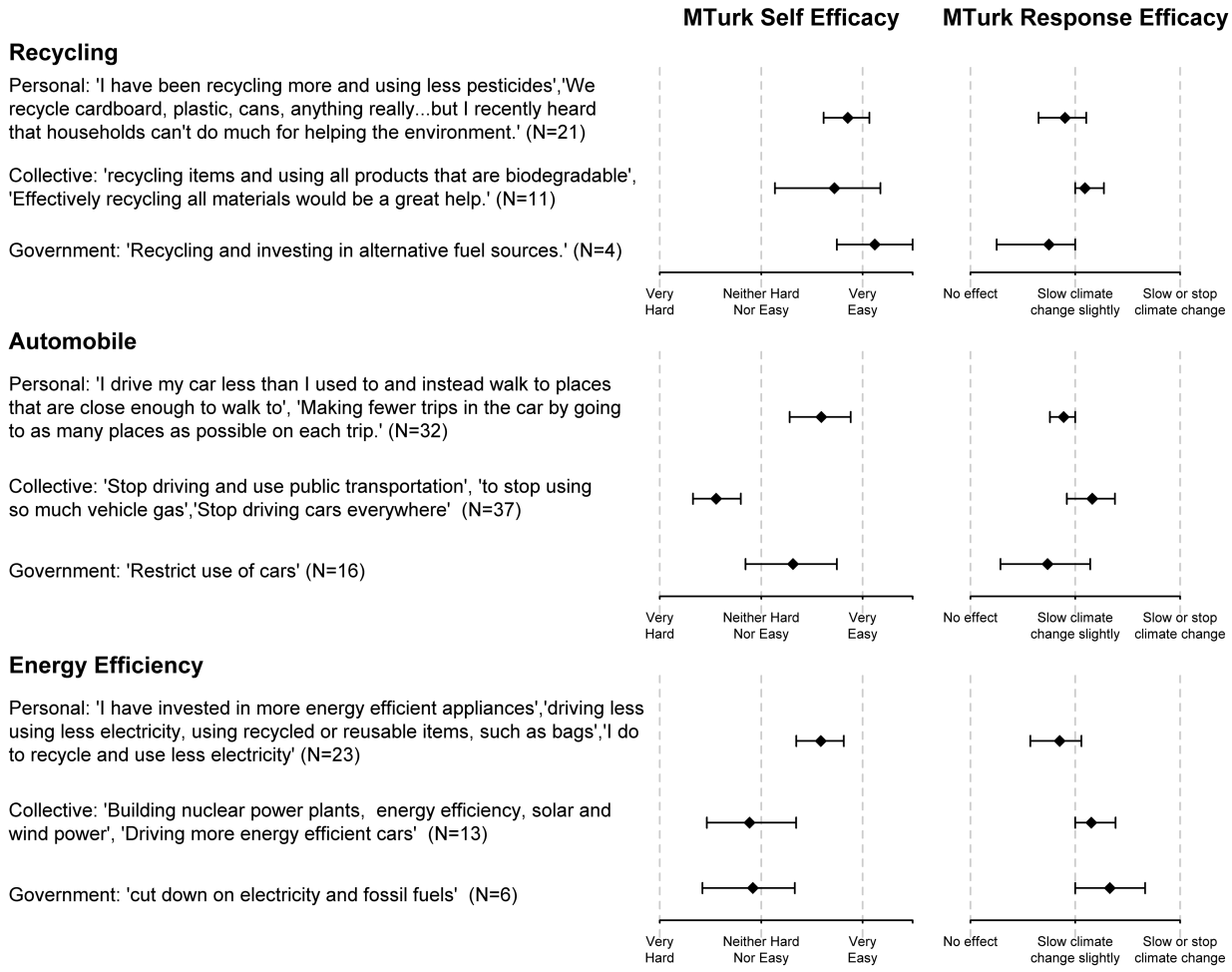

Figure 2. Comparative efficacy ratings for salient actions nominated by MTurk respondents across types of mitigation activities, and across all levels of action. Efficacy ratings are for statements coded as including the action category. Responses were coded at the most specific level possible. Quotes are verbatim (raw data) to illustrate the nature of responses, some of which included several actions and were coded accordingly.

Market-based instruments were judged as the more effective government response by the few GfK respondents who mentioned them (avg. 0.75, between "slow or stop [global warming/climate change] slightly (a trivial amount)"=0.5 and "slow or stop [global warming/climate change]"=1.0) (Fig.

3), while general policy solutions were perceived as most effective by the few MTurk respondents who nominated them (avg. 0.83).[7]

Respondents who mentioned an action that they personally had taken to slow or stop climate change identified that action as *very* to *somewhat easy* for them, on average (0.41 MTurk; 0.28 for actions thought of but not taken; 0.43 GfK), with very few differences across actions (Figs. 2, 3). Both GfK and MTurk respondents deemed the personal actions they suggested as easier to take (i.e., higher self-efficacy), than either the collective actions they nominated (0.37 vs. -0.08, $p<0.001$, Welch's t-test, MTurk only) or the government actions they nominated (MTurk 0.37 vs. 0.09, $p<0.001$, Welch's t-test; GfK 0.42 vs. -0.10, $p<0.001$) (Figs. 2-4). The government and collective actions respondents mentioned were judged as *neither easy nor hard* on average (0.09 and 0.08, respectively, MTurk; -0.10 for government only, GfK) (Figs. 2-4).

However, MTurk respondents judged personal actions less effective (i.e., lower response efficacy) than collective actions (0.44 vs. 0.57, $p<.001$, Fig. 4). Respondents judged as similarly effective the personal and government actions they nominated (0.44 vs. 0.52, $p=.07$ MTurk; 0.45 vs. 0.50, $p=.001$ GfK) (Figs. 2-4). On average, respondents across both studies expected personal and government actions to *slow climate change slightly,* while collective actions (MTurk respondents only) were expected to do a bit more than *slow climate change slightly*, leaning toward *slow or stop climate change* (Figs. 2-4)

Efficacy judgments for all actions nominated by GfK respondents in response to open-ended questions are compared in Figures 5 and 6 to efficacy judgments for specific survey items by level of action and by political ideology (GfK responses weighted to be nationally representative).

[7] Note that respondents provided a single estimate of self- and response efficacy for each of their open-ended responses. Where responses included multiple actions, any answer that included a given code is counted and contributes to both the percentages and means reported (i.e., some responses contribute to prevalence percentages for multiple actions). Percent of respondents mentioning is calculated as the percent of respondents who received the question and who provided a meaningful response (e.g., 30.4% of the 134 MTurk respondents who responded to the item asking what the United States government could do to slow or stop global warming or climate change gave an answer that was coded as *regulation*).

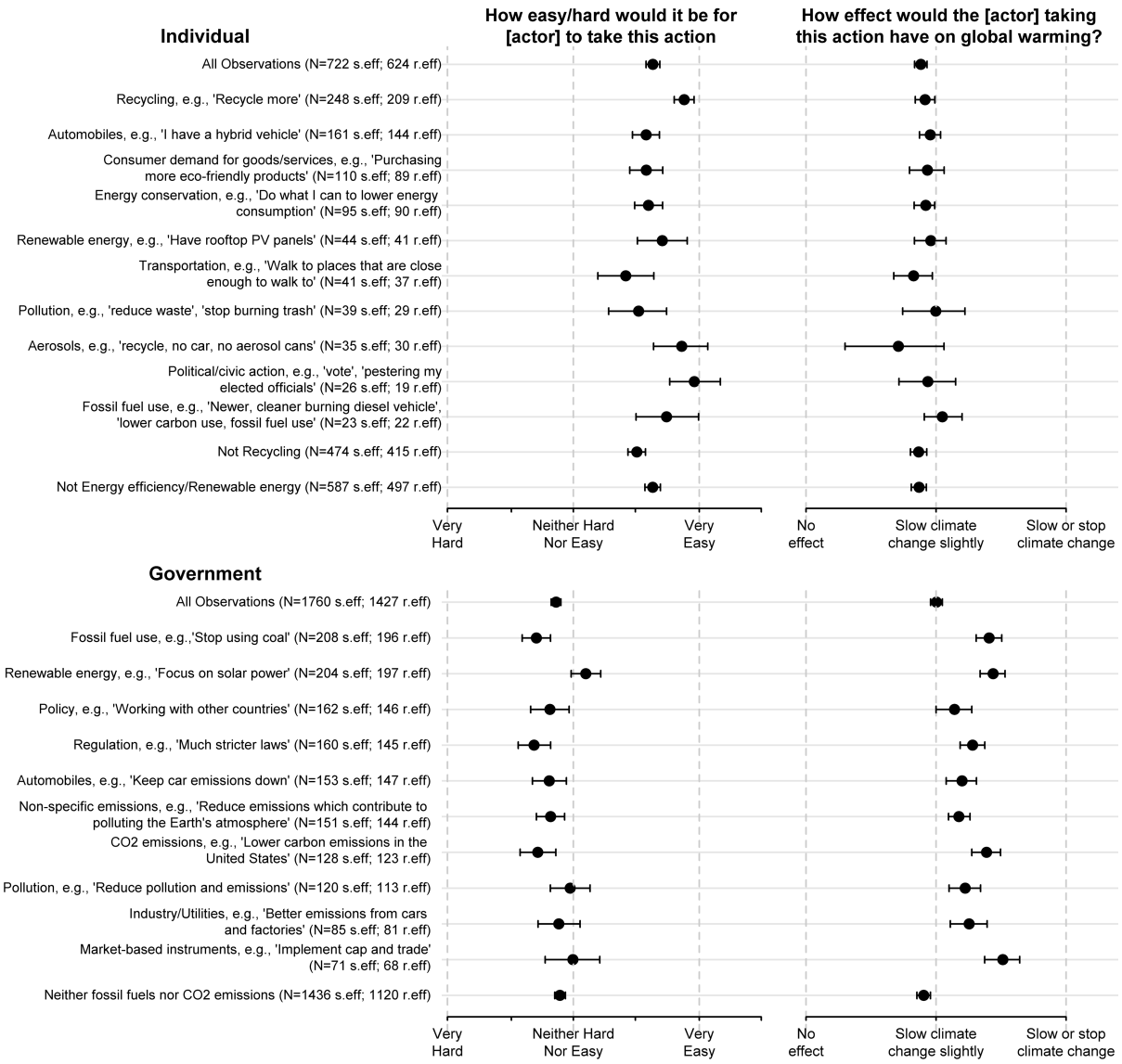

Figure 3. Efficacy ratings for actions volunteered by GfK respondents, by concept. [Left] Mean (weighted) self-efficacies of actions nominated by respondents: Taken or thought of at the government level (top) GfK n=1760; personal level (bottom) GfK n=722 responses; Response scale: *Extremely easy* (1.0), *very easy* (0.66), *somewhat easy* (0.33), *neither easy nor hard* (0), *somewhat hard* (-0.33), *very hard* (-0.66), *extremely hard* (-1.0). [Right] Mean (weighted) response efficacies of actions nominated by respondents: Taken or thought of at the government level (top) GfK n=1427; personal level (bottom) GfK n=624 responses. Response scale: *slow or stop global warming* (1.0), *slow global warming slightly (a trivial amount)* (0.5), *No effect* (0), *speed global warming slightly (a trivial amount)* (-0.5), *speed global warming]* (-1.0)

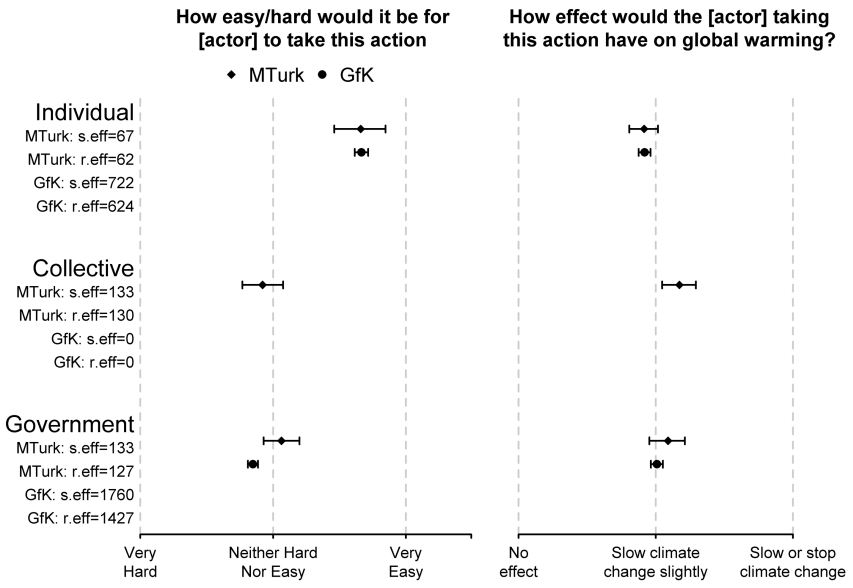

Figure 4. Comparison of mean reported self- and response efficacies across actions provided in response to open-ended climate change mitigation items, disaggregated by level of action. Sample sizes for self-efficacy ratings labeled s.eff, for response efficacy r.eff.

3.1.2 Closed-ended efficacy items

Closed-ended responses were largely consistent with open-ended results in both studies. Consistent with open-ended findings, personal-level actions were perceived as easier than collective actions: respondents saw reducing annual air travel by 50% as easier for them to do personally (between *somewhat* and *very easy* for air travel (0.55 MTurk, 0.42 GfK), than for everyone in the United States to do collectively (on average between *somewhat hard* and *neither easy nor hard*, -0.25 MTurk, -0.28 GfK) ($p<0.001$, paired t-tests, Fig. 5 "FLY"). Reducing household energy use by 20% was seen as easier to do individually (between *neither easy nor hard* and *somewhat easy*, 0.07 MTurk, 0.06 GfK), than collectively (-0.17 MTurk, -0.14 GfK) ($p<0.001$, paired t-tests, Fig. 5 "HEU"). Personal self-efficacy judgments did not differ much by political ideology, with the exception of judgments of the ease of

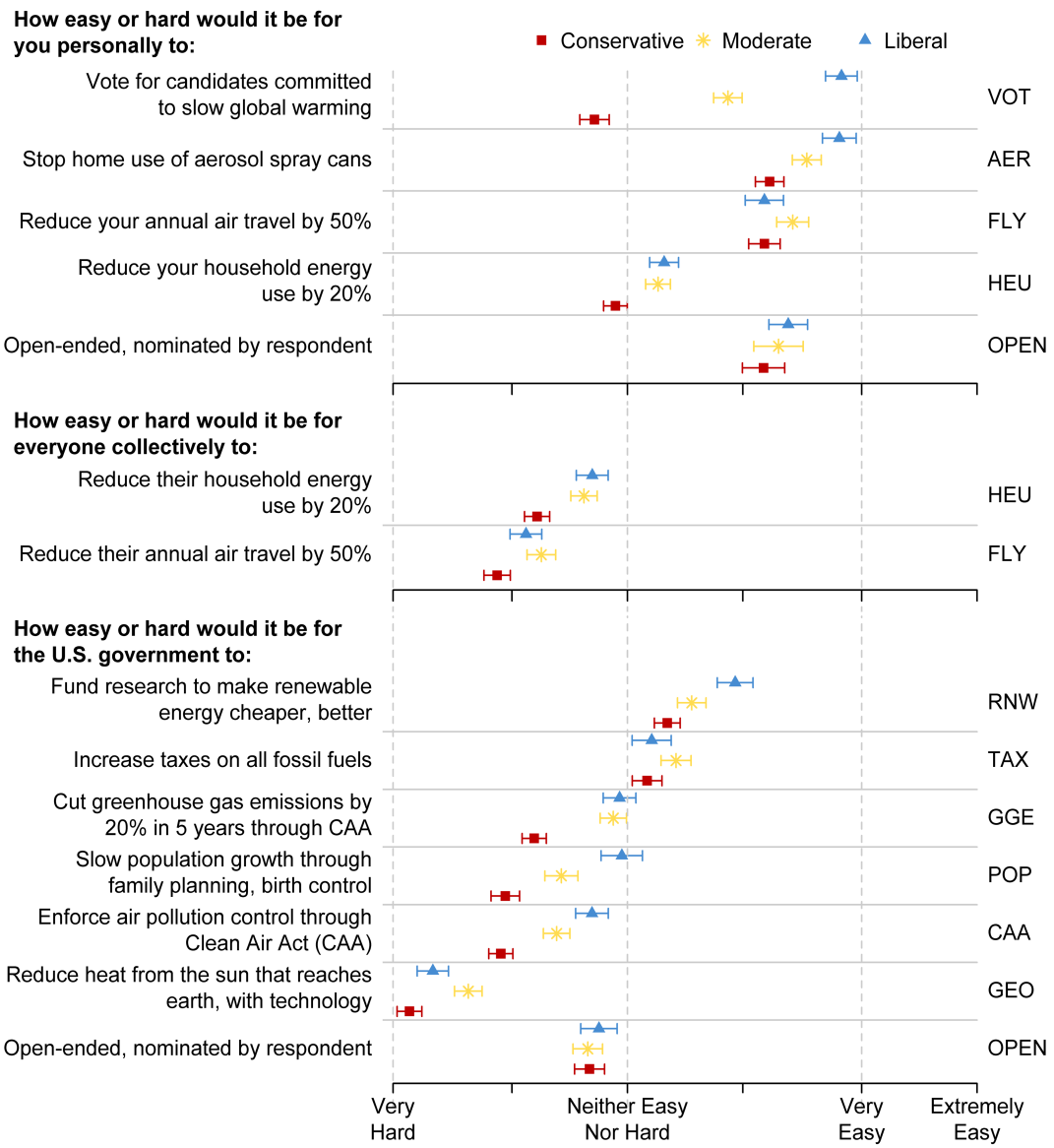

Figure 5. Self-efficacy ratings of suggested and self-nominated climate change mitigation actions, by actor and political ideology in the GfK study. Don't know responses and refusals are excluded, for which reason sample sizes vary (e.g., 44 respondents refused to answer the government self-efficacy question regarding geoengineering, which was the highest number of refusals). For full wording of survey items see online Supplement.

voting for candidates committed to reducing or stopping global warming, and, to a lesser extent, judgments of the ease of stopping the use of aerosol spray cans and reducing home energy use by 20%. Liberals judged all of the preceding as easier than conservatives, with moderates falling in between. However, government self-efficacy did differ by political ideology, with liberal respondents perceiving a

number of government actions (funding research into renewable energy, cutting greenhouse gas emissions by 20% in the next 5 years, slowing population growth, and fully enforcing air pollution standards in the Clean Air Act) as easier than conservative respondents, with moderates falling in between.

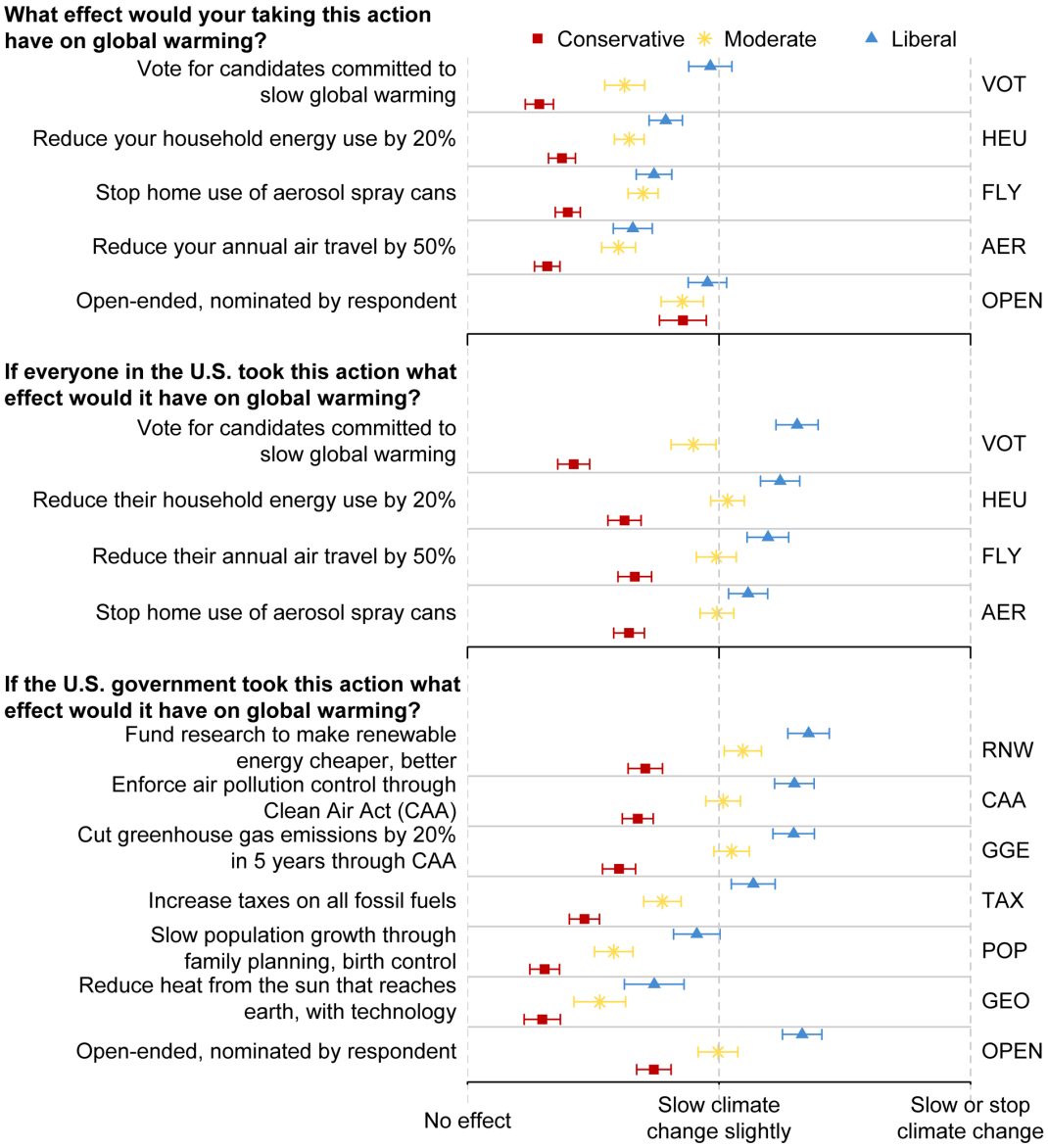

Figure 6. Response efficacy ratings of suggested climate change mitigation actions, by actor and political ideology in the GfK study. Don't know responses and refusals are excluded, so sample sizes vary (e.g., 354 respondents reported they didn't know the effect of the U.S. government promoting family planning on global warming, and 737 respondents reported they didn't know the effect geoengineering might have on global warming. For full wording of survey items see online Supplement.

Despite these differences, funding research into renewable energy and taxing fossil fuels were seen as the easiest government actions by all respondents.

As expected, and consistent with open-ended findings, respondents from both samples indicated that, on average, actions taken personally are less effective in slowing or stopping climate change (between *no effect* and *a slight effect*) than those same actions taken collectively (on average *a slight effect*), regardless of the nature of the action (Fig. 6). This held for stopping the use of aerosol spray cans (0.27 personal vs. 0.50 collective MTurk, 0.32 vs. 0.45 GfK), reducing annual air travel by 50% (0.28 vs. 0.50 MTurk, 0.27 vs. 0.46 GfK), reducing household energy use by 20% (0.28 vs. 0.57 MTurk, 0.31 vs. 0.48 GfK), and voting for candidates committed to reducing or stopping global warming (0.33 vs. 0.51 MTurk, 0.31 vs. 0.41 GfK), all $p<0.001$, paired t-tests).

Funding research on renewable energy received the highest government response efficacy ratings, followed closely by enforcing the air pollution control standards specified in the Clean Air Act, and then by reducing greenhouse gas emissions through Clean Air Act regulations (Fig 6). Liberals consistently judged all actions as more efficacious in slowing or stopping climate change (higher response efficacy) than did conservatives, with moderates again inhabiting the middle ground.

Perhaps not surprisingly, given the absence of geoengineering among actions named by respondents in their open-ended responses, 41% reported that they did not know what the effect of geoengineering would be, while those who did rate the efficacy of geoengineering rated it as both far more difficult and far less effective in slowing or stopping climate change than other possible actions. Similar to geoengineering, respondents omitted family planning or population growth as options in their open-ended responses. In response to closed-ended items, 19.7% reported that they did not know what effect the U.S. government promoting family planning and supporting access to birth control would have on global warming; those who did rated it as significantly more difficult and less effective than all other actions save geoengineering.

3.2 Actions and ideology

3.2.1 Taking action and efficacy

Across these closed-ended questions, mean self- and response efficacy perceptions of those who reported having taken action on climate change were higher than of those who did not in both the GfK and MTurk samples. Those who responded yes to "Have you taken any actions to slow or stop [global warming/climate change]?" rated both the self- and response efficacy of personal level actions provided in closed-ended items as significantly higher than their counterparts who have not taken action (mean self-efficacy 0.44 vs. 0.2 in GfK, 0.54 vs. 0.21 in MTurk ; mean response efficacy 0.41 vs. 0.18 in GfK, 0.43 vs. 0.19 in MTurk; $p<.001$ for each). Differences in mean response efficacy persist even after controlling for ideology, although the difference in self efficacy is smaller and no longer statistically significant.

3.2.2 Ideology and action, open-ended items

Of the 481 liberal respondents in the GfK sample, 300 reported an action they had personally taken (62%), versus 39% (251/643) of moderates, and 27% (187/685) of conservatives ($p<.0001$; liberal respondents more likely to have taken action). The pattern was similar for MTurk respondents, though of lower magnitude and not statistically significant; of 36 self-identified liberals in the MTurk personal-level open-ended response condition, 20 (60%) had taken action, as compared to 14 (42%) of the 33 self-identified moderates or conservatives (Tau=0.13, p=0.28). The individual actions respondents reported doing in the open-ended responses showed no discernible differences by political ideology.

In both the GfK and MTurk data, more conservative respondents rated self-efficacy of the actions they nominated in response to open-ended questions slightly lower than did more liberal respondents, but this difference was small and not statistically significant (Tau=-0.04, p=.14, GfK; Tau=-0.13, p=.17). More conservative respondents in the GfK data rated the response efficacy of the actions they mentioned as lower than did more liberal respondents (Tau=-0.09, $p<.001$ aggregated into 3 ideological categories in Fig. 6), but this difference was not evident in the MTurk dataset (Tau=0.05,p=.64).

3.3 Do respondents treat self- and response efficacy as conceptually distinct?

3.3.1 Open-ended items

Within a given level of action, MTurk respondents did not perceive much connection between how easy or hard an action is and that action's effect on climate change: self- and response efficacy judgments for respondent-provided actions were not highly correlated at the personal level (Tau=0.12, p=0.22), collective (Tau=-0.09, p=0.23) or government levels (Tau=-0.10, p=0.18). At the personal level GfK respondents' perceived response efficacy tended to be slightly higher the higher their perceived self-efficacy ratings (Tau=0.09, p=0.003), but not at the government level (Tau=-0.03, p=0.16) (see online Supplement).

3.3.2 Closed-ended items

For those actions suggested in the survey (closed-ended items), self- and response efficacy judgments for a given action were positively correlated for a variety of actions taken personally, collectively and by government. However, most of these correlations are weak or modest. At the low end are correlations of .05 in MTurk, for self- and response efficacies associated with collective air travel reduction, and -0.035 for government geoengineering in GfK, ($p>0.01$). The remaining correlations are statistically significant at $p<0.01$ for all but collective reduction of annual air travel in MTurk and GfK, and for government geoengineering and taxes on fossil fuels in GfK. At the high end of these correlations are those for personal-level voting, at 0.32 in MTurk and 0.46 in GfK (see online Supplement). Controlling for political ideology and subjective likelihood that humans have caused climate change tends to further reduce the strength of these correlations. For example, the correlation between self- and response efficacies for collective reduction of household energy use by 20% is reduced from 0.081 ($p<0.01$) to a partial correlation of 0.04 ($p=0.31$) after accounting for political ideology and anthropogenic beliefs.

Finally, respondents were asked to nominate more effective actions, which suggests that those who did volunteered an action in an open-ended response would rate it as more effective than other actions, and as more effective than others who did not nominate it. While the coding of the open-ended responses does not correspond exactly to the closed-ended items, in general, respondents who nominated

a particular action were not more likely to see that action as particularly effective compared to other respondents who nominated different substantive actions. An exception to this generality is respondents who mentioned market-based instruments tended to rate carbon taxes as having greater response efficacy compared to respondents who volunteered substantive government actions other than market-based instruments. However, while respondents who mentioned market-based instruments tended to perceive carbon tax as have greater response efficacy compared to other respondents, they still rated the response efficacy of a carbon tax lower on average than other government actions, such as renewable energy subsidies and Clean Air Act regulation.

4. DISCUSSION

Actionable information and efficacy have taken center stage in risk communication in recent years, as political polarization and global temperatures have continued to increase. Analysis of prior studies reveals a proliferation of efficacy measures, highlighting a need for better understanding how people think about the ease and effectiveness of actions to mitigate the risks of climate change, and what types of actions they have in mind. Addressing this gap, our two national survey studies explore lay thinking and how it aligns with theoretical dimensions of efficacy, qualitatively and quantitatively. Our approach accomplishes aims of open-ended topic analyses (Tvinnereim, Fløttum, Gjerstad, Johannesson, & Nordø, 2017), but builds on prior theory and research, in part by using a coding framework derived from integrated climate assessment modeling and decision analyses (Bostrom et al., 1994; Morgan et al., 2002). This coding framework represents, at a general level, the types of actions that should be included in research instruments to represent the range of causal and intervention strategies most likely to influence or be perceived to influence climate change and mitigate the risks it poses.

Just under half of our respondents across both surveys reported having taken action to slow or stop climate change. Respondent-volunteered personal actions to tackle climate change or global warming contrast with recent top action lists published in the popular press, with the exception of driving less. At the personal level, respondents volunteered strategies related to recycling and automobiles

(buying a hybrid vehicle), as found in prior studies (Read et al., 1994; Whitmarsh, 2009). However, our respondents also nominated reducing consumer demand for goods and services, conserving energy, increasing reliance on renewable energy sources, and addressing transportation more broadly (for example mode switching, walking more). Of all of these, recycling actions were judged easiest (highest self-efficacy), while use of renewable energy sources was viewed as the most effective personal action (highest response efficacy), though indistinguishable statistically from the perceived effectiveness of other individual actions nominated by respondents. The popularity of recycling among our respondents, in particular, may reflect how well institutionalized municipal recycling has become across the United States and the likelihood that respondents report thinking of, or taking, actions they perceive as easier (Attari, DeKay, Davidson, & de Bruin, 2011b), as well as people's tendency to conflate environmentally-friendly and climate-friendly behaviors into a "green mental model" (Reynolds et al., 2010).

When respondents were asked what the U.S. government could do, their top nominated actions included actions associated with fossil fuels, renewable energy sources, policy and regulation (e.g., tighten emission standards), automobiles, market-based instruments (e.g., implement a carbon cap-and-trade scheme), and reducing CO_2 emissions. Almost a third of the meaningful responses regarding what the U.S. government could do (representing a fifth of the GfK sample) nominated regulation or policy in their open-ended responses, including mention of market-based strategies (e.g., cap-and-trade). Increasing reliance on renewable energy sources (e.g., focus on solar energy) was mentioned by almost as many, and was seen as easiest by both sets of respondents, while policy approaches (MTurk) and market-based instruments (GfK) were deemed most effective.

Respondents omitted family planning strategies from their self-nominated climate actions, and showed skepticism about the ease and effectiveness of such practices when directly asked. The carbon cost of an additional child in developed countries is salient in risk management and communication efforts (e.g., Wynes & Nicholas, 2017), although recent statistical analyses highlight that population is far less important than GDP and carbon emission intensity (Rafferty, Zimmer, Frierson, Startz &Liu, 2017)

Perhaps more importantly, respondents did not mention geoengineering strategies in their assessments of actions the government could take to slow or stop global warming (open-ended responses), and when directly asked about geoengineering (closed-ended responses) they rated it as unfamiliar, extremely difficult, and less effective than other actions. These findings help contextualize the public antipathy toward geoengineering found in focus groups in the U.S. and other countries (e.g., Wibeck et al., 2017). By implication, this also suggests that people do not perceive anthropogenic greenhouse gas emissions as intentional, nor as geoengineering, despite the fact that they effectively constitute uncontrolled geoengineering on a massive scale.

Geoengineering and slowing population growth as climate change risk mitigation strategies have been regarded by many experts as too risky (e.g., National Research Council 2015) or ineffective (Rafferty et al., 2017) as well, although the omissions and perceptions reported here could also be driven by risk perceptions and the affect heuristic, or ideological beliefs about the proper role of government. In light of this and the negative emissions assumed in some IPCC scenarios (Fuss et al., 2014; Peters & Geden, 2017), lay risk assessments and perceptions of geoengineering and other riskier risk management strategies deserve further attention.

As noted, respondents reported higher self-efficacy for personal actions than for collective or government actions across both open- and closed-ended items. As many of the actions named in response to the open-ended personal self-efficacy question were self-reports of behavioral changes that the respondent had already made, it is possible that the significant differences between actors found in the open-ended analysis largely reflect earlier findings showing that individuals are more likely to take actions they perceive as easier (Attari, DeKay, Davidson, & de Bruin, 2011b). Additionally, cognitive bias likely influenced estimates of self-efficacy for past actions taken; something you've already done seems easier in hindsight than something you omitted or chose not to do. These results should be interpreted with caution in light of the considerable evidence that our prospective assessments suffer from numerous biases (Gilbert & Wilson, 2009), and that our hindsight differs systematically from our predictions (Fischhoff & Beyth, 1975).

Analysis of our closed-ended items did, however, show a similar pattern. Taken in tandem, our findings suggest that personal climate action is seen as easiest, while collective and governmental actions are seen as most effective. Our respondents seem alive to the collective action problem at the heart of climate change mitigation. If Americans believe that individual climate action is easy but ineffective, and collective or governmental climate action is difficult but more effective, the consequences for climate change risk messaging are clear. Messages (e.g., descriptive and injunctive norms (Leiserowitz, Maibach, Rosenthal, Kotcher, Ballew, Goldberg & Gustafson, 2018) that stress the feasibility (self-efficacy) of collective or governmental action may lower the perceived bar for societal action, while messages that emphasize the effectiveness (response efficacy) of individual contributions to those societal efforts may increase individuals' willingness to act.

Ideological differences in perceived efficacy, particularly response efficacy, persist. Despite ordering the effectiveness of government actions similarly, conservative respondents remained more skeptical than liberals that government action will have an appreciable effect on climate change, for both open-ended and closed-ended responses. Liberal respondents were also more likely to report having taken personal action to mitigate climate change. However, it is possible that conservatives would report engaging in similar levels of pro-environmental behavior as liberal respondents, but rejected that these activities have an effect on, or are motivated by concerns about, climate change (Hall, Lewis, & Ellsworth, 2018). In general, Americans are both more convinced that climate change is happening, and more concerned about its effects, than ever before (Leiserowitz et al., 2018). On a scale of extremely likely to extremely unlikely, less than 7% of our GfK national sample rated it extremely unlikely that human actions have changed global climate, but, of those, only 15% self-reported as liberal. Encouraging climate-friendly behavior requires understanding the motivations of individual actors, including how ideology may influence reactions to actions framed as climate mitigation.

Many of our results are reassuring from the perspective of the scientific consensus on climate change risk mitigation. Firstly, respondents do not appear to conflate the ease of taking action with the effectiveness of that action, as demonstrated by the weak to non-existent correlations between self- and

response efficacy in both the open-ended and closed-ended data. Furthermore, assessments of potential broader societal action do reflect strategies that could plausibly reduce emissions. Open-ended answers indicate that respondents perceived market-based instruments, renewable energy and addressing fossil fuel use as the most effective government responses to climate change, while closed-ended responses ranked government investment in renewable energy technologies, full enforcement of the air pollution standards specified in the Clean Air Act, and taking action on greenhouse gas emissions as most effective. The perceived effectiveness of these options relative to one another was unrelated to respondents' political ideology.

Our findings, however, also demonstrate that in aggregate respondents failed to distinguish effectively actions that might successfully mitigate climate change from those that are simply good environmental practices but might have minimal effects on atmospheric greenhouse gas concentrations (Reynolds et al., 2010). Nor did they differentiate between actions that science shows may have an effect on climate change (e.g., collectively reducing household energy use), and those that should have little to no measurable effect on climate change (e.g., collectively reducing aerosol spray can use). Admittedly, the avoided greenhouse gas emissions and global warming achieved by the Montreal protocol are significant, on the order of 30% of current emissions/warming (Morgenstern et al., 2008), but CFCs in hairspray were banned in the U.S. in 1977. Furthermore, the judgment that governmental investment in renewable energy is most effective may reflect motivated reasoning (e.g., Bolsen et al., 2014). While it is clear from our open-ended responses that other governmental actions come readily to mind for our respondents, it seems telling that the action our respondents rated as most effective is also one that would not mandate or require any behavior change from individuals.

A central question that emerges from these findings is how risk communicators can best capitalize on some respondents' ability to identify potentially effective government actions on climate change. Efforts are complicated by the fact that, despite decades of research on related risk perceptions, risk communicators and managers still face disconnects between actual and perceived effectiveness of individual actions (Bostrom et al., 2018; Whitmarsh, 2009). Addressing these disconnects may be critical

if individual actions and emissions targets are essential for progress, as some have argued (la Fuente, Rojas, & Mac Lean, 2017). Although this may not be the case if instead, as suggested by the findings in Bostrom et al. (2018), the ease of taking climate risk mitigation action personally matters more for support for climate change action than does perceived effectiveness of personal actions.

Future studies should strive to clearly delineate self- and response efficacy in their measures, as they differ, and both matter for risk management. Indeed, our work points to the need for a standardized approach to studying the distinctions between types and levels of efficacy, one that aligns with how laypeople think about both efficacy and the types of climate actions they and society as a whole might take.

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