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Climate change communicators' carbon footprints affect their audience's policy support

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Abstract

Global warming is caused mainly by CO_2 emission from burning fossil fuels and is beginning to have large negative impacts on human well-being and ecosystems (IPCC 2014; IPCC 2018). Policies that mitigate CO_2 emissions will require public support. Here, we examine how support for several possible decarbonization policies varies as a function of the personal carbon footprint of a researcher who advocates the policy. We find that people are more likely to support policies if the advocate for these policies has a low carbon footprint. Replicating our prior work, we find that the communicators' carbon footprint massively affect their credibility and intentions of their audience to conserve energy (Attari, Krantz and Weber 2016). Our new finding is that their carbon footprint also affects audience support for public policies advocated by the communicator. In a second study, we show that the negative effects of a large carbon footprint on credibility are greatly reduced if the communicator reforms their behavior by reducing their personal carbon footprints. The implications of these results are stark: effective communication of climate science and advocacy of both individual behavior change and public policy interventions are greatly helped when advocates lead the way by reducing their own carbon footprint.

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1 Introduction

The risks of climate change have been discussed by climate researchers, with a call to action brought to the public by Hansen et al. (1981). Paths to reduce these risks by stabilizing atmospheric CO_2 concentration have been developed by scientists, advocacy groups, and policy makers. Such paths depend on coordinated choices by people, organizations, and governments that depart from current patterns of behavior (Pidgeon et al. 2014; Geels et al. 2017). We need a diverse set of strategies to mitigate and adapt to climate change, including bottom-up and top-down strategies. Some possible risk reduction strategies involve voluntary consumer choices that will reduce emissions, e.g., enhancing energy efficiency in homes and workplaces, or curtailing automobile use (Dietz et al. 2009; Gardner and Stern 2008; Clayton et al. 2015). For other possible risk reduction strategies, government action is essential, e.g., taxing CO_2 emissions, or subsidizing investment in public transportation (Nordhaus 2007; Chapman 2007). Adopting these behaviors and policies in a democracy generally requires fairly broad public support. This makes the public response to such proposed policies and to messengers advocating them important (Carvalho et al. 2017; Ockwell et al. 2009; Maibach et al. 2008; Pidgeon and Fischhoff 2011).

Scientists who analyze and report on the risks of climate change sometimes also advocate for policies to reduce greenhouse gas emissions. Such advocacy can be effective if the scientists are perceived as experts whose principal goal is benefits to society, and to help the public navigate through socio-political contexts (Kotcher et al. 2017; Scheufele 2014; Pidgeon and Fischhoff 2011). Effective advocacy can be boosted when advocates behave in a manner that is consistent with their message. Kraft-Todd et al. (2018) show that advocates for installing solar panels are far more effective at convincing others to adopt solar panels when they also installed solar panels, compared to those who advocated installation without adopting solar panels themselves.

When advocates do not behave in a manner that is consistent with their message, they may be criticized for apparent hypocrisy. Such criticisms and ad hominem arguments (to the person as opposed to the issue) are directed against communicators advocating for climate solutions as well as climate change deniers (people who do not believe that anthropogenic climate change is occurring); indeed, ad hominem arguments seem prevalent in almost every debate nowadays. One might prefer that attention be directed only to scientific evidence, but ad hominem arguments can be effective and sometimes helpful in calling attention to the biases of advocates on either side of a question (Walton 1987).

Attari et al. (2016) showed that the perceived credibility of a climate scientist is an important factor in shaping intentions to change a participant's energy conservation behavior. Information about a researcher's high personal carbon footprint reduces her credibility (compared with a low personal footprint) and consequently affects the reported intentions of audience members to adopt individual-level conservation behaviors (conserving home energy, flying less, using public transportation more). Attari et al. (2016) found very large effects of finding out about a researcher's high versus low carbon footprint, both on the participants' perception of the researcher credibility and their behavioral intentions. These effects occur among people for whom climate change is an important concern as well as among people less concerned. We do not know whether such effects on personal behavioral intentions would carry over to support for public policy. Does a researcher's carbon footprint affect audience support for a public policy that she advocates, in addition to the effects on personal behavioral intentions? In short, we now ask to what extent does an ad hominem argument based on the advocate's carbon footprint affect support for a public policy that aims to reduce CO_2 emissions?

2 Study 1: Researcher credibility, policy support, and behavioral intentions

We selected six different policy proposals for study, based partly on the responses received from 12 climate change and energy policy researchers to the following question: "What are five policies that you believe would be effective in stabilizing greenhouse gas concentrations?" (The Supplemental Text contains the anonymized responses to this query, which was posed and answered by e-mail in December 2016.) We conducted this expert elicitation to ensure we had captured the main policies that energy and climate experts thought were important to include in our study. Answers included implementing a carbon tax, research and development of alternative energy sources and energy storage modes, better public transportation, deploying nuclear energy, and banning coal. We chose among these expert suggestions based on shared recurring themes, and added one additional policy that has often been discussed (stabilizing human population) (Wynes and Nicholas 2017; Holdren and Ehrlich 1974). The six selected policy proposals were:

1. regulate CO_2 emissions
2. tax CO_2 emissions
3. increase generation of nuclear power
4. stabilize human population
5. increase renewable energy
6. enhance infrastructure for public transit

Each of these was embedded in a short paragraph spelling out some details and providing a rationale for the policy (see 2.1. Questionnaire design for the exact wording). Each was tested under one of two conditions: the researcher advocating the policy was said to have either a high or low home carbon footprint. We focused on the researcher's home energy use because it yielded the largest effects in Attari et al. (2016) and because many participants may excuse flying because it can be viewed as being required for the researcher's job. There were thus 12 vignettes: 6 policies × 2 levels of home energy use. Each participant considered only one vignette, randomly chosen from among these 12.

The vignette was followed immediately by a question about the participant's support for the given policy, and then followed questions about the participants' intentions to reduce their own energy use, about their perception of the researcher's credibility, and about their beliefs related to climate change. The questions concluded with a few demographic items. (Details are in the 2.1. Questionnaire design section and the Supplemental Text.)

Although we are interested in attitude differences toward the six policies explored here, our main focus concerns the factors that influence support for each policy, including a possible implicit ad hominem argument based on the researcher's own carbon footprint. The sample size was slightly over 600 participants per policy (300 each for the researcher's high and low carbon footprint). This allowed us to learn with modest precision about the correlates of support for each policy.

The questions about participants' intention to conserve energy privately and about their perception of the researcher's credibility provide a partial replication of Attari et al. (2016), where climate communicators who have a high carbon footprint are deemed less credible. Given that most climate scientists, by virtue of the current practices of their profession, have a carbon footprint significantly higher than that of the general public (Le Quéré et al. 2015), these are troubling results. In study 2 described later on, we explore whether credibility once lost can be regained.

2.1 Questionnaire design

Participants for an online survey were recruited via Amazon's Mechanical Turk Internet panel (MTurk) and were restricted to participants in the USA and above 18 years of age. Each participant began by reading a vignette describing a talk in which a distinguished climate researcher discusses climate change, recommends personal behavioral changes to his audience, and advocates one change in public policy. The researcher's supposed personal home energy use is brought out in a description of the question period following the talk.

This vignette structure resulted in a 6×2 design: only one of six possible policy changes was advocated, and the communicator's personal home energy use was either modest or profligate.

Since this vignette structure is crucial for our study, we give the verbatim details here. The complete survey is provided in the Supplemental Text. All data for our analysis for this paper are included in supplementary information files.

2.1.1 Vignettes

The vignettes shared a common opening narrative, which included recommendations for voluntary behavior change. (Note that we use the pronoun "He" in all of our vignettes as prior research has shown no significant differences between female and male researchers in advocating for change (Attari et al. 2016).) The vignettes then diverged, continuing with one of six different policy suggestions. They concluded with an account of a question period, which brought out the speaker's personal home energy use (high versus low). Six different policy suggestions were crossed with the two levels of reported researcher home energy use to yield 12 conditions.

2.1.2 Opening narrative

You attend a talk by a leading climate researcher. He has been publishing scholarly articles about climate science since 1974 and has over 150 publications in leading journals, including Science and Nature. The researcher explains that individual actions have a large collective impact on the environment. For example, air travel and high energy use at home have negative environmental effects. The researcher advises the audience to reduce energy use by flying less, using less energy at home, and using local public transportation. He goes on to say that while voluntary action by individuals is important, society must also modify public policies in order to reduce carbon dioxide emissions. His main policy recommendation is to…

2.1.3 Six policy suggestions

The vignette then continued with one of the following six paragraphs (including the paragraph label, in bold font):

> ***…regulate carbon dioxide as a pollutant:*** *Society should regulate carbon dioxide as a pollutant. After a transition period, regulations will lead to improved technology for capturing large-scale emissions of carbon dioxide, which will be stored as solid rock (i.e., carbonate minerals) that will not return to the atmosphere for millions of years.*

…tax carbon emissions: *Society should estimate the financial cost of carbon dioxide emissions and recover it from a revenue-neutral tax on gasoline and on use of electric power. (Other taxes will go down equal to the increase from the new tax.) This tax would be adjusted up or down as the environmental cost of carbon dioxide emission changes over time.*

…increase nuclear power: *Society should resume construction of nuclear power plants using the best current technology for safety, efficiency and disposal of nuclear waste. New nuclear plants will replace coal-fired power plants.*

…stabilize human population: *Society should stabilize human population by promoting education and work opportunities for women and by lowering the cost of children's education for parents who restrict themselves to no more than 2 births.*

…increase renewable energy: *Society should invest heavily in research to improve renewable energy (*e.g.*, solar and wind power) and should also provide incentives for renewable energy industries to implement the discoveries that result from this research.*

…increase public transit: *Society should reduce pollution from cars and trucks by investing strongly in infrastructure for public transportation, including rapid, convenient local rail and transit for people and energy-efficient transport of agricultural and manufactured products.*

2.1.4 Question period

The vignette concluded with an account of the question period, in which the researcher's carbon footprint emerged. There were two alternative accounts:

Low footprint: *During the question period a member of the audience asks the researcher how much energy he himself uses at home. He replies that he has a modest home with a low energy bill; he has switched to a slightly more expensive but green electricity provider and has invested in energy-efficient appliances.*

High footprint: *During the question period a member of the audience asks the researcher how much energy he himself uses at home. He replies that he has a large home with a high energy bill; he has not yet switched to a slightly more expensive but green electricity provider or invested in energy-efficient appliances.*

2.1.5 Procedure

Participants read one of the 12 vignettes, generated by combining one of the 6 policy recommendations with one of the 2 levels of home energy use. Assignment of vignettes was random. The vignette was followed by 6 groups of questions: we outline them here in the order encountered by participants

1. Policy support: Participants indicated support or opposition to the suggested policy on a 5-point scale (strongly support to strongly oppose).
2. Behavioral intentions: Next, participants were asked about their intentions to reduce energy use by flying less, conserving energy at home, and making greater use of public transport. This query was identical to that used by Attari et al. (2016). It is based on seven yes/no answers.

3. Researcher credibility: Participants then rated their agreement with 6 statements about the researcher's credibility, using a 5-point scale, from strongly agree to strongly disagree. These statements are identical to those used by Attari et al. (2016), and were combined into a scale in that same way.
4. Attitude toward researcher influence: The following new item was inserted next, to gauge participants' views on the proper role of researchers in the formation of public policy:

I believe climate researchers need to influence policy decisions that affect how society responds to climate change.

This again used the 5-point scale from strongly agree to strongly disagree.

5. Climate change beliefs and attitudes: Participants then answered questions about climate change. The lead-in passage and items were similar to those used by Leiserowitz et al. (2013).

Recently, you may have noticed that climate change has been getting much attention in the news. Climate change refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world's climate may change as a result. What do you think?

Responses to two of the items will be used below in several analyses:

Do you think that climate change is happening?

(Definitely Yes, Probably Yes, Probably No, Definitely No)

How important is the issue of climate change to you personally?

(Very, Somewhat, Not too, Not at all)

6. Other items: The survey concluded with questions about political orientation and some demographic items: gender, age, income, and education.

2.1.6 Participants

In May 2017, 3646 participants were recruited on MTurk and completed the survey. Each received on completion a $1.50 gift certificate to Amazon.com. Median age was 34 years, with 48% male. They were well educated, with 70% having some college or a college degree, and an additional 20% with some graduate education or graduate degree.

The participant group was politically liberal, compared to the general US population: about 40% identified as liberal or extremely liberal, and only about 14% as conservative or extremely so. The remaining 46% fell in the three intermediate categories: somewhat liberal, moderate, or somewhat conservative. The use of this 7-point scale for political orientation makes direct comparison with representative samples (divided into 3 broader categories) problematic, but it seems clear that in the general US population, liberals do not currently outnumber conservatives (Gallup 2017). Although our MTurk sample is not representative of the US population in education or political orientation, it does allow us to estimate how demographic

variables, political orientation, beliefs about climate change, and the policy advocate's own carbon footprint affect participants' support for a suggested policy. To see how our sample compares to Attari et al. (2016), kindly consult the Supplemental Text.

2.2 Results

2.2.1 Researcher credibility

Credibility was assessed based on agree–disagree responses for six survey items:

1. I believe that the researcher's behavior is consistent with their advice.
2. I believe the researcher's advocacy is sincere.
3. I do not trust the researcher's authority with respect to climate science.
4. I believe that the researcher has good reasons for his behavior.
5. I doubt the researcher's credibility.
6. I believe that the researcher provides quality advice.

The responses were analyzed as in Attari et al. (2016): agreement was coded numerically 1–5, in order of increasing credibility (i.e., "strongly agree" was coded as 1 for the third and fifth items, but as 5 for the others). These codes were summed and the sum rescaled, with the maximum score (+1) representing strong researcher credibility for all six items and the minimum score (− 1) being contrary agreement for all six. This six-item scale has high reliability. The variation in credibility by vignette (see Fig. 1) makes it necessary to calculate reliability separately for low and high home energy vignettes. Cronbach's α was estimated to be 0.91 for low home carbon footprint, 0.85 for high.[1]

Effect of vignette on credibility Figure 1 contrasts high vs. low home energy use in the initial vignette. The researcher's alleged carbon footprint has a large effect on credibility. The average credibility score is + 0.51 for low home energy use but only + 0.07 for high. This result is similar to the averages + 0.55 and 0.00, found by Attari et al. (2016) for the same vignette design (home energy use introduced through an audience question). The detailed features of these two bar graphs are interesting (see Fig. 1); we see them clearly by combining across all six policy vignettes. Sample size (~ 300) does not permit identification of these features for each policy separately, but the separation in central tendency for low versus high home energy use is seen for each policy (see Fig. 2).

Researcher credibility variation is not fully captured by comparing means: the distribution has multiple location features (see Fig. 1), including a strong ceiling effect. Nonetheless we used multiple regressions to approximate the relation of researcher credibility to demographic variables, beliefs and attitudes regarding climate change, general political attitude, and features of the vignette (including the policy change advocated and the alleged home energy use). Table 1 shows the explanatory variables, their scales, the estimated coefficients, and their estimated standard errors for this linear regression. We included all statistically significant explanatory variables, plus political orientation, which is important in the analyses we conduct

[1] In Attari et al. (2016), α was around .87 for the 15 vignettes without high home energy use but only about .76 for the 3 high home energy vignettes.

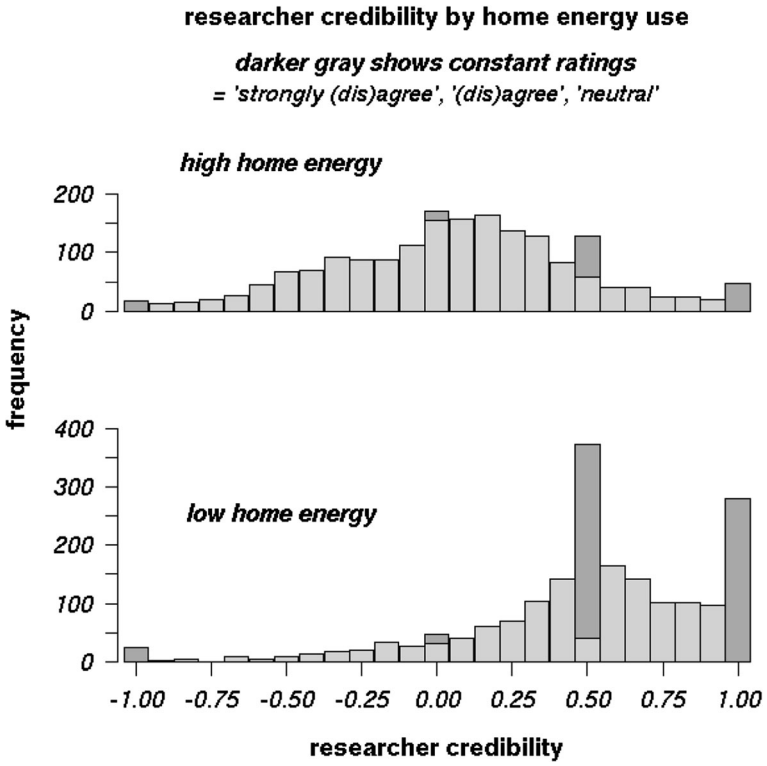

Fig. 1 Barplots show values of researcher credibility for the vignettes describing high and low home energy use (results from all six policy suggestions are combined). The plots show a large effect of home energy use on researcher credibility. The darker shading on the bars at − 1, 0, + 0.5, and + 1 shows the contribution of consistent responding across the six credibility items. The ceiling score (+ 1) is only achievable by consistent responses: strong agreement with all four positively worded items and strong disagreement with both negative items. Similarly, the floor score (− 1) is only achievable by the consistent opposite pattern. The spike at + 0.5 is often achieved by consistent use of moderate responses, agree and disagree. There are also slight elevations at 0, for which consistent use of the neutral response across all six items is largely responsible

below. Most of direct effect of Political Orientation on researcher credibility disappears when specific beliefs about climate change are incorporated in this model.

The only demographic variable that predicts perceived researcher credibility is gender: men give researchers a slightly higher credibility score than women. Political Orientation (extremely liberal to extremely conservative) correlates moderately (− 0.27) with researcher credibility in isolation but is not statistically significant in a multiple regression that includes three responses specific to climate change: (1) *climate change is important to me personally*, (2) *climate change is happening*, and (3) *climate researchers need to influence policy decisions.* Apart from the large negative effect of reported high home energy use on the part of the researcher, researcher credibility also decreased slightly for vignettes where he advocated either use of nuclear energy or stabilizing the human population.

The above three responses specific to climate change are included below in analyses of support for specific policies and of behavioral intentions for personal energy conservation. We also include political orientation: some, but not all, of its effects seem to disappear when the three specific climate change responses are included.

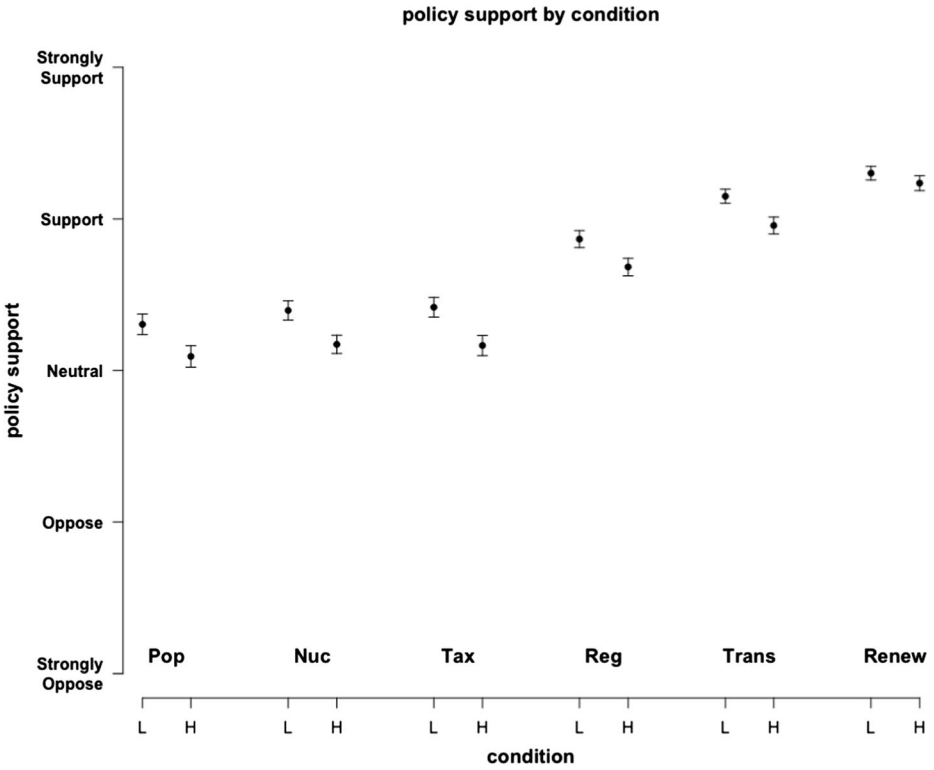

Fig. 2 Mean policy support by condition ± 1 SE. "L" indicates low home energy use and "H" indicates high home energy use conditions. The policies are arranged from low support to high support, starting with the lowest support for stabilizing human population (Pop), followed by increasing nuclear power (Nuc), carbon tax (Tax), carbon dioxide regulation (Reg), increasing public transit (Trans), and increasing renewable energy (Renew)

The linear regression shown in Table 1 is similar to what was found by Attari et al. (2016). Their vignette effect was -0.550 ± 0.027, as compared with -0.417 ± 0.011 in the present study (the much smaller standard error estimate being a consequence of sample size ≈ 6 times larger in the present study). In the present study, the effect on credibility, though still very

Table 1 Linear regression for researcher credibility

Explanatory term	Scale	Coefficient estimate	Standard error estimate
Intercept	− 1 to + 1	− 0.491	± *0.042*
Individual variables			
Male	0–1	+ 0.057	± *0.011*
Climate change importance	1 to 4	+ 0.056	± *0.009*
Climate change is happening	1 to 4	+ 0.048	± *0.010*
Climate researchers need to influence policy	1 to 5	+ 0.172	± *0.007*
Political orientation (Lib–Con)	1 to 7	− 0.006	± *0.004*
Vignette features			
High home energy	0–1	− 0.417	± *0.011*
Advocates nuclear energy	0–1	− 0.068	± *0.015*
Advocates stable population	0–1	− 0.064	± *0.014*

r^2 for model = 0.506

large, might have been reduced by the focus on public policy and and/or by the query inserted about the policy recommendation, which separated the credibility queries from the vignette. The overall model r^2 for the most comparable groups in the 2016 study (dropping the Influence variable, but including the larger effect of home energy) was 0.479.

2.2.2 Support for policy change

Effect of vignette High personal home energy use not only reduces researcher credibility, as shown in the previous section and replicating the result in Attari et al. (2016) but also reduces support for the policy advocated by the researcher. Figure 2 shows mean policy support for all 12 conditions. Note first that there is some positive support for all six policies: mean values are neutral or higher. Participants expressed the lowest overall support for stabilizing population and the highest support for increasing renewable energy. Second, note the difference in mean support for each policy between the "L" and "H" vignette. This answers our key question: Researchers' policy recommendations are better supported if the message recipients believe the researchers conserve energy at home. The magnitude of this effect on support may vary from one policy to another and is not measured precisely in the present sample. Standard errors of the differences between the L and H vignette are about 0.07 scale points for each policy, based on about 300 responses for each vignette. The difference between the means for L and H is about + 0.2 scale points, except for the best supported policy (renewable energy), where the difference is only + 0.07 points and is thus not statistically significant.

Correlates for policy support Table 2 shows linear models for policy support. The same explanatory variables were used for each policy: researcher credibility and the five individual variables of Table 1.

The effect of researcher credibility dominates in all six models. Its inclusion reduces the need to include the vignette itself (L versus H footprint) in the model for each policy. Note, however, that the model fits poorly for population policy and very poorly for nuclear policy. It is striking that the effects of researcher credibility on policy support range across policies from + 0.4 to + 1.0 scale points. This is much larger than the change ascribed to vignette in Fig. 2 (0.2 scale points or less). Researcher credibility includes not only the effect of vignette but factors pertaining to the individual participant (Table 1) and is plausibly the chief factor in determining policy support. The residual effect of vignette, after taking account of credibility and other variables in Table 2 is negligible, as shown by the very low (mostly non-significant) Δr^2 for vignette (2nd last row of Table 2).

Also noteworthy is the effect of political orientation on all but population and nuclear policies: conservatives tend to oppose the four policies whose links to reduction of carbon emission are most obvious. The relationships of political orientation to population and nuclear policies are unclear; we do not have a good account of support for those two policies (apart from the gender difference). Gender differences are substantial: men are more supportive than women of population and nuclear policies while women are more supportive of carbon tax.

Other demographic variables (age, education, and income) were not included in these models: the last row in Table 2 shows the negligible Δr^2 for these three variables taken together.

Table 2 Linear regressions for policy support: coefficients ± 1 SE

Coefficient	Scale	Policy					
		Stabilize population	Nuclear power	Tax CO_2 emission	Regulate CO_2	Subsidize transport	Promote renewables
Intercept	1 (oppose) to 5 (support)	+ 1.47 ± 0.34	+ 3.08 ± 0.32	+ 1.22 ± 0.27	+ 1.54 ± 0.25	+ 2.38 ± 0.26	+ 2.50 ± 0.22
Researcher credibility	− 1 to + 1	+ 0.81 ± 0.11	+ 0.94 ± 0.10	+ 0.59 ± 0.09	+ 0.52 ± 0.08	+ 0.51 ± 0.08	+ 0.43 ± 0.07
Political orientation	1 (liberal) to 7 (conservative)	− 0.03 ± 0.03	+ 0.02 ± 0.03	− 0.09 ± 0.02	− 0.06 ± 0.02	− 0.06 ± 0.02	− 0.05 ± 0.02
Male	0–1	+ 0.24 ± 0.09	+ 0.28 ± 0.08	− 0.14 ± 0.07	+ 0.04 ± 0.06	+ 0.05 ± 0.06	+ 0.03 ± 0.05
Climate change importance	1 (not at all) to 4 (very)	+ 0.10 ± 0.07	− 0.20 ± 0.06	+ 0.21 ± 0.05	+ 0.18 ± 0.05	+ 0.12 ± 0.05	+ 0.19 ± 0.04
Climate change is happening	1 (definite N) to 4 (definite Y)	+ 0.21 ± 0.08	+ 0.06 ± 0.08	+ 0.08 ± 0.06	+ 0.14 ± 0.06	+ 0.13 ± 0.06	+ 0.14 ± 0.05
Researchers influence policy	1 (oppose) to 5 (support)	+ 0.13 ± 0.06	+ 0.06 ± 0.05	+ 0.36 ± 0.05	+ 0.31 ± 0.04	+ 0.20 ± 0.04	+ 0.16 ± 0.04
r^2 for model		0.276	0.188	0.518	0.472	0.357	0.393
Δr^2 for low carbon		0.008	0.013	0.001	0.001	0.003	0.003
Δr^2 for age + education + income		0.002	0.004	0.003	0.006	0.008	0.001

We believe it is important to report the values of the regression coefficients on their natural scale along with their standard errors, to avoid the dichotomization of reports of statistical significance

Finally, beliefs and attitudes around climate change are an important component. Especially important is the belief that scientists should influence policy, which is correlated with stronger support for all the proposed policies except for nuclear. Personal importance of climate change and belief that climate change is happening are correlated with each other, with political orientation, and with researcher credibility, but they ask distinctly different questions and both responses add some information about degree of support for several of the policies. In particular, belief that climate change is happening correlates with support for stabilizing population while personal importance of climate change correlates with support for a carbon tax.

2.2.3 Behavioral intentions

Attari et al. (2016) showed that behavioral intentions reported immediately after a vignette about a climate researcher's talk depend heavily on researcher credibility (assessed by the same six items as in the current study) but also on the personal importance of climate change, on some of the demographic variables, and, in the case of intentions to use public transport more, on political orientation. The present study measured the same intentions but differed in three ways. It was conducted about 2 years later; beliefs and attitudes about climate change have changed somewhat (see Supplemental Text for this analysis). The present survey emphasized public policy as well as individual behavior change and the reported intentions were elicited only after an intervening question about support for the suggested policy. Finally, we included here the question labeled above as scientist influence, which turned out to be a strong explanatory variable in our models of researcher credibility (Table 1) and policy support (Table 2). This question was included because there has been some debate in the literature on whether or not scientists should be advocates for policies or not (Kotcher et al. 2017). We included not only the explanatory variables from our 2016 models for behavioral intentions, but also both scientist influence and belief that climate change is actually happening.[2]

The coefficients for the fitted logistic regression models are shown in the Supplemental Text. They differ only somewhat from those in the earlier study (Table 1 of Attari et al. (2016)). Researcher credibility and personal importance of climate change continue to be very important, but the coefficients for researcher credibility are smaller for both home energy use and curtailment of flying than was found in the earlier study. Political orientation again matters for use of public transport but not for home energy or curtailment of flying. The same demographic variables are important as in the earlier study: women are readier than men to save energy at home but men are (marginally) more willing to increase their use public transport; participants with more education and higher income are less willing to curtail flying; willingness to increase use of public transport goes up with education but down with income; and older people are more willing to curtail flying but less willing to increase use of public transportation. Note that age, education, and income have explanatory value for these individual behavioral intentions, though Table 2 shows that they are little relevant to policy support.

[2] The three behavioral intentions are analyzed in separate logistic regressions. These three dichotomous responses were part of a set of seven yes/no items, presented together in one section of the survey. The multivariate structure of these seven responses was analyzed in Attari et al. (2016) but does not add much of interest beyond modest intercorrelation of the intentions.

Belief that climate change is happening perhaps has marginal influence on home energy use; belief that scientists should influence climate policy is quite important for the intentions to conserve energy at home and to curtail flying.

2.3 Summary of findings

Attari et al. (2016) showed that researchers who fly often, and especially those whose home energy consumption is high, lose credibility with an audience; the audience, in turn, is much less likely to form an initial behavioral intention to follow their advice, by saving energy at home, flying less, or using public transport. Both the reduction in credibility as a function of the researcher's high home energy use and the consequent reduction in the audience's stated intention to conserve energy have been replicated here, where the researcher emphasizes the need for policy change as well as individual behavioral change. Additionally, we find here that high home energy use decreases expressed support for five of the six policies tested. (The decreased support for the policy of developing and deploying renewable energy sources may be smaller; it is not statistically different from zero.) The large size of all these effects suggests high vulnerability to ad hominem attack of advocates of either private or government measures to reduce carbon emissions.

3 Study 2: Researcher credibility lost, regained, or maintained

Here in study 2, we tested whether a climate communicator can regain credibility by reforming his or her past high carbon behaviors.

3.1 Questionnaire design

Participants read one of the six reform vignettes.

3.1.1 Six reform conditions

We replaced the various accounts of researcher carbon footprint with versions that reflected either flying or home energy use reformed to different degrees (e.g., *used to fly all over but now mostly uses videoconference*). The vignettes used three variations: *no reform, some reform, and complete reform*, for either flying or home energy use. Assignment of the vignette focus (flying or home energy) and the reform condition was random.

The three versions for fly were:

> **Fly no reform:** *You later find out that the researcher flew across the country to give the talk that you attended, and that he regularly flies to give talks all over the world, even though avoiding flying would reduce his carbon footprint.*
>
> **Fly some reform:** *You later find out that the researcher used to fly to give talks all over the world. However, he now flies only twice a year to give talks, and participates in the rest by videoconferencing, which has reduced his carbon footprint.*

Fly complete reform: *You later find out that the researcher used to fly to give talks all over the world. However, he has now given up flying altogether. Instead, he participates in events by videoconferencing, which has significantly reduced his carbon footprint.*

The three versions for home were:

Home no reform: *You later find out that the researcher consumes much more energy than the average person at home. He has a large house with a high home energy bill, and does not invest in clean energy or in energy efficient appliances, even though investment in energy efficient appliances would reduce his carbon footprint.*

Home some reform: *You later find out that the researcher used to consume much more energy than the average person at home. He had a large house with a high home energy bill, and did not choose to invest in clean energy or in energy efficient appliances. However, he has now installed energy efficient light bulbs in his home. He is also very active in decreasing his home energy use by changing his thermostat settings, which has reduced his carbon footprint.*

Home complete reform: *You later find out that the researcher used to consume much more energy than the average person at home. He had a large house with a high home energy bill, and did not choose to invest in clean energy or in energy efficient appliances. However, he has now moved into a smaller home and has made energy efficient upgrades to his home including installing energy efficient light bulbs, better attic insulation, and better windows. He is also very active in decreasing his home energy use by changing his thermostat settings, and has since installed solar panels on his roof, which has significantly reduced his carbon footprint.*

Following the vignette, participants were asked about their own intentions to fly less, to conserve home energy, and to use public transport. Next, they were questioned about the credibility of the researcher described in the vignette (the same questions used in the original and the present study). That survey concluded similarly, with attitude questions and demographic questions. The Supplemental Text contains the entire survey.

3.1.2 Participants

In March 2016, 1772 participants were recruited on MTurk and completed the survey. The survey was completed in March 2016 by 1772 participants. Each received on completion a $1 gift certificate to Amazon.com. Median age was 32 years, with 54% male.

3.2 Results

Figure 3 shows that reform of the researcher's energy use has a large effect on credibility. We find that no reform is similar to the results of a high carbon footprint (Attari et al. 2016), but that some and complete reform are similar to a low carbon footprint. The data from the 2016 study belonged to vignettes that were similarly worded, "*You later find out..*" for high and low home energy, and high and low fly.

This is relevant to preparation for and defense against ad hominem arguments. Lost credibility is regained and intentions to conserve energy are restored when the researcher changes his or her behavior. The researcher is judged based on current (reformed) behavior rather than on past behavior.

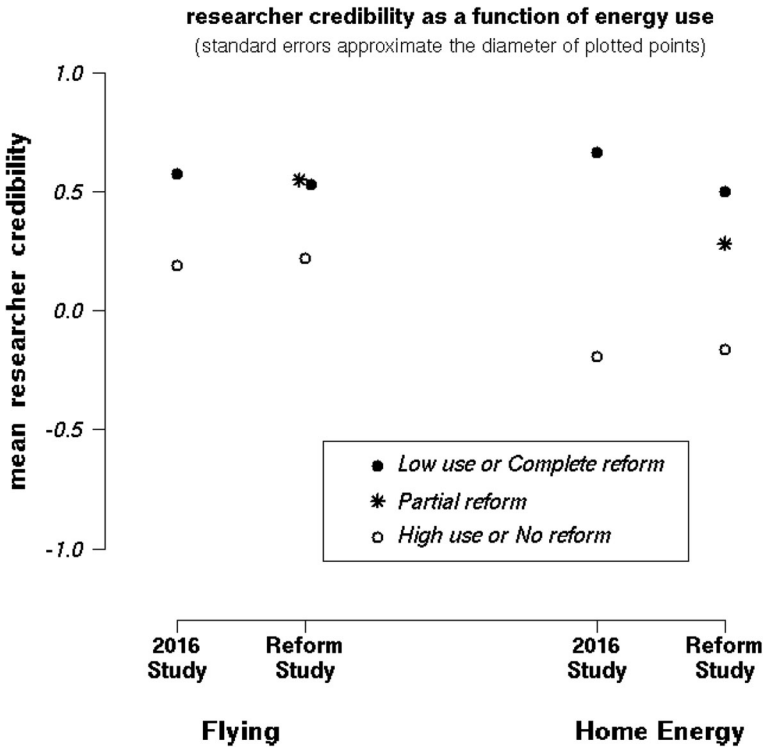

Fig. 3 Mean researcher credibility scores for the low fly, high fly, low home, and high home conditions from Attari et al. (2016) study compared with the six reforming behavior conditions from study 2. Reforming behavior has a large effect on researcher credibility

4 Discussion

Over the past century, laboratory experiments have shown repeatedly that shifts of attitude in response to a message depend on characteristics of the messenger (Hovland et al. 1953). We find that people are more likely to support policies if the advocate for these policies behave in a manner that is consistent with their message. Thus, our basic finding is not new. We have shown, however, that in the climate change debate, the personal behavior of an advocate can have an enormous effect on audience intentions to conserve energy and a substantial effect on audience support for climate-related public policies. In our earlier study, the intention to conserve energy at home varied from less than 30% of participants to nearly 90%, depending on the degree to which the messenger is rated as credible (Attari et al. 2016). In this current replication, the fitted model indicates that this same intention varies similarly: from 32% when credibility = − 1 up to 92% for credibility = + 1.

Similarly, we now find that policy support is strongly associated by credibility of the advocate. For example, when credibility is below − 0.50, 26 out 34 participants in the present study either oppose or strongly oppose a carbon tax while only 4 of the 34 support it, but for credibility above + 0.75, 69 out of 81 participants either support or strongly support the tax and only 6 out of 81 oppose it.

Our plausible conclusion is that the credibility, in turn, is most strongly affected by the advocate's home energy use (Table 1), secondarily by audience opinions related to climate change and to the role of researchers in setting policy, and very little by political orientation (after taking into account the effects of attitudes directly related to climate).

We find that high home energy use similarly affects support for other policies that a researcher advocates. This finding is significant and strong for all policies save renewable energy development (where overall strong support for this policy overshadows the effect of high home carbon footprint).

Advocates for energy conservation and for policies that reduce carbon emissions must expect ad hominem arguments based on their own energy use. Such arguments are probably best countered personally, by leading the way and demonstrating how to act in concordance with one's own beliefs and recommendations, and by being an exemplar others can follow (Kalmus 2017; Kraft-Todd et al. 2018), rather than relying primarily on communicating scientific facts about global warming and its risks. There are seemingly growing movements of academics and climate communicators that call for less flying and other personal behavioral changes while also calling for deeper and more meaningful institutional changes indicating that some climate researchers are indeed trying to walk the talk.[3]

The main limitation of our study is that we do not know how self-reported intentions relate directly to actual future behaviors nor do we know how policy support expressed in a survey translates into concrete political action. Levine and Kline (2017) show that changes in public opinion are usually not sufficient to create political action. They show that on average legislators are far more responsive to organized activists than they are to public opinion. Policy change likely rests on both public opinion and collective political action. There are cases where public opinion can drive the political agenda and vice versa, but the likelihood of policy change can be increased when both public opinion and political activism are strongly endorsing the proposed policy change. Other limitations include the ecological validity of our vignettes and that we have yet to assess the durability of the effects on credibility and the consequent effects on audience intention and policy support. Future online and field experiments could address these limitations.

Author contributions S.Z.A. and D.H.K. designed research; S.Z.A. collected the data; S.Z.A. and D.H.K. analyzed data; and S.Z.A., D.H.K., and E.U.W. wrote the paper.

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Compliance with ethical standards

This research was approved by Indiana University's Internal Review Board at the Office of Research Administration, and informed consent was received from all participants.

Conflict of interest The authors declare that they have no conflict of interest.

[3] see, e.g.: http://noflyclimatesci.org/

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