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The critical role of second-order normative beliefs in predicting energy conservation

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Sustaining large-scale public goods requires individuals to make environmentally friendly decisions today to benefit future generations[1–6]. Recent research suggests that second-order normative beliefs are more powerful predictors of behaviour than first-order personal beliefs[7,8]. We explored the role that second-order normative beliefs—the belief that community members think that saving energy helps the environment—play in curbing energy use. We first analysed a data set of 211 independent, randomized controlled trials conducted in 27 US states by Opower, a company that uses comparative information about energy consumption to reduce household energy usage (pooled $N = 16{,}198{,}595$). Building off the finding that the energy savings varied between 0.81% and 2.55% across states, we matched this energy use data with a survey that we conducted of over 2,000 individuals in those same states on their first-order personal and second-order normative beliefs. We found that second-order normative beliefs predicted energy savings but first-order personal beliefs did not. A subsequent pre-registered experiment provides causal evidence for the role of second-order normative beliefs in predicting energy conservation above first-order personal beliefs. Our results suggest that second-order normative beliefs play a critical role in promoting energy conservation and have important implications for policymakers concerned with curbing the detrimental consequences of climate change.

Although new technologies that may help to limit the effects of climate change are becoming increasingly widespread and affordable, behavioural and interpersonal barriers continue to hinder the adoption of sustainable behaviour. To design policies that are needed to address climate change and other environmental and social public goods, researchers need to more closely understand the factors influencing conservation behaviour and how interventions can best make use of these factors. Currently, interventions often target an individual's first-order personal beliefs, that is, one's understanding of oneself and one's world[9]. Many people in the United States continue to believe that climate change is not a real threat or a human-induced problem[10] and one might expect that targeting these beliefs will lead to attitude and behavioural changes that may help to reduce the impact of climate change.

However, such information-centred approaches are both expensive and surprisingly ineffective in influencing conservation behaviour[11]. Research has found that first-order personal beliefs are often resistant to change, especially deeply held views such as environmental beliefs[9,10]. For example, one study found that providing car drivers with information about savings from reduced car usage or information on environmental harm, or both, had virtually no effect on their driving behaviour and instead lead to psychological commitment to their initial personal belief[11]. Attempting to change an individual's first-order personal beliefs and behaviours, especially if they are central to an individual's self-view, has proven to be challenging[12]. Subsidies for energy-efficient goods, as well as educational campaigns that aim to provide accurate information on climate change and recognize it as a threat to human society, are also expensive and have had fairly limited success[13,14].

Instead, recent research has found that better predictors of behaviour than first-order personal beliefs are second-order normative beliefs, that is, perceptions about what is commonly believed[7,8]. For example, decades of research in cultural psychology has assumed that cross-cultural differences in behaviour are driven by differences in personal values. However, recent studies have found that second-order normative beliefs are better predictors of culturally consistent behaviour[15]. One study found that Chinese participants who believe that most of their fellow citizens hold collectivistic values acted in a more culturally consistent way[16]. Similarly, blame judgements by Americans and Koreans were more culturally consistent to the extent that individuals believed that other citizens held culturally consistent beliefs[17]. Across both studies, second-order normative beliefs predicted how people behaved and judged others, over and above culturally relevant first-order personal beliefs.

Early work in prejudice reduction also theorized that interventions were effective to the extent that they changed people's first-order personal beliefs[18,19]. However, research has found that interventions designed to decrease prejudice and bullying are successful mainly due to their influence on second-order normative beliefs, rather than on first-order personal beliefs. For example, a large-scale field experiment in Rwanda found that when a radio soap opera featured prejudice-reduction messages, intergroup prejudice decreased through listeners' perceptions of second-order normative beliefs; conversely, these messages had little effect on people's first-order personal beliefs. Overall, the radio programme, which ran over the course of 1 year and repeatedly exposed groups of listeners to prejudice-reducing messages, influenced listeners' beliefs of the collective norm, which then shifted their behaviours in the direction of that norm[20,21]. Similarly, changing a peer group's public reaction towards bullying alters student's harassment behaviour by altering perceptions of collective norms[22]. Thus, several lines of research converge to show that second-order normative beliefs are a powerful predictor of behaviour.

We explore the importance of second-order normative beliefs in predicting energy conservation behaviour beyond first-order personal beliefs in the context of descriptive norm information. In recent years, a wide variety of studies have shown that people change their behaviour in response to receiving information about the descriptive norm, that is, what the majority of people in one's community are doing. From increasing honest tax reporting[23], reducing alcohol abuse[24,25] to reducing energy consumption[26,27],

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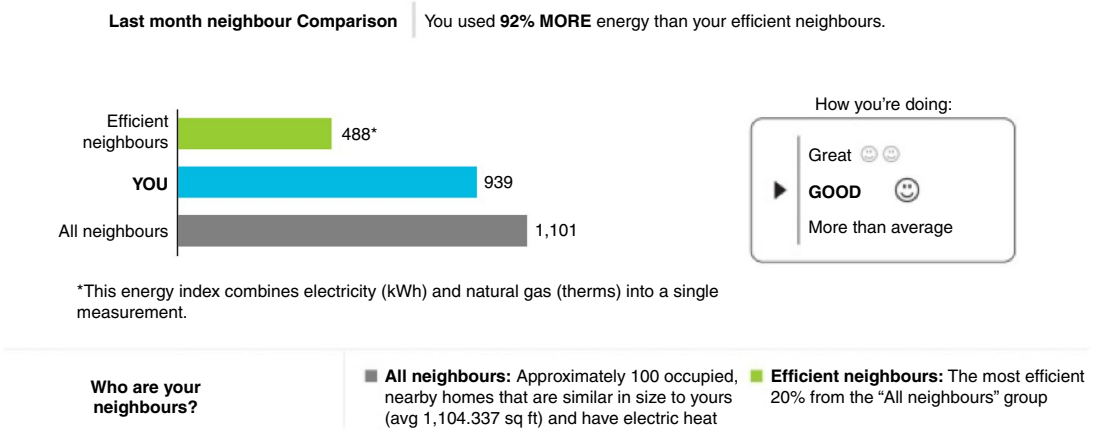

Fig. 1 | An example of an Opower Home Energy Report. Customers in the treatment condition receive a bimonthly (or less frequent) mailing that compares their energy usage with that of similar, nearby households. These descriptive norm messages have been shown to be effective in influencing people to conserve energy, but the effectiveness of the descriptive norm varies across US states.

there is little doubt empirically that the provision of descriptive norm information is an effective means to initiate behaviour change, but various theories have been proposed to why that is the case.

One popular account[7,8] suggests that descriptive norms provide previously unknown information and by doing so shape an individual's views of what is the right thing to do: the reasoning goes that, if everyone is doing it, then it must be a sensible thing to do. However, if this were the case, then the behavioural change produced by the provision of descriptive norm information should be relatively similar across different areas. Several studies do not provide evidence for this conclusion, finding that descriptive norm interventions do not affect all individuals equally[23–29].

Take the large set of randomized controlled trials (RCTs) carried out by Opower, a firm that is contracted by utility companies to help meet energy conservation requirements. Over the past few years, Opower has systematically provided descriptive norm information across the United States and tested its effects on energy conservation behaviour. We analysed a data set that we obtained of 211 RCTs using descriptive norm interventions across the 27 US states where Opower operates and find that the effectiveness of norm information varies between 0.81% reduction in some RCTs and 2.55% in others, a relative difference of about 300% between states. Although the provision of descriptive norm information has successfully reduced energy consumption overall, there is remarkable variation between RCTs. This makes it highly unlikely that descriptive norm information consistently and solely changes individuals' views of what is the right thing to do.

Thus, we propose an alternative account: instead of descriptive norms creating behaviour change by altering first-order personal beliefs, as has been previously suggested[7,8], we hypothesize that descriptive norm information combines with second-order normative beliefs to influence behaviour. To understand how descriptive norm information influences behaviour, it is necessary to consider an individual's second-order normative beliefs. We propose that descriptive norm information predicts energy conservation behaviour when an individual holds a second-order normative belief that is consistent with the descriptive norm information. That is, we argue that people follow descriptive norm information more when they believe that other people in their community support that norm. This is in part the case because, as early as childhood[30], individuals adapt to and internalize norms to avoid violating them as norm violations can be costly: offenders may be punished, avoided, ostracized, shamed or directly attacked by their community for violating the norm[31–35]. In addition, not sharing normative views with others hinders one's ability to form close relationships with them[36]. Conversely, those individuals who comply with a norm are rewarded for their efforts by being valued highly by their community[32,37].

To test these predictions, we first analysed a large set of RCT results carried out by Opower. After establishing the predictive effect of second-order normative beliefs on energy conservation, we subsequently conducted an experimental study that manipulated second-order normative beliefs to provide causal evidence.

As previously mentioned, the provision of descriptive norm information showed wide variation in effectiveness across the RCTs within the 27 states where Opower operates. We applied our theoretical framework to clarify the roles of first-order personal and second-order normative beliefs in explaining the impact of descriptive norm interventions. We predicted that an individual's likelihood to change their behaviour—and thus, save energy—depends on both exposure to descriptive norm information (that is, the Opower treatment assignment) and an individual's second-order normative beliefs (that is, whether an individual believes that their neighbours or community care about energy conservation). More precisely, we predicted that second-order normative beliefs would predict energy conservation behaviour over and above first-order personal beliefs.

In our first study, we tested the relationship between first-order personal and second-order normative beliefs on behaviour change following descriptive norm interventions by combining two large data sets. The first data set comprises 211 large-scale RCTs from Opower. This data set includes energy consumption rates at the RCT level from 16,198,595 households over 7 years across 27 states. Households in these energy savings trials were randomly assigned to either a control or treatment condition. In the treatment condition, households received regular descriptive norm information about their neighbours' energy consumption. In addition to the descriptive norm information, participants in the Opower trials also received prescriptive norm information regarding their current energy conservation (for example, 'good' and a smiley face in Fig. 1). This additional information was introduced to ensure that participants who were already conserving more energy than their neighbours would not change their behaviour to consume more energy, as earlier studies have found[27]. By contrast, households in the control condition received no additional communications and were treated no differently than they would have been otherwise (for a more detailed explanation, see refs [26,29,38]). The data set that is the focus of the current investigation represents an expanded

version of a previous set of Opower data, which contained 111 RCTs involving 8.6 million households[38].

All Opower RCTs include a core programme element, a so-called Home Energy Report (see Fig. 1) that graphically illustrates the focal household's energy usage and the average energy usage of similar, nearby households over the same time period. Although small variations in the layout of the energy reports exist, the fundamental aspects of these trials are identical (that is, a series of comparable 'procedural field experiments')[39]. Thus, it is highly unlikely that the variability of the outcome across RCTs can be explained by small differences in experimental design.

The most likely source for the variation is where in the United States the trial was conducted. Indeed, we find that the effectiveness of the provision of descriptive norm information in achieving energy savings varies on a state-by-state basis (mean = 1.59%, s.d. = 0.5%, min = 0.81%, max = 2.55%), which we take as a starting point for our investigation.

The dependent variable in our research is the standardized average monthly rate of energy conservation by RCT in each state during Opower's trial period. The energy savings rate is defined as the percentage of energy saved in the treatment group relative to the control group usage by RCT. The energy savings data arises from real behavioural changes in household behaviour as measured by utility companies.

The second data set comes from a sample of survey respondents (N = 2,001) from the same 27 states. The questionnaire answered by these respondents measured both first-order personal and second-order normative beliefs. Participants were asked whether they themselves believe that energy conservation helps to save the environment (first-order personal beliefs) and whether they believe that the majority of their neighbours believe that saving energy helps to save the environment (second-order normative beliefs). Both questions were scored on a 7-point scale ranging from 1 (not at all) to 7 (very much). We aggregated individual-level responses from the survey to the state level, as this was the level at which we could match to the Opower RCT data, which (in line with ref. [39]) were aggregated on the RCT level within a state and used as the unit of analysis. Unless otherwise noted, we cluster robust standard errors at the state level (for methodological details, see the Supplementary Information).

In the regressions presented below, we control for several variables previously associated with the Opower treatment effect. For example, treatment effects vary considerably by how long the trial has been running[38]. Thus, we followed the regression strategy outlined in ref. [39], controlling for programme duration. Consistent with past work, we weighted observations by the inverse variance of the cohort size. We also controlled for the average household energy usage in the state, population density and survey respondents' demographics. Finally, we use standardized z-scores of both the independent and the dependent variables for the analysis because our variables have different magnitudes and units; however, not standardizing these variables does not alter the significance or interpretation of our results[40] (for more details on the analytical strategy, see the Supplementary Information).

We hypothesized that second-order normative beliefs would predict the effectiveness of descriptive norm information on the energy savings rate over and above first-order personal beliefs. This is exactly what we found: second-order normative beliefs predicted energy savings rates (coefficient = 0.755, s.e. = 0.323, P = 0.030; model 1 in Table 1). By contrast, first-order personal beliefs did not predict energy savings rates (coefficient = 0.209, s.e. = 0.324, P = 0.527; model 2 in Table 1). These results hold when entering both predictors simultaneously: second-order normative beliefs predicted energy savings rates (coefficient = 1.138, s.e. = 0.446, P = 0.020), whereas first-order personal beliefs did not (coefficient = −0.696, s.e. = 0.478, P = 0.162; see model 3 in Table 1). In addition, because first-order personal beliefs and second-order normative beliefs are moderately correlated (Pearson r = 0.58, Spearman r = 0.62, P < 0.001), we tested for multicollinearity, and the variance inflation factor remained within acceptable standards[41] (that is, below 10). Furthermore, the results were robust to the inclusion of control variables (model 5 in Table 1) and were similar when analysing RCTs from states with at least 50 survey respondents (N = 195), as well as when we included every RCT (model 6 in Table 1). Figure 2 provides a graphical illustration of model 3 (main sample without covariates), model 5 (main sample with covariates) and model 6 (full sample with covariates).

In the Supplementary Information, we report further robustness checks using alternative sampling weights to control for survey uptake in each state, restricting our analysis only to trials without imputed averages for missing variables, including survey respondents who did not pass the attention quiz, and using the amount of energy saved as the outcome variable; results are qualitatively similar across all specifications. In our supplemental analyses, we rule out, for example, that our effects are driven by differential sample selection biases across states. To do so, we use inverse variance weights based on representative gender and age demographics in each state from the 2010 US Census and replicate our findings (see Supplementary Tables 1–5 and Supplementary Information for more details).

In summary, the results from our analysis of the Opower data show that second-order normative beliefs, but not first-order personal beliefs, are associated with an increased energy savings rate following the provision of the energy comparison information. This data provide correlational support into the relationship between second-order normative beliefs and energy conservation behaviour. Next, we conducted an experimental study to provide causal evidence for the role of second-order normative beliefs.

To provide causal evidence for the role of second-order normative beliefs in predicting energy conservation behaviour, we conducted a pre-registered experimental study (see http://aspredicted.org/blind.php?x=xy3a4f). Both the sample size and the exclusion criteria that we describe below were pre-registered in advance of data collection. We recruited 561 participants (mean age = 36.96, s.d.$_{age}$ = 11.84, 52.23% female) from Amazon Mechanical Turk (AMT), who were first asked to indicate what state and county they lived in (see Supplementary Information for additional information). Next, all participants were asked to imagine that their energy provider recently sent them a bill including information about their energy consumption. This information was presented in text and graphically and showed that participants used 28% more energy than their neighbours and was closely modelled to resemble the neighbourhood comparison information that Opower sends to its customers (see Fig. 3).

All participants were then told that we would access information about the energy conservation beliefs of individuals living in their home county. A loading screen appeared on the page and it took 4 seconds to retrieve information about participants' home county. The information subsequently provided to participants represents our random assignment to the low second-order beliefs and the high second-order beliefs conditions (for a similar methodology, see ref. [43]).

In the low second-order beliefs condition, participants were told that their county was in the 11th percentile of energy conservation beliefs in the United States. We further elaborated, "[t]hat means that there exists very low awareness that households in your home county can help save the environment: most of your neighbours do not believe that saving energy is important to help the environment." In the high second-order beliefs condition, participants were told that their county was in the 89th percentile of energy conservation beliefs in the United States. We further elaborated, "[t]hat means that there exists very high awareness that households in your home county can help save the environment: most of your neighbours believe that saving energy is important to help the environment".

As our dependent variable, we assessed participants' likelihood of reducing their energy consumption with the following question:

Table 1 | Second-order normative beliefs, but not first-order personal beliefs, predict energy savings rates

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Second-order normative beliefs	0.755* (0.323)	–	1.138* (0.446)	–	1.030* (0.385)	1.082*** (0.281)
First-order personal beliefs	–	0.209 (0.324)	−0.696 (0.478)	–	0.006 (0.629)	−0.341 (0.499)
Control group daily energy usage	–	–	–	0.030 (0.071)	0.072 (0.066)	0.080 (0.069)
Programme start date	–	–	–	−0.370*** (0.050)	−0.341*** (0.052)	−0.339*** (0.051)
State population density	–	–	–	−0.075 (0.071)	−0.154* (0.074)	−0.124* (0.061)
Average age of respondents in the state	–	–	–	−0.084 (0.277)	0.298 (0.272)	0.232 (0.256)
Female respondents in the state (%)	–	–	–	−0.702 (0.462)	−0.588 (0.531)	−0.595 (0.433)
Constant	−0.240** (0.072)	−0.214* (0.081)	−0.237** (0.072)	−0.147* (0.063)	−0.173** (0.056)	−0.165** (0.057)
Observations	195	195	195	195	195	211
R^2	0.031	0.002	0.041	0.250	0.283	0.264

Second-order normative beliefs predicted energy savings in 211 large-scale energy savings RCTs (pooled N =16,198,595), whereas first-order personal beliefs did not. Model 1 shows that second-order normative beliefs predictedenergy savings rates, whereas model 2 shows that first-order personal beliefs did not predict energy savings rates. Model3 lists the control variables derived from past research on Opower trials. When control variables are added to the mainmodel in model 4, the effect of second-order normative beliefs remains significant. The main sample of US states with atleast 50 respondents is used in models 1–5. All states regardless of sample size are included in model 6. All variables arestandardized (z-scores). Observations are weighted using cohort size by inverse variance. Robust standard errors areclustered at the state level. ***$P<0.001$, **$P<0.01$, *$P<0.05$.

how willing would you be to decrease your energy consumption in the next month? Responses were given on a 7-point scale ranging from 1 (not at all willing) to 7 (extremely willing).

As a manipulation check, we asked participants to report their second-order beliefs with the question: to what extent do you believe your neighbours (or community) think that reducing household energy contributes to saving the environment? To control for participants' first-order beliefs in our analyses, we also assessed participants first-order beliefs with the question: to what extent do you believe that reducing household energy contributes to saving the environment? Both questions were presented in counterbalanced order and responses to both questions were given on a 7-point scale ranging from 1 (not at all) to 7 (very much). Because the order of questions had no significant effect on the responses to these questions, we collapsed across order in our subsequent analyses. At the end of the study, participants were asked whether they believed the information provided about energy conservation beliefs in their home county. Consistent with our pre-registration plan, we excluded suspicious participants; importantly, all results hold with and without any data exclusions (see Supplementary Information) and there was no significant difference in suspicion across conditions ($t(559)=0.83$, $P=0.41$).

To summarize the experimental set-up: we manipulated second-order beliefs, held constant the descriptive norms information and measured and controlled for first-order personal beliefs. As a result, our design allows us to test whether second-order normative beliefs have a causal effect on energy conservation behaviour over and above first-order personal beliefs.

We first examined whether the manipulation of second-order beliefs was successful. We find that participants in the high second-order beliefs condition had significantly higher levels of second-order normative beliefs (mean = 5.66, s.d. = 1.22) than participants in the low second-order beliefs condition (mean = 4.01, s.d. = 1.45; $t(346)=11.45$, $P<0.001$). Thus, we conclude that our manipulation was successful.

We subsequently tested whether the manipulation of second-order beliefs influenced participants' willingness to reduce their energy consumption in the next month. We find that participants in the high second-order beliefs condition were significantly more willing to reduce their energy consumption (mean = 5.83, s.d. = 1.17) than participants in the low second-order beliefs condition (mean = 5.33, s.d. = 1.30; $t(346)=3.65$, $P<0.001$). The effect of condition holds even when controlling for measured first-order personal beliefs ($B=0.332$, s.e. = 0.115, $P=0.004$). We note that, unlike the first study based on the Opower field data, higher first-order personal beliefs were significantly related to an increased willingness to reduce energy consumption ($B=0.557$, s.e. = 0.044, $P<0.001$). The 95% confidence intervals around the experimental manipulation of second-order normative beliefs condition and the measurement of first-order personal beliefs overlapped, indicating that they are both of similar size.

The results of the experimental study provide support for the causal role of second-order beliefs in the formation of energy-saving intentions. Consider that all participants in this study received the same descriptive norm information that they used more energy than their neighbours, similar to what participants in the Opower treatment received. However, when participants were also told that their neighbours believe that saving energy is important to them, they were more willing to subsequently reduce their energy consumption, in comparison to participants who were told that their neighbours do not believe that saving energy is important to them. These results provide further evidence of the important role of second-order normative beliefs in predicting energy savings behaviour, over and above first-order personal beliefs.

Current approaches to reduce energy consumption typically focus on interventions that attempt to motivate individuals to change their first-order personal beliefs[9–11,13,14]. These interventions make intuitive sense: by educating and informing citizens about the importance and dangers of global warming, policymakers may intend to change the first-order personal beliefs of its citizens.

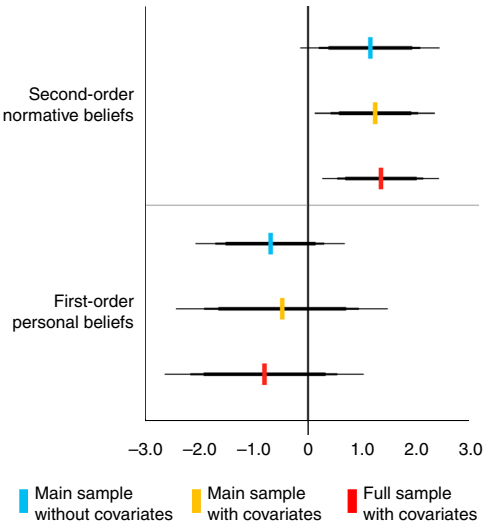

Fig. 2 | Second-order normative beliefs predict energy savings in 211 large-scale energy savings RCTs. The effect of second-order normative beliefs is plotted for a regression model with standardized coefficients based on the main sample (that is, US states that had at least 50 survey respondents) with and without covariates, as well as for a regression model with all states. Regardless of the survey response rate and covariates, second-order normative beliefs significantly predicted savings rate in all model specifications, whereas first-order personal beliefs did not. For each estimate, the outer (thin) error bar represents the 99% confidence interval, the middle error bar represents the 95% and the inner (thick) error bar represents the 90% confidence intervals. Pooled $N = 16{,}198{,}595$.

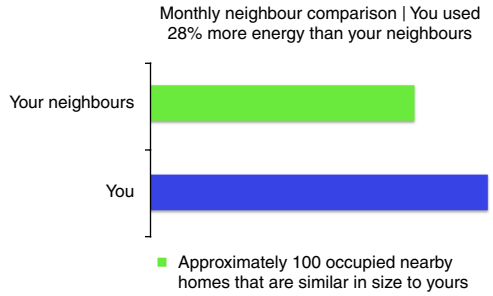

Fig. 3 | Information given to all participants about their energy consumption in the experimental study. The design was closely modelled after the information that Opower sends to its customers. The *x* axis represents the amount of energy consumed.

However, this information-centred approach is expensive and often inefficient in altering behaviour[11]. We believe that a better policy approach for changing behaviour requires policymakers and researchers to more closely understand what factors drive behaviour change and how these factors can best be implemented at all levels of policy-making.

To this end, sustainable energy-use behaviour—one important element in curbing climate change—has been encouraged in recent years through the application of descriptive norms[16,17]. However, these norm interventions vary in their effectiveness, with some previous research unable to find any effect of these norm-based manipulations on behaviour altogether[23–29]. Indeed, in the large-scale Opower data set that we present here, the effectiveness of descriptive norm information in producing reductions in energy usage varied by 300% across different states. Because interventions need to be maximally successful to limit the effects of global warming, we set out to understand why descriptive norms worked better in some states than in others. To do so, we leveraged recent research on the importance of second-order normative beliefs in predicting behaviour change. Stated simply, we proposed that second-order normative beliefs toward energy conservation would predict energy-saving behaviour, over and above first-order personal beliefs.

Our findings provide insight into why descriptive norm messaging produces a change in behavioural outcomes in some cases but not in others. In a data set of 211 RCTs, we found that the provision of descriptive norm information was associated with greater energy conservation in those states where individuals believed that energy conservation was valued by members of their community, that is, where they possessed higher treatment-consistent second-order normative beliefs. In a subsequent experimental study, we provide causal evidence for our proposition that receiving descriptive norm information about a household's energy usage relative to similar neighbours is more effective when household members believe that their neighbours value energy conservation. Because this experiment manipulated second-order beliefs, while holding constant normative information and measuring and controlling for the first-order beliefs, it demonstrates that second-order beliefs have a causal effect over and above first-order beliefs.

These results mirror earlier findings that both cross-cultural differences and prejudice reduction are driven by second-order normative beliefs[15–17,20–22]. When we think that our community cares about a behaviour, we worry more about the costs of norm violation[32,37,42]. Indeed, second-order normative beliefs may have implications for our understanding of sustainable and cooperative behaviours more generally. For example, recent work finds that beliefs about others' intention to cooperate shape one's intuitive cooperativeness in social dilemmas[43]. Under what circumstances cooperation is intuitive (that is, the default behaviour) has recently received considerable attention[45–47]. In the context of sustaining large-scale public goods, such as combating climate change, saving energy or recycling, future work needs to be conducted to further our understanding of the conditions—including the role of second-order normative beliefs—that lead to intuitive, habitual, sustainable behaviours[47,48].

These findings have important implications for policymakers. On the basis of our findings that the combination of descriptive norms and second-order normative beliefs is associated with greater energy conservation behaviour, utility companies could consider implementing descriptive norm information programmes in areas where second-order normative beliefs are higher, as they are likely to be more effective there. In addition, because previous research has shown that second-order normative beliefs are more amenable to change than first-order personal beliefs[20,22,49], our results also suggest that a communication strategy focused on changing second-order normative beliefs, in combination with providing descriptive norms, may be more effective than current approaches that focus only on affecting individuals' first-order personal beliefs. For example, communities could engage in public demonstrations of desirable behaviours, especially those that may help to limit the effects of climate change.

We chose to rely on AMT for the study population because AMT workers tend to be younger, less wealthy and less educated but more racially diverse than the general US population and comparable survey samples[50,51]. This is important because previous research found that wealthier, well-educated households were more likely to be in neighbourhoods that were early adopters of the Opower trials, and those early trials tended to have higher savings rates[38]. However, if anything, this implies that our findings are a conservative test of our hypothesis: we find that second-order normative beliefs predict conservation rates, even among a less-wealthy, less-educated population. In addition, in the Supplementary Information, we report analyses in which we created weights for gender and age bins for

each state based on US Census data, and all results remain qualitatively similar. This provides additional evidence that differential sample selection biases (that is, non-randomness) are unlikely drivers of our effects. That said, we encourage further research into different population segments to better understand the heterogeneous effects of wealth, education and other demographics on sustainable energy behaviours.

In addition, future research would benefit from investigating other levels of analysis of first-order personal and second-order normative beliefs. For example, it is feasible that first-order personal and second-order normative beliefs also vary within a state, such that communities with high second-order normative beliefs exist in states with low first-order personal beliefs (for example, Austin in Texas) and vice versa[52,53]. Moreover, although the Opower intervention focuses specifically on energy use in households, curbing individual-level energy use is only one of the many factors to limit the devastating effects of climate change. Indeed, other important approaches include urging individuals to change their equipment, such as installing solar panels or insulating their house. It is possible that second-order normative beliefs may also influence individuals to adopt a wider range of energy-efficient household equipment and a sustainable lifestyle, beyond the individual-level energy use measured by the Opower trials. A more detailed mapping of first-order personal and second-order normative beliefs to other sustainable behaviours may not only deepen our understanding of the underlying psychology of descriptive norms but could also help to refine climate change communication strategies.

Finally, subsequent research could investigate additional mechanisms for why second-order normative beliefs combine with descriptive norm information to predict energy savings. Our theorizing built off previous literature in cross-cultural psychology and prejudice reduction, which proposes that individuals worry more about the costs of norm violation when they have higher second-order normative beliefs[32,37,42]. However, we believe that there are probably additional pathways. One such possibility concerns the role of attributions[55–57]. Consider that a neighbours' reduced energy use could be attributed to the punishment of norm violation ('their neighbours scolded them for leaving their lights on'), volition ('they saved energy because they took conscious steps to do so') or happenstance ('they saved energy because they weren't home much in the past few months'). One possibility is that higher second-order normative beliefs increase one's tendency to conclude that one's neighbours purposefully reduced their energy consumption. As a result of these second-order normative beliefs, the descriptive norm information becomes a more relevant standard and more likely to guide individuals' behaviour. We encourage future research to further uncover the mechanisms involved in the role of second-order normative beliefs.

Ultimately, combating environmentally damaging behaviours requires individual-level cooperation[1–6], which is difficult to achieve because self-interest can quickly lead to free-riding[31,32,37]. Past research has found that how we view our community and how likely we think that they will choose to cooperate rather than free-ride exerts a strong influence over our own decision to cooperate[57]. However, our results suggest an additional component: what we think our community thinks about an issue affects our likelihood to act. In other words, people might generally agree that reducing energy consumption is needed to help the environment and save our planet, but to make it happen, they need to believe that others care about it too.

Methods

Ethical approval. All participants in the online survey and the online experiment consented to participating in this study, and ethical approval for both the survey and the experiment, as well as the use of the Opower data, was obtained from Columbia University's institutional review board.

Opower context. The company Opower (acquired by Oracle in 2016) built a commercial platform to promote household energy conservation. As of the time of data collection, Opower operated in 27 states across the United States in collaboration with energy providers. Opower runs RCTs with most energy providers that they work with to measure programme effectiveness. Over the past decade, Opower has conducted over 200 RCTs testing the effectiveness of descriptive norm adherence on energy consumption across 27 US states. Opower programmes employ RCTs where programme households are selected, matched to similar households based on their energy usage and randomly assigned to a treatment or control group. Treatment group households receive information on how their energy consumption compares to the energy consumption of similar households. The treatment effect—energy savings rate—is defined as the percentage of energy saved in the treatment group relative to the control group usage by the RCT.

Survey sample. We surveyed individuals in the same 27 US states to assess the effects of normative and first-order personal beliefs on this treatment effect. We recruited 2,001 participants (51% female; age: mean = 37.05, s.d. = 54.88) on AMT, an online labour market[58,59], across the 27 US states in which Opower operates. In advance of data collection, we aimed for equal representation of all states in our data set and specified to have at least 50 participants per state; we stopped recruitment when the sample size per state reached 100 participants or after 3 weeks of continuous data collection, whichever occurred first. For 7 (out of 27) states, the smallest states in the Opower trials, we were unable to collect our target sample size. Unsurprisingly, the number of survey respondents in our sample was proportional to the population of the state (linear regression of state population predicting the number of survey respondents, with robust standard errors: coefficient = 2.73×10^{-6}, $P = 0.020$). Thus, smaller states were less likely to meet our minimum sample size criteria (linear regression of state population predicting the minimum threshold of at least 50 survey participants, with robust standard errors: coefficient = 2.8×10^{-8}, $P = 0.043$). Our main analysis focuses on the states where we have at least 50 participants; however, when we include participants from all 27 states, the results are qualitatively similar.

To ensure that survey responders were paying attention throughout the survey, we included an attention check, as commonly done on Mechanical Turk[60]. Ninety-one per cent out of 2,001 participants passed the attention check; thus, our final sample consists of 1,819 participants. Although our main analysis focuses on participants who passed the attention check, the results are qualitatively similar when we include participants who failed it.

Predictor variables. Our main predictor variables were individuals' first-order personal and second-order normative beliefs. Our survey participants were asked two questions about their beliefs toward energy conservation. One question elicited their first-order personal beliefs, asking to what extent participants thought 'reducing household energy contributes to saving the environment'. The other question elicited second-order normative beliefs, asking to what extent the survey respondent thought 'the majority of [his or her] neighbours (or community) thinks that reducing household energy contributes to saving the environment'. Both questions were scored on a 7-point scale ranging from 1 (not at all) to 7 (very much). First-order personal and second-order normative beliefs were elicited in randomized order. Because results are qualitatively similar regardless of the question order, our analysis collapses across order.

Dependent variable. The outcome variable in our investigation is the standardized average monthly rate of energy conservation. The commonly used measure of energy conservation in the Opower trials is the energy savings rate: the percentage of energy saved in the treatment group relative to the control group usage by RCT.

Control variables. In Table 1, we first report our results without any control variables (see models 1–3). However, to check for robustness, we repeated the analysis including numerous control variables (see models 5 and 6). First, we controlled for the duration of the RCT, as this has been implicated previously in Opower effectiveness[38]. Second, we controlled for the amount of energy used in the control group of each particular state. This takes into account that some states might have higher levels of energy usage than others. Third, to ensure that the effectiveness of descriptive norm interventions does not depend on people living closer together (for example, densely populated cities), we controlled for population density at the state level. Last, we also controlled for age and gender of survey respondents, for which we compute the state-level average in our regressions.

Analytic strategy. We used *t*-tests based on individual-level data when analysing survey responses alone. Following ref. [39], when studying correlations between survey responses and energy savings, we used linear regressions predicting average energy savings rates with inverse variance weighted by cohort size. For observations in which the cohort size was missing ($N = 12$ trials; 5.6% of all trials), we imputed the average cohort size in the sample; we followed a similar strategy with missing control group energy usage. Results are qualitatively similar when the observations with missing cohort size and control energy usage are excluded from the analysis.

Although we follow ref. [39] in most respects of the analysis, we cannot cluster standard errors on the household level because this data are not available to us. Instead, as a more conservative strategy, we cluster robust standard errors at the state level, which is the common unit of analysis between our data sets and accounts for potential correlation between first-order and second-order beliefs within a state.

Finally, we use standardized z-scores of both the independent and the dependent variables for the analysis because our variables have different magnitudes and units; however, not standardizing these variables does not alter the significance or interpretation of our results.

Reporting Summary. Further information on research design is available in the Nature Research Reporting Summary linked to this article.

Code availability. The corresponding Stata code is also available on the Open Science Framework: https://osf.io/6yug2/.

Data availability

The data set containing household energy savings from 211 large-scale RCTs is Opower's propriety data and may not currently be shared publicly. To inquire about access to the proprietary Opower data, please get in touch with J.D.O. (jdpobrien@gmail.com). The survey response data collected on AMT is available on the Open Science Framework: https://osf.io/jaz4w.

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References

1. Levin, S. A. Public goods in relation to competition, cooperation, and spite. *Proc. Natl Acad. Sci. USA* **111**, 10838–10845 (2014).
2. Clark, W. C. & Dickson, N. M. Sustainability science: the emerging research program. *Proc. Natl Acad. Sci. USA* **100**, 8059–8061 (2003).
3. Hauser, O. P., Rand, D. G., Peysakhovich, A. & Nowak, M. A. Cooperating with the future. *Nature* **511**, 220–223 (2014).
4. Fischer, M.-E., Irlenbusch, B. & Sadrieh, A. An intergenerational common pool resource experiment. *J. Environ. Econ. Manage.* **48**, 811–836 (2004).
5. Barrett, S. & Dannenberg, A. Climate negotiations under scientific uncertainty. *Proc. Natl Acad. Sci. USA* **109**, 17372–17376 (2012).
6. Dennig, F., Budolfson, M. B., Fleurbaey, M., Siebert, A. & Socolow, R. H. Inequality, climate impacts on the future poor, and carbon prices. *Proc. Natl Acad. Sci. USA* **112**, 15827–15832 (2015).
7. Cialdini, R. B., Kallgren, C. A. & Reno, R. R. A focus theory of normative conduct: a theoretical refinement and reevaluation of the role of norms in human behavior. *Adv. Exp. Soc. Psychol.* **24**, 201–234 (1991).
8. Cialdini, R. B., Reno, R. R. & Kallgren, C. A. A focus theory of normative conduct: recycling the concept of norms to reduce littering in public places. *J. Pers. Soc. Psychol.* **58**, 1015–1026 (1990).
9. Bem, D. J. *Beliefs, Attitudes, and Human Affairs* (Brooks/Cole, Oxford, 1970).
10. Howe, P. D., Mildenberger, M., Marlon, J. R. & Leiserowitz, A. Geographic variation in opinions on climate change at state and local scales in the USA. *Nat. Clim. Change* **5**, 596–603 (2015).
11. Tertoolen, G., van Kreveld, D. & Verstraten, B. Psychological resistance against attempts to reduce private car use. *Transp. Res. Part A Policy Pract.* **32**, 171–181 (1998).
12. Sedikides, C. & Alicke, M. D. in *Oxford Handbook of Motivation* (ed. Ryan, R.) Ch. 13 (Oxford Univ. Press, Oxford, 2012).
13. Abrahamse, W., Steg, L., Vlek, C. & Rothengatter, T. Review of intervention studies aimed at household energy conservation. *J. Environ. Psychol.* **25**, 273–291 (2005).
14. Gillingham, K., Newell, R. & Palmer, K. Energy efficiency policies: a retrospective examination. *Annu. Rev. Environ. Resour.* **31**, 161–192 (2006).
15. Chiu, C.-Y., Gelfand, M. J., Yamagishi, T., Shteynberg, G. & Wan, C. Intersubjective culture: the role of intersubjective perceptions in cross-cultural research. *Perspect. Psychol. Sci.* **5**, 482–493 (2010).
16. Zou, X. et al. Culture as common sense: perceived consensus versus personal beliefs as mechanisms of cultural influence. *J. Pers. Soc. Psychol.* **97**, 579–597 (2009).
17. Shteynberg, G., Gelfand, M. J. & Kim, K. Peering into the 'Magnum Mysterium' of culture: the explanatory power of descriptive norms. *J. Cross. Cult. Psychol.* **40**, 46–69 (2009).
18. Allport, G. *The Nature of Prejudice* (Addison-Wesley, Cambridge, 1954).
19. Staub, E. & Pearlman, L. A. in *Psychological Interventions in Times of Crisis* (eds Barbanel, L. & Sternberg, R. J.) 214–243 (Springer, New York, 2006).
20. Paluck, E. L. What's in a norm? Sources and processes of norm change. *J. Pers. Soc. Psychol.* **96**, 594–600 (2009).
21. Paluck, E. L. Reducing intergroup prejudice and conflict using the media: a field experiment in Rwanda. *J. Pers. Soc. Psychol.* **96**, 574–587 (2009).
22. Paluck, E. L. & Shepherd, H. The salience of social referents: a field experiment on collective norms and harassment behavior in a school social network. *J. Pers. Soc. Psychol.* **103**, 899–915 (2012).
23. Hallsworth, M., List, J. A., Metcalfe, R. D. & Vlaev, I. The behavioralist as tax collector: using natural field experiments to enhance tax compliance. *J. Public Econ.* **148**, 14–31 (2017).
24. Turner, J., Perkins, H. W. & Bauerle, J. Declining negative consequences related to alcohol misuse among students exposed to a social norms marketing intervention on a college campus. *J. Am. Coll. Health* **57**, 85–94 (2008).
25. Neighbors, C., Lee, C. M., Lewis, M. A., Fossos, N. & Larimer, M. E. Are social norms the best predictor of outcomes among heavy-drinking college students? *J. Stud. Alcohol Drugs* **68**, 556–565 (2007).
26. Allcott, H. Social norms and energy conservation. *J. Public Econ.* **95**, 1082–1095 (2011).
27. Allcott, H. & Rogers, T. The short-run and long-run effects of behavioral interventions: experimental evidence from energy conservation. *Am. Econ. Rev.* **104**, 3003–3037 (2014).
28. Fischer, C. Feedback on household electricity consumption: a tool for saving energy? *Energy Effic.* **1**, 79–104 (2008).
29. Costa, D. L. & Kahn, M. E. Energy conservation 'nudges' and environmentalist ideology: evidence from a randomized residential electricity field experiment. *J. Eur. Econ. Assoc.* **11**, 680–702 (2013).
30. McAuliffe, K., Raihani, N. J. & Dunham, Y. Children are sensitive to norms of giving. *Cognition* **167**, 151–159 (2017).
31. Fehr, E. & Gächter, S. Fairness and retaliation: the economics of reciprocity. *J. Econ. Perspect.* **14**, 159–182 (2000).
32. Rand, D. G., Dreber, A., Ellingsen, T., Fudenberg, D. & Nowak, M. A. Positive interactions promote public cooperation. *Science* **325**, 1272–1275 (2009).
33. Posner, R. & Rasmusen, E. Creating and enforcing norms, with special reference to sanctions. *Int. Rev. Law Econ.* **19**, 369–382 (1999).
34. Feinberg, M., Willer, R. & Schultz, M. Gossip and ostracism promote cooperation in groups. *Psychol. Sci.* **25**, 656–664 (2014).
35. Balafoutas, L. & Nikiforakis, N. Norm enforcement in the city: a natural field experiment. *Eur. Econ. Rev.* **56**, 1773–1785 (2012).
36. Chopik, W. & Motyl, M. Ideological fit enhances interpersonal orientations. *Soc. Psychol. Personal. Sci.* **7**, 759–768 (2016).
37. Hauser, O. P., Hendriks, A., Rand, D. G. & Nowak, M. A. Think global, act local: preserving the global commons. *Sci. Rep.* **6**, 36079 (2016).
38. Allcott, H. Site selection bias in program evaluation. *Q. J. Econ.* **130**, 1117–1165 (2015).
39. Hauser, O. P., Linos, E. & Rogers, T. Innovation with field experiments: studying organizational behaviors in actual organizations. *Res. Organ. Behav.* **37**, 185–198 (2017).
40. Wooldridge, J. M. *Introductory Econometrics: A Modern Approach (Upper Level Economics Titles)* (Southwestern College Publishing, Nashville, 2012).
41. O'Brien, R. M. A caution regarding rules of thumb for variance inflation factors. *Qual. Quant.* **41**, 673–690 (2007).
42. Côté, S., House, J. & Willer, R. High economic inequality leads higher-income individuals to be less generous. *Proc. Natl Acad. Sci. USA* **112**, 15838–15843 (2015).
43. Rand, D. G. & Nowak, M. A. Human cooperation. *Trends. Cogn. Sci.* **17**, 413–425 (2013).
44. Castro Santa, J., Exadaktylos, F. & Soto-Faraco, S. Beliefs about others' intentions determine whether cooperation is the faster choice. *Sci. Rep.* **8**, 7509 (2018).
45. Rand, D. G., Greene, J. D. & Nowak, M. A. Spontaneous giving and calculated greed. *Nature* **489**, 427–430 (2012).
46. Tinghög, G. et al. Intuition and cooperation reconsidered. *Nature* **498**, E1–E2 (2013).
47. Bouwmeester, S. et al. Registered Replication Report: Rand, Greene, and Nowak (2012). *Perspect. Psychol. Sci.* **12**, 527–542 (2017).
48. Brozyna, C., Guilfoos, T. & Atlas, S. Slow and deliberate cooperation in the commons. *Nat. Sustain.* **1**, 184–189 (2018).
49. Hauser, O. P. Running out of time. *Nat. Sustain.* **1**, 162–163 (2018).
50. Tankard, M. E. & Paluck, E. L. Norm perception as a vehicle for social change. *Soc. Issues Policy Rev.* **10**, 181–211 (2016).
51. Berinsky, A., Huber, G. & Lenz, G. Evaluating online labor markets for experimental research: Amazon.com's Mechanical Turk. *Polit. Anal.* **20**, 351–368 (2012).
52. Huff, C. & Tingley, D. 'Who are these people?' Evaluating the demographic characteristics and political preferences of MTurk survey respondents. *Res. Polit.* **2**, 1–12 (2015).
53. Harrington, J. R. & Gelfand, M. J. Tightness-looseness across the 50 united states. *Proc. Natl Acad. Sci. USA* **11**, 7900–7995 (2014).
54. Jokela, M., Bleidorn, W., Lamb, M. E., Gosling, S. D. & Rentfrow, P. J. Geographically varying associations between personality and life satisfaction in the London metropolitan area. *Proc. Natl Acad. Sci. USA* **112**, 725–730 (2015).

55. Waytz, A., Young, L. L. & Ginges, J. Motive attribution asymmetry for love vs. hate drives intractable conflict. *Proc. Natl Acad. Sci. USA* **111**, 15687–15692 (2014).
56. Ross, L. The intuitive psychologist and his shortcomings: distortions in the attribution process. *Adv. Exp. Soc. Psychol.* **10**, 173–220 (1977).
57. Heilman, M. E. & Haynes, M. C. No credit where credit is due: attributional rationalization of women's success in male-female teams. *J. Appl. Psychol.* **90**, 905–916 (2005).
58. Kelley, H. H. & Stahelski, A. J. Social interaction basis of cooperators' and competitors' beliefs about others. *J. Pers. Soc. Psychol.* **16**, 66–91 (1970).
59. Paolacci, G., Chandler, J. & Ipeirotis, P. G. Running experiments on Amazon Mechanical Turk. *Judgm. Decis. Mak.* **5**, 411–419 (2010).
60. Buhrmester, M., Kwang, T. & Gosling, S. D. Amazon's Mechanical Turk: a new source of inexpensive, yet high-quality, data? *Perspect. Psychol. Sci.* **6**, 3–5 (2011).
61. Hauser, D. J. & Schwarz, N. Attentive Turkers: MTurk participants perform better on online attention checks than subject pool participants. *Behav. Res. Methods* **48**, 400–407 (2015).

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Author contributions

J.D.O. and E.S. oversaw the Opower data collection. J.M.J. and O.P.H. analysed the data, designed the online experiment and wrote the manuscript. J.D.O., E.S. and A.D.G. provided critical revisions. All authors approved the final version of this manuscript.

Competing interests

J.D.O. and E.S. previously worked at Opower. The remaining authors declare no competing interests.

Additional information

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☐	☒	Clearly defined error bars *State explicitly what error bars represent (e.g. SD, SE, CI)*

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Software and code

Policy information about availability of computer code

Data collection	Data collection was conducted using Qualtrics.com for the Survey Data in the Opower Study, as well as for the Experimental Study. No other software was used.
Data analysis	Data was analyzed using STATA version 14.

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Behavioural & social sciences study design

All studies must disclose on these points even when the disclosure is negative.

Study description	We report the results of two studies in this manuscript. In the first study, we match data obtained from 211 independent randomized controlled trials conducted by Opower with a survey we conducted with over 2,000 participants. In the second study, we conducted a pre-registered experiment with 561 participants.
Research sample	For the first study, we matched two datasets. The first dataset is comprised of 211 large-scale RCTs from Opower. This dataset includes energy consumption rates at the RCT-level from 16,198,595 households over 7 years across 27 states. The second dataset comes from a sample of survey respondents (N=2,001) from the same 27 states. In our supplemental analyses, we rule out, for example, that our effects are driven by differential sample select biases across states. To do so, we use inverse-variance weights based on representative gender and age demographics in each state from the 2010 U.S. Census, and replicate our findings (see Tables S1–S5, and SI for more information). For the experimental study, we recruited 561 participants (Mage = 36.96, SDage = 11.84, 52.23% female) from Amazon's Mechanical Turk.
Sampling strategy	For the survey data in the first study, in advance of data collection, we aimed for equal representation of all states in our dataset and specified to have at least 50 participants per state; we stopped recruitment when the sample size per state reached 100 participants or after 3 weeks of continuous data collection, whichever occurred first. For 7 (of 27) states, the smallest states in the Opower trials, we were unable to collect our target sample size. Unsurprisingly, the number of survey respondents in our sample was proportional to a state's population (linear regression of state population predicting number of survey respondents, with robust standard errors: coeff=2.73 X 10-6, p=.020). Thus, smaller states were less likely to meet our minimum sample size criteria (linear regression of state population predicting the minimum threshold of at least 50 survey participants, with robust standard errors: coeff=2.8 X 10-8, p=.043). Our main analysis focuses on states where we have at least 50 participants; however, when we include participants from all 27 states, the results are qualitatively similar. For the experimental study, both the sample size and the exclusion criteria we describe below were pre-registered in advance of data collection (see http://aspredicted.org/blind.php?x=xy3a4f).
Data collection	Both the survey data in the first study and the data for the experimental study was collected via Qualtrics.com.
Timing	The survey data in the first study was collected in the fall of 2015. The experimental study was conducted in the fall of 2017.
Data exclusions	For the survey data in the first study, to ensure survey responders were paying attention throughout the survey, we included an attention check. Ninety-one percent out of 2,001 participants passed the attention check; our final sample thus consists of 1,819 participants. Although our main analysis focuses on participants who passed the attention check, the results are qualitatively similar when we include participants who failed it. For the second study, in our pre-analysis plan (http://aspredicted.org/blind.php?x=xy3a4f), we pre-registered both the sample size as well as an exclusion criterion. At the end of the study, participants were asked whether they believed the information provided about energy conservation beliefs in their home county. Responses were binary (yes/no), and 213 participants (37.97%) indicated they were suspicious about the manipulation. There was no statistically significant difference in suspicion levels across conditions (t(559) = .83, p = .41). In the main text, we present the analysis excluding suspicious participants, concordant with the pre-analysis plan. In the SI, we report the results when including participants that were suspicious; all results remain qualitatively similar.
Non-participation	No participant dropped out of participation.
Randomization	In the experimental study, assignment to conditions was random.

Reporting for specific materials, systems and methods

Materials & experimental systems

n/a	Involved in the study
☒	☐ Unique biological materials
☒	☐ Antibodies
☒	☐ Eukaryotic cell lines
☒	☐ Palaeontology
☒	☐ Animals and other organisms
☐	☒ Human research participants

Methods

n/a	Involved in the study
☒	☐ ChIP-seq
☒	☐ Flow cytometry
☒	☐ MRI-based neuroimaging

Human research participants

Policy information about studies involving human research participants

Population characteristics	See above.
Recruitment	Participants for both the survey and the experiment were recruited via Amazon's Mechanical Turk.