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The source is the message: the impact of institutional signals on climate change–related norm perceptions and behaviors

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Abstract
With mandates and taxes to mitigate climate change proving politically challenging to implement, some scholars and policy makers have started looking to social norms as a vehicle for large-scale behavioral change. This raises the question of whether formal institutions or organizations are able to influence social norms and behavior. We designed a randomized experiment with a sample of 3627 American residents to investigate how social norm perceptions and behaviors change in response to institutional signals about climate change, and how this varies with signal source. We found that institutional signals, in particular when originating from science or business actors, shifted perceptions of descriptive social norms about climate action. Institutional signals also influenced intended pro-environmental behaviors, but did not increase personal contributions to environmental causes, suggesting that a shift in perceived norms may be insufficient to drive personal action, especially when it involves personal costs. Our study not only emphasizes the importance of institutional signals and messengers in changing perceptions of social norms, but also highlights the complexities involved in norm interventions ultimately aimed at influencing behavior.

Keywords Social norms · Social influence · Climate change · Environment · policy · Institutions · Preregistered

1 Introduction

Achieving significant climate change mitigation requires limiting carbon-intensive technologies, processes, and practices and developing and adopting clean technologies. Ultimately, the move away from established practices will depend on large-scale collective

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action and shifts in consumption patterns (Weber 2015). Social scientists studying decision-making and behavior change increasingly acknowledge that individual decisions in the context of climate change (and beyond) are guided by perceptions of social norms (Hoffman 2020; Huber et al. 2018); that is, beliefs about what others typically think, do, or agree upon (Tankard and Paluck 2016). The coordinating role of social norms has recently raised hopes that small changes may lead to large-scale social tipping points, shifting societies to more sustainable trajectories (Nyborg et al. 2016). Such hopes seem to be even more warranted for a politicized problem like climate change, where political elites refuse to take ambitious action to introduce CO2-reducing regulations or carbon taxes, and, in the case of the USA, have even actively repealed environmental protections. Under these conditions, "softer" interventions operating through shifts in climate change–related social norm perceptions may be promising (Farmer and et al. 2019; Nyborg et al. 2016).

We follow Nyborg et al. (2016) in defining social norms as "predominant behavioral patterns within a group, supported by a shared understanding of acceptable actions and sustained through social interactions within that group." A distinction is often made between *descriptive* and *injunctive* norms (Cialdini et al. 1991). Descriptive norms refer to what people in a group typically do, while injunctive norms refer to what they consider appropriate. Additionally, there is a distinction between social norms and people's perceptions of these norms (Mildenberger and Tingley 2017), with the latter typically driving action (Tankard and Paluck 2017).

Investigations of social norms often examine their effects on individual attitudes and behavior (Bicchieri 2006; Cialdini and Trost 1998). Many studies show that providing individuals with information about descriptive social norms can lead to changes in behavior (Allcott 2011; Cialdini et al. 1991; Farrow et al. 2017; Schultz et al. 2007) that are subsequently transmitted through social networks (Christakis and Fowler 2008) and can be strengthened when supported by injunctive social norms (Thøgersen 2008; Bicchieri 2006; Bicchieri and Xiao 2009). A meta-analysis of social influence in the context of resource conservation conducted by Abrahamse and Steg (2013) highlights that while social influence may be most powerful if it involves peer-to-peer information provision (as in the "block leader approach," where volunteers help inform others about a certain issue), social norm interventions are also effective in fairly anonymous contexts that do not involve face-to-face interaction (Abrahamse and Steg 2013). These findings have led researchers to posit that policies that shift social norms may be a particularly effective and efficient way to approach collective action problems where there is a conflict between individual and social interests. However, the factors that *shape* people's perceptions of social norms have received far less attention (Tankard and Paluck 2017) and it is unclear what factors influence these perceptions (Steentjes et al. 2017). In light of findings showing that social norm information is consequential for a wide range of behaviors, examining the factors that shape perceptions of social norms is paramount for evaluating the potential impact of norm interventions in environmental contexts.

Factors shaping social norms There are several sources of information that individuals might use to update their social norm perceptions: direct observation and interaction with others, summary information or statistics about the behaviors and opinions of others, and formal institutional signals (Tankard and Paluck 2016). Here we focus on signals from formal institutions (defined as "entities that organize, govern or educate a group" (Tankard and Paluck 2016)). Such signals may influence individual perceptions of social norms if the institution is seen to represent a collection of relevant actors and/or to have expertise about, or power over, public opinion, and behaviors. Formal institutions are a potentially effective

vehicle for coordinating perceptions across a wide range of actors because they are typically well known and highly visible, resulting in the common knowledge that other individuals are simultaneously subjected to the same communication. However, different institutions may be better suited norms messengers for particular contexts or issues.

In the present study, we ask whether and to what extent messages emanating from different institutions can alter perceptions of social norms in the context of climate change. Given the inferential complexity of climate change and constraints on attention, time, and other decision-making resources, these institutional signals can be seen to operate as "source cues"—that is, individuals may rely primarily on their appraisal of the *source* of a message (i.e., different formal institutions) when adjusting their social norm perceptions (Arceneaux and Kolodny 2009). The insight that individuals tend to use information about the source of a message as a cue when updating their perceptions or preferences has origins in social and cognitive psychology (McGuire 1969) and was recently shown to be relevant in the context of climate change-related decisions (Rinscheid et al. 2020). The effectiveness of normative signals may be contingent on whether the messenger is integral to the achievement of the norm goal (Finnemore and Sikkink 1998) or it may depend on the credibility of the messenger and identity resonance with the source (Dragojlovic 2008; Druckman 2001; Lupia 1994). In recent years, there has been increasing public commitment to climate action by organizations made up of governments, businesses, and climate scientists, among others. Taking these public signals as a point of departure, our work builds on—and combines—previously separate strands of research on the effects of source cues on message efficacy (Bolsen et al. 2019; Nicholson 2011) with research on the role of formal institutions in coordinating social norm perceptions (Tankard and Paluck 2016, 2017).

While the argument that institutions might shift perceived social norms is intriguing, there is little empirical evidence on the causal effect of top-down institutional signals on norm perceptions and none in environmental contexts. Most studies examining effects of normative institutional signals focus on other outcome variables, such as individual attitudes, intended behaviors, and policy support (for a general application, see Bartels and Mutz (2009); for studies in the context of climate change, see Bolsen et al. (2014) and Huber et al. (2018)). One exception is a study looking at the introduction of a smoking law in Norway. The law changed perceived norms about the appropriateness of smoking as well as individual smoking behavior, even in unregulated zones (Nyborg and Rege 2003b). More recently, Tankard and Paluck (2017) showed that a US Supreme Court ruling in favor of same-sex marriage significantly influenced perceptions of related descriptive social norms held by the American public. Interestingly, personal attitudes and action were only marginally affected by the ruling. While these studies show a causal effect of formal institutional messaging on social norm perceptions, they do not vary the source of the message and, moreover, represent unique formal institutions and norm messages in that the signal is also legally binding.

Overview of present study With these gaps in mind, we tested the influence of three real-world matched institutional signals—each indicating a similar commitment to climate action, albeit by different actors—on perceived descriptive social norms, behavioral intentions, and incentivized donations. In keeping with the existing social norms literature, we also assessed the effects of the messages on personal attitudes, perceived injunctive norms, and unrelated social norms.

Following the American Federal Government's threat to withdraw from the 2015 UNFCCC Paris Agreement in 2017, a number of institutions responded with statements emphasizing the adverse impacts of climate change and the need for climate action. We took

messages from three different sources—a coalition of American businesses, a coalition of American state governments, and a coalition of American climate research institutions—as a starting point for creating matched real-world signals of institutional concern for climate change and commitment to climate action. Any one of these formal institutions could be perceived to be critical for climate action. We randomly assigned 4027 American respondents to one of the three message conditions (the "business signal," the "government signal," and the "climate signal") or to a control condition. The experimental variation in the source allowed us to assess whether changes in social norm perceptions or behaviors are sensitive to the messenger.

We had two primary hypotheses. First, we expected that exposure to the messages would increase (a) beliefs about the strength of climate change-related descriptive norms, (b) intention to engage in pro-environmental behaviors, and (c) "real" monetary contributions, that is, incentivized donations to environmental causes. Second, we hypothesized that messages from distinct sources might differ in their efficacy as agents of norm change and in how their effects generalize to perceived norms held by broader groups (e.g., the American public). To assess these effects, we measured perceptions of social norms in four distinct stakeholder or "norm assessment" groups: business actors, policymakers, climate scientists, and the American public. Following Tankard and Paluck (2017), we expected no effect of the treatment on personal attitudes and perceived injunctive norms, both of which are harder to shift. Unrelated social norms were included as a robustness check and are further discussed in the Supplementary Information (SI).

In addressing these hypotheses, we implemented a comprehensive analytic approach following the idea of multiverse analyses (Steegen et al. 2016). For policymakers, it is essential to know whether the effects of climate-related norms messages vary as a function of individual or sociodemographic characteristics, and whether there are conditions under which institutional signals may backfire. To illustrate, various sociodemographic variables may correlate with climate-related norm perceptions and donations, potentially leading to ceiling effects for some subgroups (e.g., for Democrats who are largely already concerned about climate change). Such main effects could mask the influence of the institutional signal unless accounted for in the analyses. Thus, in addition to presenting the results of our full model (i.e., a multiple linear regression including all of our covariates), we also conducted specification curve analyses (SCA) (Simonsohn et al. 2015; Frey et al. 2020) to gauge the robustness of institutional signals on norm perceptions across a large number of plausible model specifications.

2 Study design and methods

We conducted a survey experiment (pre-registered at the Open Science Framework) on a large sample ($n = 4027$) of respondents based in the USA. Participants were recruited online via Amazon Mechanical Turk (MTurk).

Participants Participants (54% female; mean age 36) were recruited according to the following selection criteria: based in the USA, MTurk approval rate greater than 95%, more than 50 MTurk HITs approved (for further information on sample composition, see Supplementary Table 2). The subsequent analyses are based on a final sample of 3627 American residents, after we excluded 338 participants for failing an attention check, 49 participants who failed a bot check based on compromised geolocation data, and 13 subjects who declined to report their gender, a covariate in our regressions. However, all results discussed

in the paper remain substantively the same with the full set of respondents (see SI Tables 3 and 4).

Experimental procedure Participants were randomly assigned to a control condition or one of three treatment conditions. Participants in the treatment conditions completed a survey after reading a brief (ca. 220 words) statement communicating commitment to climate action by one of the following institutions: The *United States Climate Alliance*, a coalition of state governments ("Government Treatment"); *We are still in*, a coalition of businesses ("Business Treatment"); The *U.S. Global Change Research Program*, a coalition of US climate research institutions ("Science Treatment"). Respondents in the control group completed the same survey without any institutional message.

For the treatment conditions, we created three statements using publicly available information from the websites of the three institutions. The statements consisted of two parts: first, a description of the institution sending the message; and second, a mention of the respective institution's core principles or findings. The latter was based on similar statements available on the institutions' websites or publications and included the argument that climate change mitigation is feasible, and that important progress has already been made. While the first part inevitably differed between conditions, the second part was matched in order to isolate effects arising from differences in the source from those arising from variations in the messaging. We chose these three institutions because they are primarily composed of different types of actors (state governments, businesses, and climate scientists), but take very similar approaches to promoting climate change mitigation measures. The following represents the common part of the three treatment conditions (see the SI for entire statement transcripts):

> ***Importantly****, among the alliance's [initiative's / report's] core principles [findings] is the acknowledgment that achieving global greenhouse gas emissions reductions before 2030 to limit climate change* ***is feasible****. Deployment of presently available and established clean energy technologies, in combination with a rapid decrease in the consumption of fossil fuels,* ***can make it possible to mitigate dangerous climate change****. Alliance states [Members of the initiative "We are still in" / The report highlights that several countries] have already made* ***impressive progress*** *towards achieving their climate goals.*

Outcome variables Following the treatment, we asked participants about their perceptions of the strength of climate change-related norms among different stakeholder groups (business actors, climate scientists, and policymakers, and the American public). For the assessment of perceived descriptive norms, we used an index for each actor group (see SI Table 1 for item wording and aggregation procedure). For example, to measure whether pro-environmental norms are perceived to be prevalent among American citizens, we asked respondents to answer *"To what extent do you think that American citizens are willing to change their lifestyles in order to reduce their contribution to climate change?"* using a 7-point response scale ranging from *"No willingness to change"* to *"Strong willingness to change."* We asked the same question about climate scientists, business actors, and policymakers (due to an oversight we included policymakers in place of government actors in our norm assessment groups).

We also asked participants about their personal attitudes and behavioral intentions. Responses to questions about descriptive norms, injunctive norms, attitudes, and behavioral intentions were aggregated into separate indices. Behavioral intentions include self-reported

willingness to buy carbon offsets, participate in demonstrations, and engage in discussion with peers—three different and important dimensions of climate action. In order to understand the specificity of the signal on perceived climate-related norms, we also asked about unrelated descriptive norms (e.g., support for gay marriage). For more information on relevant survey items and indices, please refer to the SI.

Finally, respondents were asked to allocate a monetary reward ($10 total, which was awarded randomly to 1 in 25 respondents) to themselves and/or up to four non-governmental organizations, two of which are committed to environmental and climate action (Trees for the Future and the Environmental Defense Fund). We selected prominent, non-partisan organizations with a clear climate change mitigation mission reflected in the name of the organization; but we did not provide additional information about these organizations. To incentivize donations, we informed participants that we would double the donated amount. This allocation decision allowed us to assess whether different institutional signals have disparate influence not only on social norm perceptions and hypothetical behaviors but also on tangible action involving a sacrifice of personal material gains.

Additional survey items and covariates As part of the survey, we collected information on a host of covariates that prior literature has found to be important predictors of pro-climate-related norms and behaviors (Howe et al. 2013; Lewis et al. 2019). These included gender, age, education, political view (a 7-point scale ranging from "Extremely Conservative" to "Extremely Liberal"), and temperature, which asks individuals to rate whether "the temperature in (their) city right now is colder or warmer than usual for this time of year" on a 5-point scale, ranging from "Much colder" to "Much warmer." Temperature accounts for natural variation in local weather conditions experienced by our participants at the time of the survey, which has been shown to influence opinions about climate change (Zaval et al. 2014). We also measured respondents' knowledge about the environment, politics, and science, and their perception of the three messengers in our treatment conditions, as proxies for familiarity with and attitudes towards the messengers and messages in our treatments. Perception of the source was a composite variable that included ascribed competence, trustworthiness, likeability, and identification—with higher values indicating higher levels of these four qualities (see SI Table 1 for item wording and aggregation).

Analytic approach Despite our large sample and random assignment of participants to the various experimental conditions, the respective groups may still not have been perfectly balanced along several dimensions that we hypothesized to be important predictors of our outcome variables (see "additional survey items and covariates" above). Hence, to estimate the treatment effect while simultaneously taking into account the potential influence of these variables, our primary analyses are multiple linear regressions that include all covariates ("full model"; for standardized coefficients see Tables 6 and 7 in the SI).

To verify the robustness of these findings, and to provide a detailed picture of the conditions under which the estimated effects of the treatment may deviate from the effects estimated in the full model, we also report specification curve analyses (SCA) (Simonsohn et al. 2015). SCA follows the idea of multiverse analyses (Steegen et al. 2016) and is a means of assessing the robustness of the primary effects of interest across all plausible model specifications for a set of independent and dependent variable (Orben and Przybylski 2019; Rohrer et al. 2017; Lejarraga et al. 2019; Frey et al. 2020). To the extent that a variable is theoretically plausible and cannot be categorically ruled out a priori, the general rationale is to include it in the SCA and to estimate the effects empirically. The procedure of

implementing SCA is as follows: First, all unique combinations of possible predictor variables and covariates are assembled. From this set, only the model specifications that include the main predictor variable are retained (i.e., in our case, the models that include institutional signals as predictors). These models are then paired with each dependent variable of interest, resulting in a separate SCA for each dependent variable. Finally, the effect sizes of the main predictor variable in each implemented model specification are plotted in a *specification curve*, which permits obtaining transparent insights into (i) the strength and direction of the predictor of interest across a large number of specifications, and (ii) the conditions under which deviations from the general pattern emerge (i.e., "inference by eye").

3 Results

In this section, we start by reporting the results of the full model for our primary hypotheses—the effects of each of the three institutional signals on (1) the *perceived descriptive norms* held by four different stakeholder groups and (2) on our two measures of behavior: *donation rate* and *behavioral intentions*. We then assess the robustness of these results using SCA, which speaks to the overall efficacy of the institutional signal on norm perceptions and behavior. Finally, we report the impact of treatment on our secondary outcome measures: personal attitudes, perceived injunctive norms, and unrelated social norms.

3.1 Full model

The regressions of norm perceptions (perceived norms among our four groups of interest), donation rate, and behavioral intentions on treatment include as independent variables the randomly assigned message treatment (i.e., government, business, science signal, or control) and eleven additional covariates enumerated above, resulting in six distinct models (see Tables 1 and 2; see SI Tables 6 and 7 for standardized effect sizes).

Effect of institutional signals on norm perceptions In general, participants exposed to the institutional signals perceived stronger pro-environmental descriptive norms among various stakeholder groups than did participants in the control group. Significance and effect sizes varied with the combination of signal source and assessment group, with the strongest effects on average from the business signal (see Table 1 and Fig. 1). First, as a manipulation test, we looked at whether a signal of commitment to climate-action by each messenger group corresponded with an increase in our respondents' perceptions of pro-climate norms held by that same group. We found a significant and large effect of the business signal on perceptions of pro-climate norms held by business actors (b=0.707, $p<.001$) and of the science signal on perceptions of norms held by scientists (b=0.174; $p<.001$). There was no significant impact of the government treatment on perceptions of norms held by policymakers, though this was likely due to an inconsistency between the message source ("a coalition of governors") and the norm assessment group ("policymakers"). See Fig. 1 for a plot of the regression coefficients of these four models side by side for comparison of relative effect sizes.

The three signals also had diffuse effects. The business signal significantly increased respondents' perceptions of pro-climate norms among climate scientists (b=0.134; $p<.01$). The science treatment had a significant effect on the perception of pro-climate norms among

Table 1 Institutional messengers and perceived descriptive norms

	Dependent variable:			
	Business norms	Government norms	Science norms	American public
Constant	3.635***	4.790***	3.144***	3.862***
	(0.188)	(0.198)	(0.164)	(0.178)
Business treatment	0.707***	0.100+	0.134**	−0.068
	(0.055)	(0.058)	(0.048)	(0.052)
Government treatment	0.060	0.067	0.125**	0.101*
	(0.054)	(0.057)	(0.048)	(0.052)
Science treatment	0.085	0.171**	0.174***	0.088+
	(0.055)	(0.058)	(0.048)	(0.052)
Female	−0.228***	−0.147***	0.034	−0.133***
	(0.040)	(0.042)	(0.035)	(0.038)
Age	0.004*	0.005**	-0.001	0.004**
	(0.002)	(0.002)	(0.001)	(0.002)
Education	0.024	0.018	0.014	−0.048*
	(0.024)	(0.025)	(0.021)	(0.022)
Temperature	0.004	−0.063**	0.005	0.025
	(0.022)	(0.023)	(0.019)	(0.021)
Political view	−0.103***	−0.161***	0.138***	−0.019
	(0.013)	(0.013)	(0.011)	(0.012)
Know environment	−0.171***	−0.194***	0.051	−0.253***
	(0.042)	(0.044)	(0.037)	(0.040)
Know politics	−0.239***	−0.157***	0.123***	−0.143***
	(0.026)	(0.027)	(0.022)	(0.024)
Know science	−0.204***	−0.211***	0.092*	−0.232***
	(0.043)	(0.046)	(0.038)	(0.041)
Perception business	0.288***	0.162***	−0.008	0.179***
	(0.025)	(0.027)	(0.022)	(0.024)
Perception government	0.228***	0.207***	−0.007	0.217***
	(0.021)	(0.022)	(0.018)	(0.020)
Perception science	−0.084***	−0.092***	0.408***	0.073**
	(0.024)	(0.025)	(0.021)	(0.023)
Observations	3627	3627	3627	3627
R^2	0.235	0.145	0.244	0.161
Adjusted R^2	0.232	0.142	0.241	0.158

$+p < 0.1$; $*p < 0.05$; $**p < 0.01$; $***p < 0.001$

Results of four multiple linear regressions (in columns) assessing the effect of a matched message from different sources on perceptions of climate change-related descriptive norms held by different groups of actors. Column 1 is perceptions of norms held by business actors; column 2 state governments; column 3 climate scientists; and column 4 the American public

policymakers (b=0.171; p<.01). Finally, the government signal had a positive and significant effect on perceived pro-climate norms among the American public (b=0.101; p<.05) , suggesting a more diffuse impact of government messages.

Table 2 Institutional messages on incentivized and intended behavior

	Dependent variable:	
	Donate to environment	Behavioral intentions
Constant	−0.167	1.115***
	(0.362)	(0.239)
Business treatment	0.040	0.121+
	(0.106)	(0.070)
Government treatment	−0.074	0.119+
	(0.105)	(0.069)
Science treatment	−0.052	0.145*
	(0.105)	(0.070)
Female	0.020	0.056
	(0.078)	(0.051)
Age	0.007*	−0.013***
	(0.003)	(0.002)
Education	0.145**	0.014
	(0.046)	(0.030)
Temperature	0.043	0.167***
	(0.043)	(0.028)
Political view	0.128***	0.299***
	(0.025)	(0.016)
Know environment	0.039	−0.038
	(0.081)	(0.053)
Know politics	−0.331***	−0.208***
	(0.049)	(0.032)
Know science	−0.079	−0.174**
	(0.083)	(0.055)
Perception business	−0.057	−0.038
	(0.049)	(0.032)
Perception government	0.105**	0.368***
	(0.040)	(0.027)
Perception science	0.347***	0.270***
	(0.046)	(0.030)
Observations	3627	3627
R^2	0.064	0.305
Adjusted R^2	0.060	0.302

$+p<0.1$; $*p<0.05$; $**p<0.01$; $***p<0.001$

Results of two multiple linear regressions (in columns). Column 1 looks at the effect of the institutional message on donations to environmental causes, while column 2 looks at the effect of the institutional message on pro-climate behavioral intentions

Effect of institutional signals on behavior Ultimately, we are interested in whether institutional signals can be used to promote direct individual climate action. We did not find a significant effect of any of the messages on incentivized donations to environmental causes,

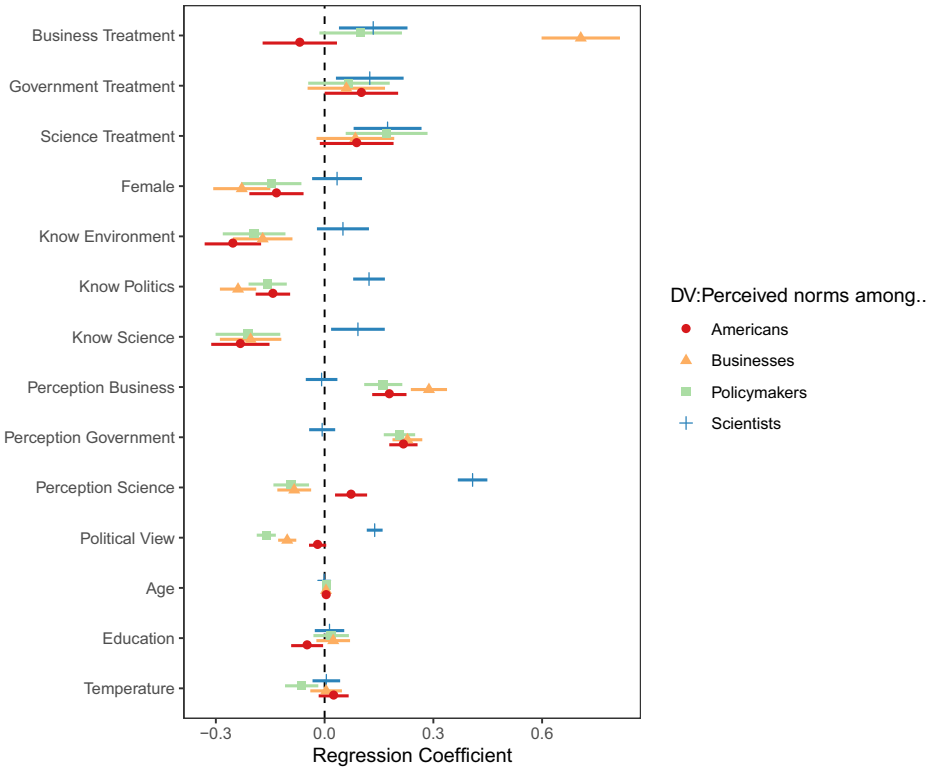

Fig. 1 Institutional messages on perceived descriptive norms among different constituencies. This figure shows the regression coefficients with 95% confidence intervals side by side for the four dependent variables of interest: perceived descriptive norms among business actors (orange triangle), scientists (blue cross), policymakers (green square), and the American public (red circle)

which involved a real monetary sacrifice, and indeed see a negative trend in the SCA below, especially for the government signal (see Table 2). We did find a significant positive effect of the science signal on pro-environmental behavioral intentions (b=0.145; $p<.05$; see Table 2). See Fig. 2 for a plot of the regression coefficients of these two models side by side for comparison.

As predicted by our secondary hypotheses, we found no change in personal attitudes or perceptions of pro-environmental injunctive norms held by any of the reference groups, nor did we find a treatment effect on perceptions of unrelated descriptive norms (for the results, see SI Table 5), suggesting that the effects are specific to the content of the message.

Other covariates of note While institutional signals did not significantly influence donations, a range of variables did correlate with donations to environmental causes. Age, educational attainment, and self-identification with more liberal political views were all significantly correlated with donations to pro-environmental causes. Political views were measured using the classic 7-point ideology scale, which ranges from Extremely Conservative (1) to Extremely Liberal (7). Moreover, more favorable perceptions of government and science were significantly associated with greater donations and behavioral intentions, while knowledge of politics was associated with a sharp reduction in both.

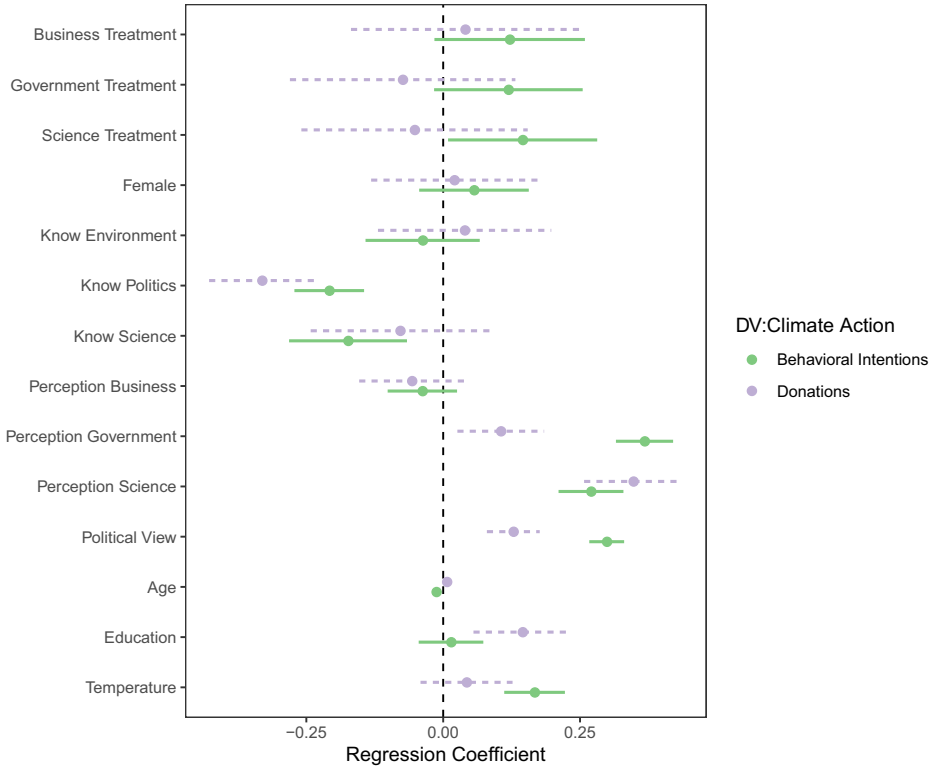

Fig. 2 Institutional messages on donations and behavioral intentions. This figure shows the regression coefficients with 95% confidence intervals side by side for the two dependent variables of interest: amount donated to environmental causes (dashed lilac), and behavioral intentions (solid green)

With respect to norm perceptions (see Table 1), age, political view, knowledge, and perception of the source had the most consistent effects. Unsurprisingly perhaps, a more liberal political view was negatively correlated with the perception of pro-climate norms among business and government actors, but positively correlated with the perception of climate norms among scientists. A parallel pattern was observed for knowledge. Separate indices quantifying our respondents' knowledge of environment, politics, and science were significantly and negatively correlated with perceptions of climate norms held by businesses, governments, and the American public, while knowledge of politics and science were positively correlated with perceptions of norms held by scientists (see Table 1 and Fig. 1 for effect sizes and standard errors).

With respect to the indices representing respondents' perceptions of messengers, a favorable perception of the messenger was positively related to the belief that the institution holds stronger norms on climate change (see Table 1). An interesting divide emerged between perception of businesses and governments on the one hand and perception of scientists on the other. A more positive perception of business and government actors was positively related to the perceptions of pro-climate norms among those actors as well as those held by the American public, but negatively related to perceived climate norms among scientists. On the other hand, positive perceptions of climate scientists were negatively related to the perceptions of pro-climate norms held by government and business actors, but positively related

to those held by scientists as well as the American public. Interestingly, independent of the institutional signals, positive perceptions of any of the three types of messengers (businesses, state governments, climate scientists) were associated with the belief that American citizens have strong norms on climate change.

3.2 Specification curve analyses

All of the SCAs include as independent variables the randomly assigned message treatment (i.e., government, business, science signal, or control) and up to eleven additional covariates described above (see red and blue rows of Figs. 3 and 4). The inclusion or exclusion of these predictors resulted in 2048 (i.e., 2^{11}) unique model specifications for each of the dependent variables (i.e., four in the case of descriptive norm perceptions, one for donation rate, and one for behavioral intentions).

3.2.1 Descriptive norm perceptions

General pattern As in the analyses reported above, the SCAs examining the effects of our three institutional signals focused on the perceptions of the prevailing descriptive norms held by four different stakeholder groups: business actors, government actors, scientists, and the American public (these correspond to the first four rows of Fig. 3, depicted in red). The four dependent variables resulted in 8192 distinct models (4 × 2048 specifications). The vast majority of these specifications indicate a positive effect of institutional signals on norm perceptions relative to the control group (see Fig. 3 and Table 3). The mean effect size across all specifications was 0.23 for the business signal, 0.09 for the government signal, and 0.13 for the science signal. The business signal had a positive effect on norm perceptions in 76% of specifications, 63% of which were significant. The government signal had a positive effect in 100% of specifications, 31% of which were significant. The science signal had a positive effect in 100% of specifications, 51% of which were significant. Overall, and in line with the full model results reported above, institutional signals increase perceptions of climate-related descriptive norms, irrespective of the stakeholder group and covariates. The business signal had the strongest positive effects on norm perceptions. However, these estimates also varied the most across model specifications, as described next.

Patterns as a function of specific IVs and DVs A number of specifications deviated systematically from the general pattern described above, as can be inferred from the clustering of the tick marks in the specification panel. Specifically, there were clear clusters for the DVs (i.e., see clustering of red tick marks in Fig. 3), whereas there were few clusters for the IVs (i.e., see clustering of blue tick marks in Fig. 3). This pattern suggests that the effects of the institutional signals on norm perceptions differed by stakeholder group, but were relatively robust to the inclusion or exclusion of different covariates. The robustness to model specification can be visually inferred from the relatively random dispersion of blue tick marks along the continuum from higher to lower effect size of each institutional signal, going from left to right.

The business signal had a large influence on the belief that pro-climate norms are strong among business actors (see box A in Fig. 3). Conversely, it had a small negative effect on beliefs about the American public (see box B in Fig. 3). In comparison, the effects of the government signal also clustered for the different DVs (see box C in Fig. 3) but these clusters were less clear-cut and the effects were more homogeneous. Finally, the science

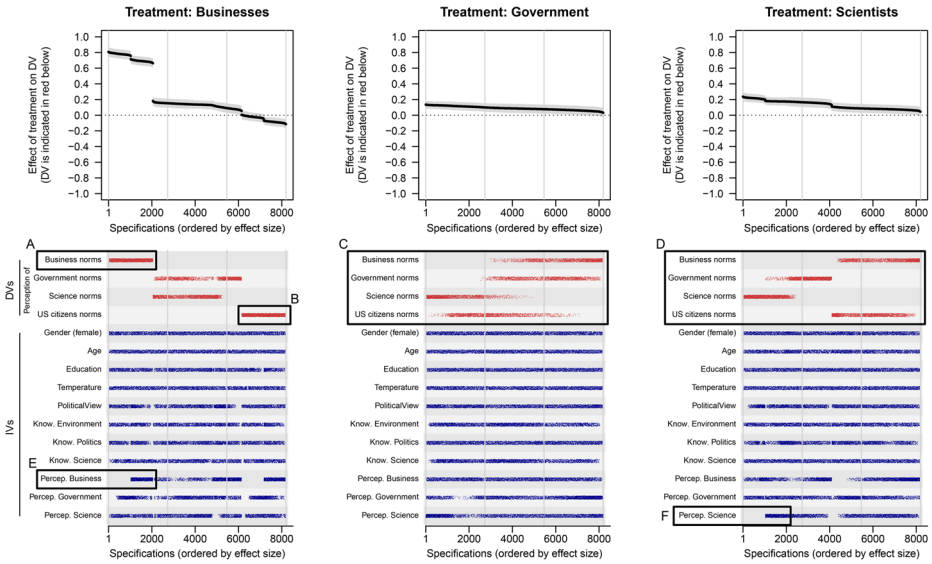

Fig. 3 Institutional messages and perceived descriptive norms (SCA). The top panels depict the specification curve, that is, the effect of the three institutional signals (i.e., the treatment relative to the control group) on each of the four dependent variables, estimated in all 8192 model specifications. To generate the specification curve, the estimated effects of the respective signals were sorted according to their effect size (i.e., from large positive effects on the left to large negative effects on the right; light gray lines depict estimates +/− one standard error of the mean). In the specification panels, the tick marks indicate which dependent variable (DV; red tick marks) and which independent variables (IV; blue tick marks) were used in each of the model specifications (N = 3627 for each of the implemented models)

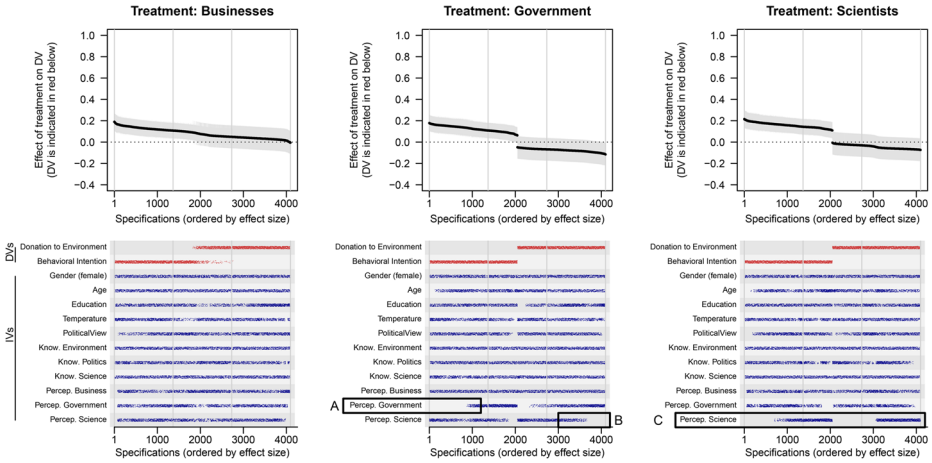

Fig. 4 Institutional messages and behavior (SCA). The top panels depict the estimated effects of the three treatments (relative to the control group) on monetary amount donated to environmental causes and on behavioral intentions, as a function of the inclusion or exclusion of different covariates, indicated by the blue marks in the lower panels. N = 3627 in each model

Table 3 Results of specification curve analyses

DV	Signal	*N*	Mean	Median	Pos. est.	Neg. est.	Signif. pos.	Signif. neg.
Norm perception	Bus	8192	0.23	0.14	6223 (76%)	1969 (24%)	5119 (62.5%)	39 (0.5%)
Norm perception	Gov	8192	0.09	0.09	8192 (100%)	0 (0%)	2495 (30.5%)	0 (0%)
Norm perception	Sci	8192	0.13	0.12	8192 (100%)	0 (0%)	4186 (51.1%)	0 (0%)
Donation rate	Bus	2048	0.04	0.04	2032 (99.2%)	16 (0.8%)	0 (0%)	0 (0%)
Donation rate	Gov	2048	−0.08	−0.07	0 (0%)	2048 (100%)	0 (0%)	0 (0%)
Donation rate	Sci	2048	−0.04	−0.05	0 (0%)	2048 (100%)	0 (0%)	0 (0%)
Behavioral intention	Bus	2048	0.12	0.12	2048 (100%)	0 (0%)	299 (14.6%)	0 (0%)
Behavioral intention	Gov	2048	0.12	0.12	2048 (100%)	0 (0%)	550 (26.9%)	0 (0%)
Behavioral intention	Sci	2048	0.16	0.16	2048 (100%)	0 (0%)	1440 (70.3%)	0 (0%)

DV dependent variable (norm perception; donation rate). *Signal* institutional signal (government, business, scientists). *N* number of implemented specifications. *Mean* mean estimate across all specifications. *Median* median estimate across all specifications. *Pos./neg.est.* number (percentage) of specifications with positive / negative estimates. *Signif.pos./neg.* number (percentage) of specifications with significant positive / negative estimates

signal showed clear-cut clusters for the different DVs but the variation in effect sizes was marginal in magnitude and positive throughout (see box D in Fig. 3).

The effects of the institutional signals were by and large consistent to the inclusion or exclusion of other variables. However, there were some notable patterns with the inclusion of the perception of the messenger variables. For instance, the effect of the business signal on perceptions of climate-related norms held by business actors decreased when accounting for a respondents' perception of business actors (see box E in Fig. 3). This same pattern holds when we include perception of climate scientists (see box F in Fig. 3).

3.2.2 Donation rate and behavioral intention

General pattern Social norm interventions are ultimately aimed at shifting behaviors so we also looked at the effects of the signals on amount donated to environmental causes and pro-environmental behavioral intentions (see the red rows in the "specification panel" of Fig. 4), resulting in 2 × 2048 model specifications. Across most of our model specifications, the business signal increased the monetary amount donated to environmental causes relative to the control group, whereas the government and science signals decreased the amount donated (see Fig. 4 and Table 3). The mean effect size across all specifications was 0.04 for the business signal, −0.08 for the government signal, and −0.04 for the science signal. The business signal was positively related to amount donated in 99% of specifications, while the government and science signals were negatively related to donations in 100% of specifications. However, none of these estimates was significant. Overall, the messages did not substantially influence donation to environmental causes.

In contrast, all three signals had positive effects on behavioral intentions (see Fig. 4 and Table 3). The mean effect size across all specifications was 0.12 for the business signal, 0.12

for the government signal, and 0.16 for the science signal. For all three signals, all model specifications showed a positive relationship between the signal and behavioral intentions (100%). Of these, 15% were significant for the business signal, 27% for the government signal, and 70% for the science signal. Overall, the three signals thus clearly increased behavioral intentions.

Patterns as a function of specific IVs and DVs Looking in more detail, we again saw some clusters emerge around the inclusion of the perception of source variables, although the effects were less pronounced than in the previous analyses for norm perception. The effect of the government signal on behavioral intentions became slightly more negative with the inclusion of the perception of government variable (see box A in Fig. 4) and a similar pattern was true for donation rates. On the other hand, the effect of the government signal on donation rate became slightly less negative with the inclusion of perception of scientists (see box B in Fig. 4). Finally, the science signal had a smaller positive relationship to behavioral intentions and a more negative relationship with donations when perception of scientists was included (see box C in Fig. 4).

4 Discussion

Several recent papers point to descriptive norms as an important lever for behavioral change in the context of collective action problems, like climate change and biodiversity loss (Nyborg et al. 2016). Changes in perceived descriptive norms represent changes in individuals' understanding of society, and can shift attitudes and behaviors (Tankard and Paluck 2016). However, the impact of social influence is highly dependent on various factors, including the reference group, norm content and type (e.g., descriptive or injunctive), heterogeneity of beliefs and preferences, and culture (Byerly et al. 2019; Bohner and Schlüter 2014; Niemiec et al. 2020). Thus, social norm messages can require deep contextual knowledge not only to be efficacious but also to avoid unintended or adverse effects (e.g., boomerang effects; Schultz et al. 2007).

While descriptive social norms have been shown to influence behavior, the question of how social norms are formed and updated has received less attention. In particular, we do not know of any prior studies examining the effects of "top-down" institutional signals on perceptions of social norms in the context of climate change. Most work on norm change has focused on bottom-up factors, such as peer influences and the transmission of norms through social networks (Tankard and Paluck 2016), the observation of behavior, or statistical information, and is often inferred from observed behavioral changes. However, given that many signals about the multi-dimensional and complex problem of climate change come from formal institutions and organizations, they are a potentially important pathway towards shifting social norms.

To our knowledge, there is also limited empirical work looking at the efficacy of similar messages emanating from different formal institutions—an especially important medium for a global issue like climate change. Addressing climate change requires collective action on an unprecedented scale and rapid government responses. However, it has become an increasingly politicized and divisive topic in some countries, including the USA. In such contexts, where there is a paucity of private and public action, signals from formal institutions may act as a coordinating mechanism, synchronizing perceptions of pro-climate descriptive norms and in turn proclivity for pro-climate action. Furthermore, while studies have shown that signals from formal institutions can shift perceptions of social norms—for

example, the Supreme Court's rulings on same-sex marriage shifted perceptions of related social norms—the signals in these studies have been accompanied by legal mandates and represent unique formal institutions that cannot be readily directed towards social norm interventions (Tankard and Paluck 2017; Nyborg and Rege 2003b).

Our work expands on earlier research by showing that signals from different institutional actors vary in their effectiveness for changing perceptions of social norms in the context of climate change, both in the strength and diffuseness of their effects. In particular, for respondents in the USA, a matched real-world message had a stronger and more widespread impact on norm perceptions when it was issued from a coalition of businesses or climate scientists as compared to state governments. Indeed, we found that a pro-environmental message from a coalition of state governors had little impact on perceptions of pro-environmental norms among either government or business actors, though the lack of influence on perceptions of norms held by government actors may be due to a discrepancy between the message source ("a coalition of governors") and the norm assessment group ("policymakers"). The stronger and more diffuse effects of the business signal might be due to the fact that the business community, in particular in the US context, might be perceived as less controversial compared to governments and scientists in times of high political polarization and science skepticism. This result reveals how the business community can be a crucial actor in shifting perceived climate change–related norms among a circumscribed albeit sizable and important constituency. For context, the influence of the business signal on perceived pro-environmental norms among business actors was comparable in absolute magnitude to the effect one would obtain on this same outcome variable by moving a respondent from the most conservative end of the political ideology spectrum to the most liberal one, holding all else constant. Of course ideology was not a manipulated variable, but comparing standardized coefficients shows that the effect of the business signal was four times as strong as a one standard deviation shift in political ideology would be—a characteristic that is also likely much harder to shift with a simple intervention (see SI Table 6).

Our results suggest that positive effects of institutional signals indicating a commitment to climate action on the perception of pro-climate norms are robust and consistent across a diverse sample. However, they also show that, despite positive effects on norm perceptions, pro-climate commitments may have little direct effects on individual behavior. For example, we found that donation behavior did not change in response to commitments by institutions, which could be due to the direct and immediate monetary cost to participants but could also follow from several other factors. The impact of donations on climate change mitigation may not have been obvious to participants and the private nature of the decisions reduced the potential for reputational benefit, a strong predictor of donation behaviors (Imas and Loewenstein 2018; Nyborg and Rege 2003b). Several studies have also shown that information about monetary valuations in the context of the environment can reduce the intrinsic value ascribed to pro-environmental attitudes and behaviors (Vohs and people's thoughts 2015; Goff et al. 2017). Crowding-out of contributions by individuals has been observed in public goods games with intervention by central authorities (Nyborg and Rege 2003a) and in empirical studies of the impact of government support for non-profit organizations. These studies find that government intervention is associated with a decrease in private donations, and that environmental domains are especially susceptible to these effects (de Wit and Bekkers 2016; De Wit et al. 2016).

Studies in various fields have shown how the effect of interventions by authorities on individual action depend crucially on how these interventions impact the sense of personal responsibility. Our institutional messages highlighted not only the need for climate action

but also the progress made so far in fighting climate change, which may have eroded the sense of personal responsibility to donate. That said, we do see positive influences of the messages on behavioral intentions, including willingness to participate in demonstrations and discussions with peers. This suggests that the message of commitment on the part of large institutional actors may be more important for stimulating some types of behaviors than others—whereas financial contributions may seem less relevant when large efforts are already underway, political action and civic engagement may be seen as complementary or synergistic with those efforts. In light of these results, future work could investigate how different types of institutional signals shape different types of behaviors.

Our findings suggest that public efforts by formal institutions to shift social norms and encourage individual climate action should be carefully designed and tested, taking into account how the institution is perceived, the type of action that is being encouraged, and the relationship between the social norm perception and climate action.

5 Conclusion

Our study makes two main contributions. First, it highlights the importance of considering the reach or generalizability that messages from different institutional actors have in influencing norm perceptions in the context of climate change. While we have focused on the climate context here, we expect that the sensitivity to the messenger will hold across contexts, though the efficacy of different actors will change. Second, we show that institutional signals can shift the perceptions of norms held by diverse actors and yet not have the intended effects on individual action. These two findings highlight the complexity and limitations of using norm signals as levers for change and suggest that caution, care, and attention to context are needed when designing social norm interventions.

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Author contribution S.M.C., S.P., A.R. and E.U.W. designed the study. S.M.C., S.P. and A.R. programmed the questionnaire under the supervision of E.U.W. S.M.C. analyzed the data, based on feedback from S.P., A.R., and E.U.W. R.F. did the specification curve analysis. S.M.C., S.P., A.R., R.F., and E.U.W. drafted and approved the final version of the manuscript.

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Data availability Data and code will be made available by email request to the corresponding author.

Declarations

Competing interests The authors declare no competing interests.

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