Systematic review raises doubts about the effectiveness of framing in climate change communication

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Systematic review raises doubts about the effectiveness of framing in climate change communication

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Abstract

Ambitious climate policy requires acceptance by millions of people whose daily lives would be affected in costly ways. How to get the mass public on board to prevent a political backlash against costly climate policies? Many scholars regard 'framing' as an effective communication strategy for changing climate beliefs, attitudes, and behaviors. In contrast, skeptics argue that people hold relatively stable opinions and doubt that framing can alter public opinion on salient issues like climate change. We contribute to this debate by conducting a first systematic review of 121 experimental studies on climate and environmental policy framing, published in 46 peer-reviewed journals. We find that the vast majority of these experiments report significant framing effects. However, the robustness of these results cannot easily be checked because only few studies make their data publicly available. A survey of framing researchers suggests that when scholars successfully publish non-significant effects, these were typically bundled together with other, significant effects. Re-analysis of studies focusing on framing differences by partisanship (a key driver of climate change attitudes) also shows that these effects are often not robust when accounting for omitted interaction bias. To improve confidence in climate communication research, we propose some best-practice standards, including preregistration of study designs, publication of replication materials, and use of advanced post-design solutions.

Emphasis framing occurs when actors use messages to alter people's preferences by changing the presentation of an issue or an event[1,2]. In climate policy, politicians or other stakeholders may emphasize specific subsets of preexisting arguments – such as economic or health-benefits of climate change mitigation[3–5] – in an attempt to influence public opinion in favor of (or against) climate action. Is framing an effective climate communication technique to alter public opinion about climate change? Many studies on climate communication suggest that strategic emphasis framing can effectively influence public opinion because it safeguards individuals' identities by appealing to their existing values and prior beliefs[6–11]. Framing theory holds that the effectiveness of framing in altering people's attitudes varies according to whether the related information is stored in individuals' memories (i.e., is available), is retrievable (i.e., accessible), and is evaluated as appropriate (i.e., is applicable) in a given situation[2,12]. The framing literature also builds on a bounded rationality model[13] and often assumes that citizens have limited capacity to process information systematically[2,14–16]. From this perspective, individuals use frames as simple heuristics to minimize cognitive effort when forming policy attitudes[12,17,18].

Most framing studies on climate communication look at heterogeneous framing effects – a variation of framing effects across population subgroups. According to directional-motivated reasoning models[1], framing political messages around prior beliefs and values can reduce cognitive dissonance[19,20] and increase framing effects. For example, empirical studies have shown that individuals perceive frames tailored to their ideological core beliefs as less threatening. Accordingly, many studies (especially in polarized political contexts such as the United States) assume that frames aligned with citizens' ideologies and party identification are more effective at altering climate policy attitudes[1,21–23].

Empirical evidence for the effect of framing is primarily generated through experiments embedded in survey-, field-, or lab studies. Typically, study participants are randomly confronted with messages emphasizing subsets of arguments or aspects related to an issue. The aim is to assess how these different framing treatments alter respondents' climate beliefs, attitudes, and behaviors, particularly across population subgroups. For example, Bernauer and McGrath[5] as well as Bain et al.[4,24] randomly assigned individuals to different messages that either emphasize the risks of failing to combat climate change (control frame) or highlight different co-benefits of climate mitigation, such as economic, community building, and health benefits (treatment frames), to study if framing climate mitigation policy around co-benefits instead of risks increases public support. While many researchers (see e.g., Bain et al.[4,24]) presume framing to be an effective communication technique for altering mass public opinion and behavior concerning climate change[1,4,7,24–26], some scholars (see e.g., Bernauer and McGrath[5]) have expressed doubts[5,16,27–32]. Skeptics argue that on salient and contested issues, such as climate change, people are likely to hold relatively stable, consciously formed preferences and cannot be easily manipulated through simple framing[5,16,27–29,32]. Some also suspect a bias against reporting non-significant effects in the current framing literature[17,32]. They criticize the use of established experimental designs and statistical methods that involve risks of producing weak and noisy effects with low external validity, especially when studying heterogeneous framing effects across population subgroups[17,33–35].

We contribute to this debate by offering a first systematic review of existing framing experiments on climate and environmental issues. Given the prominence of discussions about the robustness of partisan framing effects across ideological subgroups, we also re-analyze data from a set of published studies using (compared to most published work to date) more advanced statistical methods. Finally, we provide guidance for pre- and post-design solutions that could help improve climate communication research.

Review of framing experiments on climate and environmental issues

Our review is based on the PRISMA identification standard[36] (see further details in the Method section). We identified 121 studies published in 46 peer-reviewed journals between 2007 and 2020, all of which use an experimental design to study the effects of different types of framing treatments on individuals' climate and environmental beliefs, attitudes, and behaviors (see Methods and SI for the complete list of studies). While most studies we consider relate specifically to climate change, many studies also include treatment groups and dependent variables related to other environmental issues, such as air pollution. We decided to include all these studies to increase the scope of our findings. According to the experimental stimuli used in these 121 studies, we classified them into six climate and environmental framing research categories (see SI-Table 1).

Potential risk of over-reporting significant framing effects

Figure 1: Overview of 121 framing experimental studies in the field of climate and environmental politics, economics and psychology published between 2007 and 2020.

Our primary goal is to review existing framing experiments on climate and environmental issues and assess the robustness of reported results on the effectiveness of framing as a strategy for shaping public opinion. Figure 1 provides an overview of our review's results (see Methods and Supplementary Information, SI-Table 2 for further details). Approximately 92 percent (n=111) of the framing studies we reviewed report significant main framing effects. Only 7 percent (n=9) report non-significant main

effects, and 1 percent (n=1) does not report any main effects. Around 20 percent (n=24) of all studies do not report and discuss any heterogeneous treatment effects (e.g., interactions between participants' characteristics, such as party ideology, and framing treatments). In contrast, 69 percent (n=85) of all reviewed studies identify at least one significant subgroup effect, while 11 percent (n=12) report no significant subgroup effects at all. In other words, 87 percent (n=85) of all studies that report on heterogeneous treatment effects (n=97) find some significant subgroup effects. These results point towards a potential risk of over-reporting significant results, as discussed in the next section.

Only 12 percent (n=14) of the studies reviewed compare effects across different countries. While 60 percent (n=72) of studies focus on the United States only, and 7 percent (n=8) on the United States and another country, 33% (n=41) of all reviewed studies conduct their experiments in countries other than the United States. Also, only 7 percent (n=8) use a panel design (i.e., repeated measurements for the same study participants at two or more points in time) to study whether framing effects vary over time (e.g. how long the effect of a one-time exposure lasts), whereas 93 percent (n=113) do not. While 95 percent (n=115) of the reviewed studies use a survey- or lab-experimental design, only 5 percent (n=6) employ a field experiment (i.e., conducted outside the laboratory or survey setting). Moreover, our review shows that 87 percent (n=105) of the reviewed studies use messages focusing on one side of a political debate (e.g., pro climate mitigation) and do not employ frames that emphasize competing arguments (e.g., contra climate mitigation) – only 13 percent (n=16) of all studies do this.

Moreover, 50 percent (n=61) of all reviewed studies use a convenience sample, often with a small sample size (n<500), while the other 50 percent (n=60) of reviewed studies use a non-convenience sample, often with larger (n>1000) sample that aim to be representative of a country's population.

Bundling non-significant and significant effects to achieve publication

One concern that arises in view of such a large proportion of studies finding statistically significant framing effects is that there may be a file-drawer problem, where only significant effects are published [17]. To assess how the authors of these published framing experiments experienced the publishing process and dealt with non-significant framing effects they encountered, we implemented an online survey (see SI-Section V). We contacted all 173 authors of the 121 publications via email and received a total of 63 responses (a response rate of 36 percent). We find that around 80 percent (n=50) of the respondents have also identified non-significant effects in their framing experiments. Around 60 percent (n=38) of these authors tried to publish their results, including non-significant effects in peer-reviewed journals. Only 63 percent (n=24) of these authors were able to publish studies with non-significant effects successfully. However, according to these authors, in most cases, publishing their findings was only possible when non-significant results were bundled together with other, significant effects. Therefore, the observed gap between the small number of published non-significant framing effects (see Figure 1 above) and the substantially larger number of identified non-significant framing effects reported by the surveyed authors strongly suggests a publication bias towards significant treatment results.

File-drawer problem and lack of publicly available data

Previous research has also highlighted a potential 'file-drawer problem', i.e., the under-reporting of non-significant results[17]. Assessing this problem's existence and magnitude would require public access to the data and a re-analysis of the original study results. However, only 23 percent (n=28) of the 121

articles we reviewed made their data publicly available. In addition, out of those 93 reviewed articles whose data was not published, we obtained data for 29 studies by contacting authors via email (i.e., overall, we could not get access to the data of more than 53 percent (n=64) of all reviewed studies). The large number of experiments that report significant framing effects without publishing data thus raises significant barriers for researchers attempting to assess the robustness of published results. For example, extra and often unsuccessful efforts to obtain access to data increase the costs to systematically re-analyze existing studies, assess the robustness of their results, and estimate the size of the potential file-drawer problem.

Re-analyzing framing effects to check for omitted interaction bias

As mentioned above, climate communication researchers are often interested in how framing effects vary across population subgroups. Druckman and McGrath[1], for instance, note that "rather than continually testing the impact of one frame after another, the literature would benefit from […] investigating which types of messages resonate in light of motivations and particular prior beliefs, values and identities." For example, based on directional-motivated reasoning, a prominent argument in the climate communication literature is that frames aligning with peoples' prior beliefs reduce cognitive dissonance[19,20] and are more effective at shifting public opinion about climate change.

Researchers, therefore, typically split their sample into groups based upon respondent characteristics and then re-estimate their statistical models to assess, for example, whether the framing effect is significant for Democrats or Republicans in the United States. However, this approach is prone to *omitted interaction bias*[73,74], where differences between the sub-groups on other characteristics, such as age, education, and income, also result in heterogeneous treatment effects that are left unmodelled. In essence, several studies[33–35,39–41] have shown that standard specification choices and statistical methods (e.g., ordinary least squares [OLS] regressions) can run the risk of producing non-robust and noisy heterogeneous framing results because of overfitted models, even in perfectly randomized experiments[33,34]. Excluding this potential risk requires an assessment of how sensitive published heterogeneous framing effects are to model misspecification. Advances in machine learning allow researchers to estimate such heterogeneous framing effects across population sub-group effects and prevent *omitted interaction bias*[34,37,38] (see further details in Method section). To re-assess published framing effects along these lines, we employed one such method[30]. A large number of studies in our review focus on the politically polarized country case of the United States and study how framing effects vary by respondents' partisanship. Given this fact, we decided to illustrate the sensitivity of heterogeneous framing effects by testing the robustness of partisan subgroup effects for studies with publically available data.

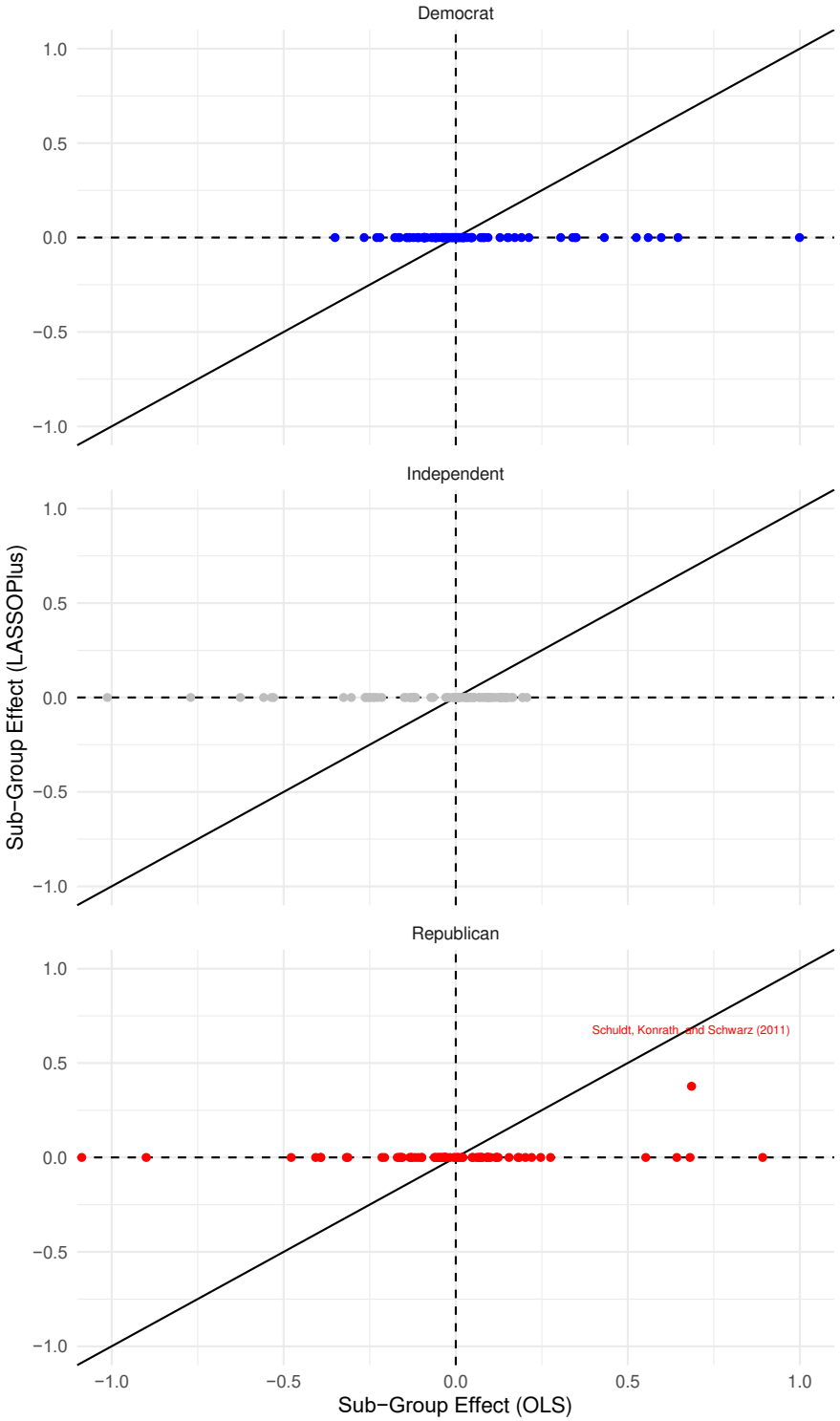

Figure 2: Partisan Sub-Group effects are not robust. Points indicate estimated treatment effects for sub-group framing effects by partisanship. The y-axis displays the estimated sub-group treatment effects estimated using LASSOplus that allows for all possible covariate interactions. The x-axis displays the estimated sub-group effects when estimated using OLS and not allowing for covariate interactions, equivalent to a difference-in-means tests. The solid black line displays the 45 degree line, with points falling on this indicating identical estimates for the different methods of estimating sub-group effects.

Framing effects by partisanship are not robust

Figure 2 displays re-estimated subgroup effects for Democrats, Independents, and Republicans for ten studies with publically available data. We compare effects estimated using both classical OLS and more advanced LASSOplus[30]. LASSOplus allows for simultaneous estimation of sub-group effects for all included pretreatment covariates (e.g., age, education, income, and gender) and for regularization of insignificant effects to avoid overfitting (see further details in the Methods section).

While all of the original studies report significant partisan subgroup effects when using OLS (see x-axis of Figure 2), we find that for the vast majority of re-analyzed studies (9 out of 10) partisan sub-group effects are not statistically distinguishable from zero when using LASSOplus (see y-axis of Figure 2). The exception is Schuldt, Konrath and Schwarz[42], where reframing has a significant effect amongst Republicans, even when using the LASSOplus method.

In addition to assessing the robustness of published subgroup effects by partisanship, we also explored other potential subgroup effects (e.g., by age, education, income, gender) that were not the focus of the original studies. However, also in this explorative analysis of heterogeneous framing effects, we do not find support for robust variation in framing effects across different subgroups (see SI-Tables 3-12).

Overall, our re-analysis of heterogeneous framing effects with more advanced statistical methods shows that the differences in framing effects detected by the original analyses are not robust and should not be considered causal due to *omitted interaction bias*.

Pre- and post-design stage solutions for future research on framing

Researchers can use a number of potential solutions to increase the validity and robustness of their experimental framing results. These solutions can be applied both when designing framing experiments and when analyzing the experimental data. In the following, we discuss some pre-design and post-design stage solutions that could improve confidence in climate communication research focused on framing.

Pre-design stage solutions

First, while different types of frames have been subject to empirical evaluation, our review shows that most of these experiments were embedded in surveys at one point in time and in one specific country, mostly the United States. The lack of comparative and panel designs strongly limits the external validity of results. In reality, framing is likely to unfold its effects over time[2,43] and vary by context[17,44,45]. Moreover, messages emphasizing only one side of a political argument can lead to artificially large framing effects and reduce the external validity of experiments[17,44–46]. In reality, different political elites employ multiple combined and competing rational and emotional cues, building on voice, imagery, and written text[47]. In this sense, the communication context and individual-level heterogeneity interact in many ways[17]. Future research can account for this by reconsidering established methods and study designs to improve the robustness of climate communication research. While there is certainly room for using survey-embedded experiments at one point of time and context, we believe that climate communication research would greatly benefit from embracing more comparative and panel approaches that systematically combine multiple treatments across different contexts and periods of time.

Second, field-experiments are very useful for studying how framing interventions affect both attitudes and behaviors in real-world settings[48]. For example, by comparing stated attitudes and revealed

behaviors in both survey-experimental and field-experimental environments, Levine and Kline[48] show that two different climate risk frames increased people's stated concern about climate change in a survey-embedded setting. However, these two frames also decreased participants' revealed engagement in political action in field-experiments. These results point to a puzzling divergence between stated attitudes and revealed behaviors and caution against an overly optimistic view about the behavioral effects of framing.

Third, preregistration of experiments and journal requirements to publish data are important pre-design solutions to reduce the file-drawer problem and improve the replicability of results. Preregistration can also incentivize researchers to formulate clear-cut expectations based on framing theory, rather than exploring and over-reporting (undertheorized) significant effects. This approach is essential to advance both theories and empirical evidence in climate communication research.

Fourth, researchers can combine different quantitative and qualitative methods to improve their results' internal and external validity. These mixed-methods approaches would also allow analysts to elucidate the moderating and mediating factors that influence how individuals process information and react (differently) to framing treatments. For example, field-experiments, social-network and natural language processing techniques could be combined with qualitative and sensory approaches to reassess the role of emotion in climate communication, and the effects of message tailoring more broadly[49]. Combining field-, survey- and lab-based experiments with qualitative and natural language processing techniques (e.g., automated text analysis of open-ended survey responses[50]) can also help advance our theoretical understanding of when, how, and why different frames effectively change public discourses, norms, beliefs, attitudes, and behaviors.

Post-design stage solutions

Climate communication researchers should also assess their framing effects' robustness after implementing their experiments using more advanced statistical methods. First, as shown in our re-analysis of partisan subgroup effects, many published framing effects are significant, but may not be robust and run the risk of so-called type-S and type-M errors[51]. A type-S error refers to the probability that an estimate's sign is in the wrong direction, i.e., finding a positive effect even though the true effect is negative. A type-M error attempts to quantify the magnitude of an overestimated effect, i.e., how much larger it is than its true value. Using the obtained treatment effect estimates, and associated standard errors, researchers can conduct post-design power calculations and calculate the degree to which their inferences are at risk from type-S and -M errors.

Second, our re-analysis raises doubts about the substantive meaning of the size of published framing effects. Researchers can move beyond null hypothesis testing to test whether the treatment effect estimated is substantively meaningful[52–54]. Equivalence tests are a prominent approach for doing so. Originating in biostatistics, but increasingly adopted in the social sciences, "two one-sided tests" (TOSTs) allow researchers to formally test whether the estimated treatment effect is statistically significantly different from a non-meaningful effect specified by the researcher. For example, for a researcher defining a meaningful change in support for an environmental policy as 1%, a treatment effect of 0.5 with a 90% confidence interval of (0.25,0.75) would constitute a statistically significant "non-meaningful" effect. While placing a greater burden on the researcher, by explicitly specifying what is a

meaningful effect and conducting additional analyses, this approach would increase (skeptical) readers' confidence that the framing effects identified are substantial and worthy of further research.

Third and finally, as demonstrated in our re-analysis of partisan framing effects, researchers can use more advanced statistical methods[34,37,38], typically based on machine learning algorithms, to check their results' sensitivity to model misspecification and potential omitted interaction bias. This approach would increase the robustness and credibility of the obtained findings. As an example, we illustrate in the supplementary materials (SI-Section II) how to employ these post-design solutions when re-analyzing data for a study on the effect of co-benefit framing on environmental policy support[5]. This illustration underscores that many published framing experiments are at risk of overestimating effects (Type-M error) that are, substantively-speaking, of negligible size and not robust when using more advanced statistical methods.

Implications for climate policy and communication

The findings reported in this paper raise doubts about the effectiveness of framing in climate communication. They point to a potential risk of over-reporting significant results[17]. Likely bias against publication of non-significant findings is unfortunate, given the manifold ways that researchers and practitioners could learn from such results in terms of when and why framing does or does not work. However, our results do not suggest that framing per se is ineffective at influencing the public's beliefs, attitudes, and behaviors. Instead, they suggest that framing effects – in the form they are currently studied in climate communication research – are often of smaller magnitude and less robust than assumed. To identify more robust and meaningful framing effects we need to reconsider the empirical approaches and statistical methods used in climate communication research focused on framing.

Exploring effective climate communication strategies requires that practitioners and researchers collaborate in more field-embedded and realistic transdisciplinary projects. Future research needs to embrace the full spectrum of available methods and engage in a more cautious but often more effortful empirical approaches. In doing so, researchers should follow best-practice standards. The most important of these are preregistration of study designs, publication of replication materials, and advanced post-design solutions to prevent over-reporting of weak effects. Future climate communication research should critically reflect on the limits of framing and employ the outlined best-practice standards in order to provide useful policy recommendations about how to promote ambitious policies to combat climate change.

Method

A systematic review of framing studies

In line with the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA)[36], we systematically reviewed framing studies in the field of environmental politics, economics and psychology according to the following three steps.

First, we conducted a scoping analysis of environment-related framing experiments published in a peer-reviewed scientific journal in Google Scholar, Web of Science, and personal databases using the following search string: (("emphasis fram*" OR "issue fram*" OR "policy fram*" OR "refram*" OR "fram* experiment" OR "information treatment" OR "communication" OR "message" OR "priming" OR "persuasive information" OR "argument") AND (("survey" AND "experiment") OR ("field" AND "experiment") OR ("lab*" AND "experiment")) AND ("climate change" OR "environment"))

In addition, we used forward and backward snowball technique to identify relevant framing experiments using citations and the reference lists of the reviewed articles. We limited the scope to studies that were published before or in 2020. We only identified relevant studies published between 2007 and 2020.

Second, during our scoping analysis, and in line with the PRISMA standard[36], we identified 121 peer-reviewed articles in 46 social science journals that we classified as framing experimental studies in the field of environmental politics, economics and psychology (see PRISMA scheme below). The PRISMA standard aims to report systematic reviews transparently and comprises an evidence-based minimum set of reporting items. We only included studies that randomly varied emphasis framing treatments and assessed their effects on individuals' environmental beliefs, attitudes, or behaviours. Therefore, we included studies that varied the information's connotation, but excluded so-called equivalence framing experiments. In contrast to emphasis framing, equivalence framing uses different, but logically equivalent phrases to label and describe an issue. An example for an equivalence frame would be to state that a person has a 20% risk of dying or an 80% chance of surviving. The rationale for focusing our review on emphasis frames is that equivalence frames are a less prominent strategy in climate communication (research) and policymaking[30]. Policymakers typically vary the emphasis on a specific subset of relevant arguments in a policy debate, rather than using logically equivalent phrases to alter public opinion. Moreover, studies that did not use a survey-, lab- or field-experimental design or did not focus on the environmental domain were not included in the review.

339 **PRISMA Flow Diagram**
340

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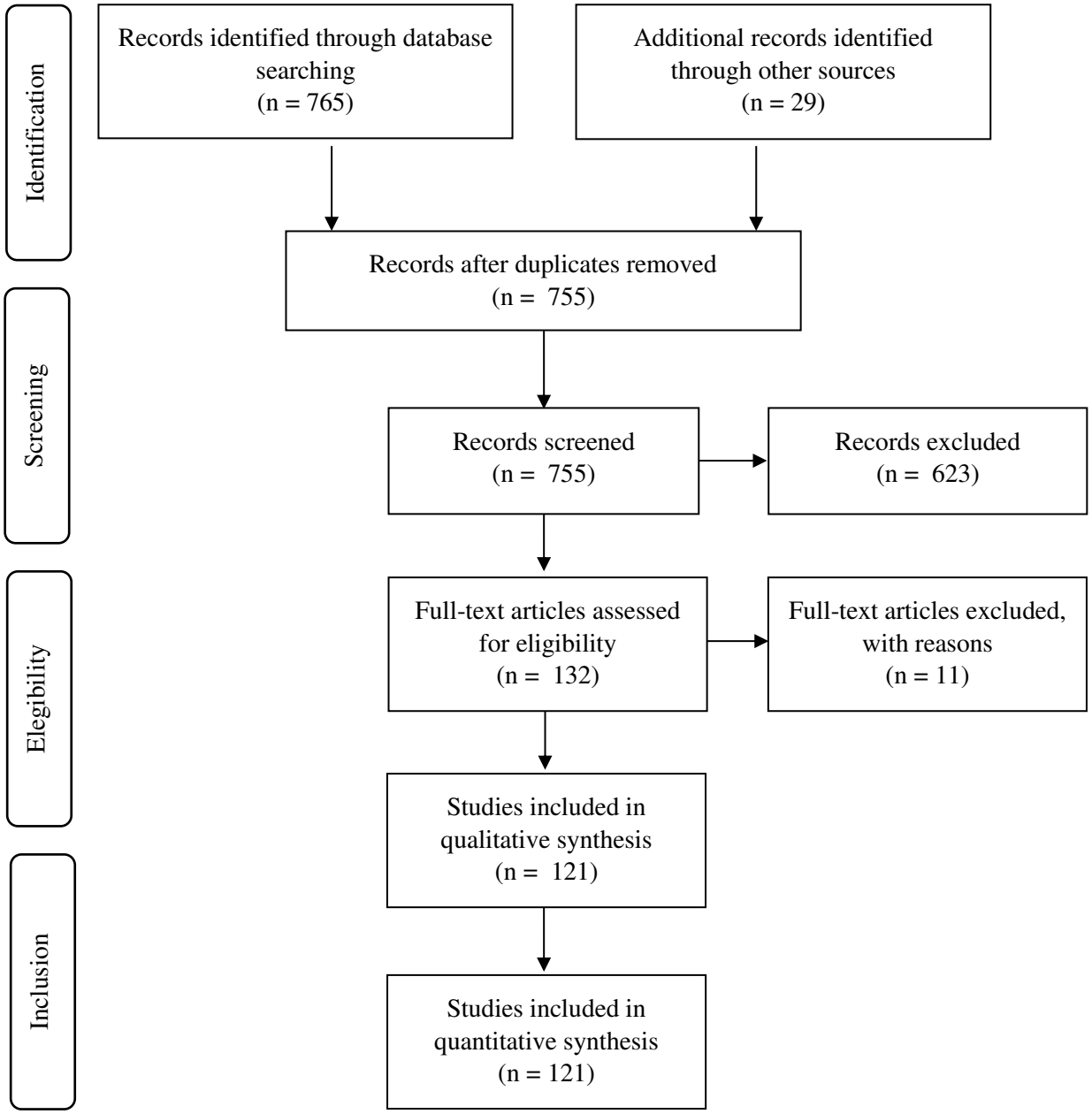

Third, we systematically analyzed those 121 articles by coding each of the articles according to the following criteria:

a) Significant main treatment effect: To what extent did the experiment report any type of significant main treatment effect? If the study included multiple treatment groups, and at least one of these had a significant effect on the outcome variable, we coded the study as reporting significant main effects. If no main effect was reported, we marked this category as not applicable.

b) Significant heterogeneous treatment effect: To what extent did the experiment report any type of significant heterogeneous treatment effect? If the study included multiple treatment groups, and at least one of these had a significant heterogeneous effect for population subgroups, we coded the study as reporting significant heterogeneous effects. If no heterogeneous effect was reported, we marked this category as not applicable.

c) Comparative research design: To what extent did the experiment use a comparative research design? If the study focused on more than one country case, we coded the study as a comparative research design.

d) Case: In which countries were the experiment(s) conducted?

e) Panel research design: To what extent did the experiment use a panel research design? We coded the study as panel research design if the study was conducted at multiple points in time (at least two data collection waves).

f) Experimental design setting: What type of experimental design did the experiment use? We coded whether the study used a field-, survey- or lab-experimental design or a combination of those experimental design types.

g) Competing frames: To what extent did the study use different, competing frames? We coded studies as using competing frames if they did not only use one-sided messages but employed frames that emphasize competing arguments and subsets of information.

h) Method used: To what extent did the study use an advanced statistical method to check for the results' robustness? We coded studies using an advanced computational method if they employed LASSOplus, LASSO, Ridge Regression, or Kernel regularized least squares.

i) Sample type: To what extent did the study use a convenience sample or a non-convenience sample? We coded studies as convenience sample if they study did not use a probability-based, stratigied or controlled quota sampling methods to aim at representing the target population. Most of the time convenience samples in our review had a sample size of below 500 and were based on student samples.

j) Published data: To what extent did the study make the data publically available? We only coded studies as publicly available material if the authors had deposited the data in a public repository, such as Harvard Dataverse.

We trained three research assistants as coders. In addition, three of the authors also coded articles and double-checked the coding results. In the case of coding-related uncertainty, we asked coders to make comments. The authors then independently looked at these comments and came to an individual decision. Subsequently, the authors discussed these pending cases to make a final decision.

We also qualitatively analyzed the sample articles and inductively created six framing-type groups, as presented in Figure 1 of the paper. Namely, these are "Issue/Solution Frames", "Value/Norm/Attribution Frames", "Re-Labelling Frames", "Psychological Distance Frames", "Consensus/Uncertainty Frames", and "Source Cue Frames". The definition of each category and relevant examples are listed in SI-Table 1 in the appendix. To clarify, the objective of making this typology was to identify the central focus of the treatment conditions in each framing experiment. For those studies that contained two types of manipulations, we coded 0.5 for each category.

Re-analysis of framing studies

As described in the main body, most framing experiments study heterogeneous treatment effects across population subgroups. To test the robustness and substantial relevance of reported framing effects, we re-analyzed ten typical and widely cited studies that report on heterogeneous framing effects across partisanship subgroups and that made replication material publically available. These re-analyses are not representative of all published framing experiments. Unfortunately, however, the quantity of publically available data material is very limited, so we could not fully assess existing results' robustness. In this sense, the re-analysis's primary goal was to investigate empirically and potentially verify our suspicion of potential bias against the reporting of non-significant effects. We also intended that the re-analysis process could familiarize applied researchers using advanced statistical methods that they may use in future communication research to check the robustness and relevance of effects.

In line with the original studies, we first used classical ordinary least squares (OLS) regressions in our re-analysis. To check for the robustness and substantive relevance of framing effects, we went beyond using these standard linear regression methods and employed a recently developed Bayesian method for variable selection in high-dimensional settings, LASSOplus[34]. Here, our premise is that robust framing effects should be detectable through different statistical methods. In essence, robust framing effects should be detectable when using classical linear regressions and using more advanced computational sparse regression techniques that punish weak and noisy effects[33,34,55]. LASSOplus belongs to a family of advanced computational and sparse regression methods developed to test the robustness and substantial relevance of (heterogeneous) experimental effects[33,34,55]. Such methods select variables relevant to predicting changes in mass public attitudes by combining regularized estimation and data-driven choices of regularization parameters. It thereby reduces the risk of over-fitting the estimation model. In other words, LASSOplus penalizes weak and noisy effects to increase efficiency and thereby lessens the risk of false positives. We use LASSOplus as it is designed explicitly for the estimation of heterogeneous treatment effects. LASSOplus allows for the estimation and selection of multiple effects simultaneously, without engaging in potentially arbitrary sub-setting of data. This approach allows the researcher to include many interaction effects to avoid potential omitted interaction bias while simultaneously preventing overfitting the model[34,37,38].

In sum, compared to classical linear regressions, this method provides more conservative and robust estimates with credible intervals. It also permits the estimation of interaction effects that can be interpreted independently of their lower-order terms (please refer for further details about LASSOplus – e.g. its Bayesian prior structure and regularization parameters – to the original methodological paper[34]). It is important to note that these more advanced computational methods are no 'manna from heaven' to draw causal inference. However, they can complement existing statistical methods (e.g., OLS regressions) to identify the most relevant and robust framing effects.

In the following, we summarise the ten studies we re-analyzed in Figure 2. The re-analyzed studies include analyzed data by Stokes and Warshaw (id17); Christenson, Goldfarb and Kriner (id35); Singh and Swanson (id41); id57: Schuldt, Enns and Cavaliere (id57); Bolsen, Leeper and Shapiro (id71); Saunders (id73); Hardisty, Johnson and Weber (id74); Bolsen and Druckmann (id83); Schuldt, Konrath and Schwarz (id86); and DeGolia, Hiroyasu and Anderson (id115). Please refer to the original studies for further details about the theoretical expectations and experimental design and the supplementary information for full regression tables (see SI-Tables 3-12).

Stokes and Warshaw (id17) use a survey experiment to study effects on public support for different renewable portfolio standards bills by varying information about the bill's residential electricity costs, jobs and pollution effects, as well as climate change framing and source cues. Their results indicate that all of these factors are important drivers of public support. Focusing on partisan differences in source cue framing effects, the authors' results indicate that Democratic (Republican) respondents are more likely to support Democratic (Republican) state legislators' bills. Using LASSOplus, we, however, cannot find any significant subgroup effects among partisan differences.

The study by Christenson, Goldfarb and Kriner (id35) uses the US nationally representative sample to conduct a survey experiment testing how information about economic and environmental costs and benefits affects fracking support. Their results provide limited evidence of motivated partisan reasoning as framing effects are most considerable for respondents with conflicting partisanship and climate change beliefs. Using LASSOplus, we can confirm that the effects only show limited evidence of motivated partisan reasoning as we could not fully reproduce these significant effects.

Singh and Swanson (id41) study the effect of the different issue- and source-cue frames on US citizens' perceived importance of climate change policy. While the original study shows that the framing conditions did not affect climate policy's perceived importance, it reports several significant subgroup effects for different ideological groups of the sample. Using LASSOplus, we can confirm the main treatment effects' null findings but cannot reproduce any of the originally heterogonous treatment effects.

The study by Schuldt, Enns and Cavaliere (id57) uses data from a probability-based survey experiment conducted among 1461 US adults in 2016 to test the prediction that respondents and Republicans respond differently whether global warming vs climate change exists. Their results show that, in the United States, Republicans are more concerned about the term "climate change" than the term "global warming". However, our re-analysis using LASSOplus did not confirm these significant heterogeneous treatment effects reported by the original study.

The study by Bolsen, Leeper and Shapiro (id71) uses a framing experiment to test whether messages highlighting social norms or mentioning science in communication affect respondents' willingness to take action against and beliefs about global warming. Their results show that attitudes about global warming, support for policies that would reduce carbon emissions, and behavioral intentions to take voluntary action are strongly affected by the norm- and science-based interventions. These effects partly differ depending on party preference. However, running LASSOplus regressions does not confirm these marginally significant differences in effects between ideological groups for the confidence outcome reported by the original study.

Saunders (id73) studies Anthropogenic Global Warming conspiracy beliefs by testing both phrasing (global warming vs climate change) and motivated partisan reasoning. Results indicate that, in line with the theoretical expectations, for the case of climate change, trust moderates hoax beliefs among Republicans. However, this is not the case for global warming, where trust does not moderate conspiracy endorsement among Republicans. Re-analyzing data by using LASSOplus does not confirm any of the significant main nor heterogeneous treatment effects reported by the original study.

Hardisty, Johnson and Weber (id74) conducted a framing experiment among 889 Americans to assess how labelling charges for environmental costs as either an earmarked tax or an offset included as a surcharge for emitted carbon dioxide affects consumer choices. Their results indicate that cost framing changed preferences for both respondents self-identifying as Republicans and Independents. Democrats' preferences were not significantly affected by these frames. Conversely, the LASSOplus results did not confirm any significant main or heterogeneous treatment effects reported by the original study.

The study by Bolson and Druckmann (id83) investigates the role of partisan group identity and the politicization of science in weakening the impact of a scientific-consensus-based message about human-induced climate change in the United States. Based on OLS regressions, the original study found that partisan identity and politicized messages can alter the effects of messages about the scientific consensus regarding the negative impacts of climate change. However, the LASSOplus results did not confirm any of the significant main nor heterogeneous treatment effects reported by the original study, which employed standard linear regression techniques.

The study by Schuldt, Konrath and Schwarz (id86) uses a survey experiment with 2267 US respondents to test how different wording of global climate change (global warming vs climate change) affects whether individuals perceive the phenomenon to be real or not. Their results indicate that, as expected, Republicans were more likely to endorse that the phenomenon is real when it was referred to as climate change rather than global warming. In contrast, Democrats were not affected by the specific question-wording. This study deems an exception amongst all the re-analyzed studies as it is the only study where reframing has a significant effect amongst Republicans when using LASSOplus.

DeGolia, Hiroyasu and Anderson (id115) use a survey experiment with a two (economic, ecological) by two (gain, loss) factorial design to evaluate how different types of benefit and loss attribute frames in environmental communication affect public support. Among other subgroup analyses, their results indicate that ecological and economic frames differed based on individuals' political ideologies and environmentalism as conservatives were most responsive to economic messaging. At the same time, liberals were most responsive to ecological framing. For this study, we also did not find any significant subgroup effects when using LASSOplus.

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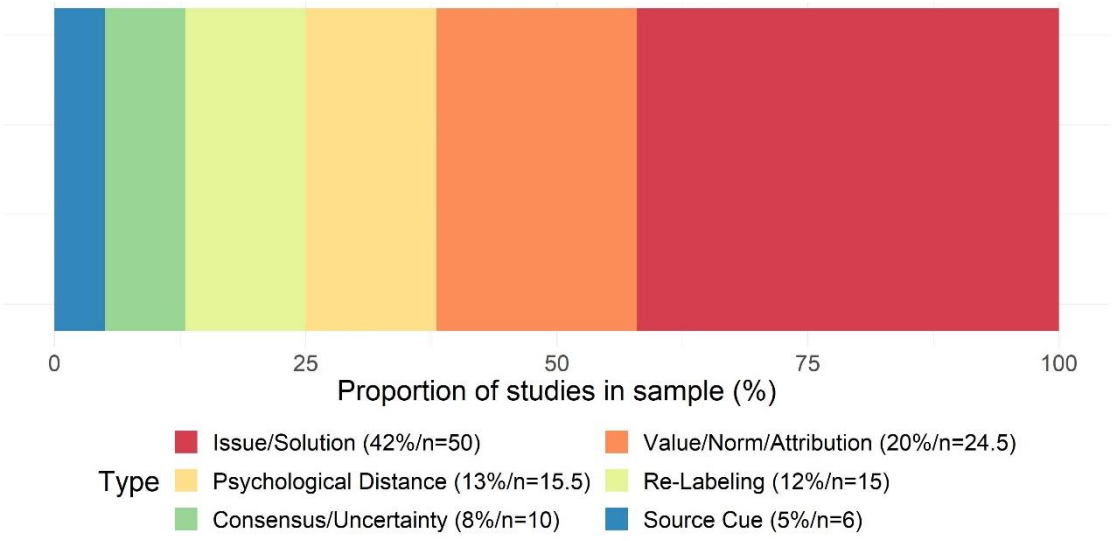
Supplementary Information

SI-Section I: Framing typology

SI-Table 1: Typology of framing experiments concerning climate and environmental policy

Category	Definition
1. Issue/Solution	The treatment provides different issue interpretations of a given problem or suggests different solutions to a given problem (e.g., experimental manipulation of information suggesting the solution to climate change will have to be based on technological innovation or lifestyle changes)
2. Value/Norm/Attribution	The treatment emphasizes different values or social norms embodied in actions to address a given problem (e.g., experimental manipulation of information indicating economic benefits vs. moral obligations of reducing carbon emissions)
3. Re-Labeling	The treatment uses different wordings to describe the same problem (e.g., experimental manipulation of information referring to 'climate change' vs 'global warming')
4. Psychological Distance	The treatment indicates different time horizons to consider a given problem (e.g., experimental manipulation of information suggesting climate change is a future vs. current problem or a global vs. local problem)
5. Consensus/Uncertainty	The treatment highlights the varying degree of consensus or uncertainty on a given problem (e.g., experimental manipulation of information suggesting scientific consensus vs. lack thereof on climate change)
6. Source Cue	The treatment highlights different sources of the same message on a given problem (e.g., experimental manipulation of information on the severity of climate change suggested by scientists vs. politicians, or different political parties)



SI-Figure 1: Proportion of studies according to stimulus type.

SI-Figure 1 shows the distribution of the 121 studies across these six categories. The first category of studies investigates the impact of issue and solution frames on study participants' climate and environmental beliefs, attitudes, and behaviors (see SI-Table 1 and SI-Figure 1, 'Issue/Solution'). This is the largest category and comprises 42 percent (n=50) of all reviewed studies. Issue and solution frames are often emphasize environmental risks and co-benefits of environmental protection or climate mitigation. For example, some studies[4,24] in this category highlight that emphasizing co-benefits of climate mitigation (such as technological innovation, green jobs, community building, or health improvements) could foster public support for ambitious mitigation policies.

The second category of studies focuses on potential effects of morally loaded frames that emphasize personal values and social norms, and attribute responsibility for environmental problems and solutions (see SI-Table 1 and SI-Figure 1, 'Value/Norm/Attribution'). We decided to group values, norms and attribution into one group because all these framing types have an explicit moral and normative dimension. This category accounts for 20 percent (n=24.5) of the studies we reviewed. For instance, research in this category finds that moral and normative frames can be more effective at motivating environmentally friendly behavior than economic appeals that focus on individual self-interest. [26,56]

The third category of framing experiments accounts for 13 percent (n=15.5) of the studies we reviewed (see SI-Table 1 and SI-Figure 1, 'Psychological Distance'). Such research seeks to examine the impact of manipulating the perceived psychological distance to environmental impacts. For example, some studies[57,58] vary the spatial, social, and temporal distance of climate change impacts to assess whether people support ambitious mitigation more when they perceive climate change as a proximate problem.

The fourth-largest category of framing studies accounts for 12 percent (n=15) (see SI-Table 1 and SI-Figure 1, 'Re-Labeling'). This research seeks to re-label specific terms or use visual cues to influence public opinion. For example, some studies[59,60] find that, in the United States, Republicans are more concerned about 'climate change' than about 'global warming'.

The fifth category of frames accounts for 8 percent (n=10) and concentrates on consensus and uncertainty (see SI-Table 1 and SI-Figure 1, 'Consensus/Uncertainty'). Many of these experiments employ messages that vary the degree of scientific consensus or uncertainty about climate change severity. For example, studies examine how[61,62] messages about the level of scientific agreement about climate change can reduce the politicization bias of scientific evidence.

The sixth category of frames relates to source cue effects (see SI-Table 1 and SI-Figure 1, 'Source Cue'). This category accounts for 5 percent (n=6) of the studies we reviewed and focuses on different messenger source effects on climate and environmental attitudes. For instance, some such studies[63,64] show that source cue effects can influence support for climate policies, especially if individuals perceive the source as credible[64] or if messages convey counter-intuitive information about the position of an actor[63].

SI-Section II: Illustration best practice standards

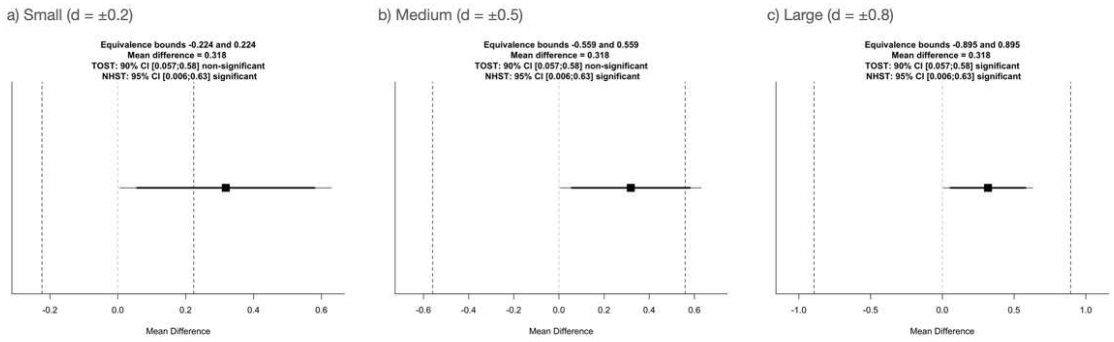
To illustrate putting our recommendations into practice, we re-analyze a prominent study on the effect of co-benefit framing on environmental policy support[5]. Bernauer and McGrath (ID11) conduct a comprehensive study that evaluates the average and heterogeneous effects of various frames upon three outcomes. Their ultimate conclusion is that reframing is unlikely to significantly boost public support for climate policy, as the vast majority (135) of these effects are insignificant.

While the overwhelming majority of effects are insignificant, there is a small number where this is not the case. For example, a frame that emphasizes how environmental policy can lead to a "good society", is found to cause a statistically significant increase in environmental policy support for Independents (effect = 0.32, std. error = 0.17, $p < 0.06$).

We thus use this effect as an example for assessing the robustness of framing effects generally, by following the recommendations we have outlined previously. We do so because we consider this example as a hard case for testing the robustness of framing effects. In essence, if we cannot find support for the few positive framing effects reported in the critical assessment of framing effects reported by Bernauer and McGrath[5], this raises doubts about the effectiveness of framing in climate communication more general.

First, we assess the potential for type-M and -S errors based upon this estimated treatment effect. Precisely, for any given treatment effect estimate the smaller the standard error, the lower the expected type-M error. Additionally, small treatment effects with large standard errors have a high probability of type-S error. In this example, we find that the probability of a type-S error is incredibly small, approximately 0.0004, meaning it is extremely unlikely the true effect is in the opposite direction, i.e. negative. The type-M error is estimated to be approximately 1.35, meaning that the magnitude of the effect we can uncover is on average 35% larger than the true effect.

Second, we assess whether the estimated treatment effect is substantively meaningful by using equivalence tests. As we do not have strong prior beliefs about a non-meaningful change in the standardized policy support variable, we base our equivalence regions on standard rules of thumb for interpreting standardized effect sizes, also known as Cohen's d. We construct TOSTs for the commonly used definitions of small (±0.2), medium (±0.5), and large (±0.8 effects).



SI-Figure 2: Equivalence tests for small (0.2), medium (0.5), and large (0.8) standardized effect sizes.

SI-Figure 2 displays the results of these equivalence tests. The tests suggest that the estimated treatment effect is consistent with being interpreted as a small or medium-sized effect. The null hypothesis of equivalence for these effect sizes cannot be rejected. However, the treatment effect is interpreted as a large effect can be rejected, as the confidence interval for the estimated effect is located entirely within the defined bounds.

Third, we assess whether the estimated effect is prone to omitted interaction bias by using LASSOPlus[34]. To do so we include all the potentially relevant subgroups previously analyzed by Bernauer and McGrath. Doing so leads to this estimated effect being set to zero, indicating that it is ultimately not a robust treatment effect. No non-zero treatment effects, whether they be average or sub-group based, are found due to this estimation. This analysis ultimately supports Bernauer and McGrath's contention that simple reframing is unlikely to affect climate policy support.

In summary, following our recommendations for assessing framing effects provides an important set of steps for assessing the robustness and significance of framing effects. Estimating the type-M and -S error rates suggest that while the probability of finding the incorrect sign is low, the effect is likely overstated in its magnitude. Equivalence tests suggest that the effect is consistent with the common interpretation of a medium-sized standardized effect, but it is not equivalent to a large effect size. However, this effect is ultimately not robust when accounting for potential omitted interaction bias using a regularized estimator, calling in to question its likely replicability and generalizability outside of the survey.

SI-Section III: Results systematic review

SI-Table 2: Results systematic review

Number	Reference	Significant main treatment effects	Significant heterogeneous treatment effects	Comparative Research Design	Case	Sample type	Method used	Panel research design	Experimental design	Competitive framing environment	Replication data published	Framing type
1	Capstick, S. B., Pidgeon, N. F., Corner, A. J., Spence, E. M., & Pearson, P. N. (2016). Public understanding in Great Britain of ocean acidification. *Nature Climate Change*, *6*(8), 763-767.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution
2	Bain, P. G., Hornsey, M. J., Bongiorno, R., & Jeffries, C. (2012). Promoting pro-environmental action in climate change deniers. Nature Climate Change, 2(8), 600-603.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution
3	Whitmarsh, L., Xenias, D., & Jones, C. R. (2019). Framing effects on public support for carbon capture and storage. Palgrave Communications, 5(1), 1-10.	Yes	Yes	Yes	USandOthers	Population	Classic	No	Survey	No	No	Issue/Solution
4	Bolsen, T., Palm, R., & Kingsland, J. T. (2019). The impact of message source on the effectiveness of communications about climate change. Science Communication, 41(4), 464-487.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Source Cue

5	Bolsen, T., Palm, R., & Kingsland, J. T. (2019). Counteracting climate science politicization with effective frames and imagery. Science Communication, 41(2), 147-171.	Yes	No	No	USonly	Convenient	Classic	No	Survey	Yes	No	Consensus/Uncertainty
6	Hart, P. S. (2011). One or many? The influence of episodic and thematic climate change frames on policy preferences and individual behavior change. Science Communication, 33(1), 28-51.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Issue/Solution
7	Ahern, L., Connolly-Ahern, C., & Hoewe, J. (2016). Worldviews, issue knowledge, and the pollution of a local science information environment. Science Communication, 38(2), 228-250.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Issue/Solution
8	Yang, Z. J., Rickard, L. N., Harrison, T. M., & Seo, M. (2014). Applying the risk information seeking and processing model to examine support for climate change mitigation policy. Science Communication, 36(3), 296-324.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm
9	Beiser-McGrath, L. F., & Bernauer, T. (2019). Commitment failures are unlikely to undermine public support for the Paris agreement. Nature climate change, 9(3), 248-252.	Yes		Yes	USandOthers	Population	Advanced Sparse/Bayesian/ML	No	Survey	No	Yes	Issue/Solution
10	Zhang, B., van der Linden, S., Mildenberger, M., Marlon, J. R., Howe, P. D., & Leiserowitz, A. (2018). Experimental effects of climate messages vary geographically. Nature Climate Change, 8(5)	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Consensus/Uncertainty

11	Bernauer, T., & McGrath, L. F. (2016). Simple reframing unlikely to boost public support for climate policy. Nature Climate Change, 6(7), 680–683.	No	No	No	USonly	Population	Classic	No	Survey	No	Yes	Issue/Solution
12	Bolderdijk, J. W., Steg, L., Geller, E. S., Lehman, P. K., & Postmes, T. (2013). Comparing the effectiveness of monetary versus moral motives in environmental campaigning. Nature Climate Change, 3(4), 413–416. https://doi.org/10.1038/nclimate1767	Yes	No	No	Others	Convenient	Classic	No	Survey and Field	No	No	Moral/Value/ Attribution/Norm
13	Mildenberger, M., Lubell, M., & Hummel, M. (2019). Personalized risk messaging can reduce climate concerns. Global Environmental Change, 55, 15–24. https://doi.org/10.1016/j.gloenvcha.2019.01.002	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Psychological Distance
14	Feldman, L., & Hart, P. S. (2018). Climate change as a polarizing cue: Framing effects on public support for low-carbon energy policies. Global Environmental Change, 51, 54–66. https://doi.org/10.1016/j.gloenvcha.2018.05.004	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Issue/Solution
15	Rickard, L. N., Yang, Z. J., & Schuldt, J. P. (2016). Here and now, there and then: How "departure dates" influence climate change engagement. Global Environmental Change, 38, 97–107. https://doi.org/10.1016/j.gloenvcha.2016.03.003	No	Yes	Yes	USandOthers	Convenient	Classic	No	Survey	No	No	Psychological Distance

16	Aklin, M., & Urpelainen, J. (2013). Debating clean energy: Frames, counter frames, and audiences. Global Environmental Change, 23(5), 1225–1232. https://doi.org/10.1016/j.gloenvcha.2013.03.007	Yes		No	USonly	Population	Classic	No	Survey	Yes	No	Issue/Solution
17	Stokes, L. C., & Warshaw, C. (2017). Renewable energy policy design and framing influence public support in the United States. Nature Energy, 2(8), 1–6. https://doi.org/10.1038/nenergy.2017.107	Yes	Yes	No	USonly	Population	Classic	No	Survey	Yes	Yes	Issue/Solution
18	Graham, T., & Abrahamse, W. (2017). Communicating the climate impacts of meat consumption: The effect of values and message framing. Global Environmental Change, 44, 98–108. https://doi.org/10.1016/j.gloenvcha.2017.03.004	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Moral/Value/ Attribution/Norm
19	Spence, A., & Pidgeon, N. (2010). Framing and communicating climate change: The effects of distance and outcome frame manipulations. Global Environmental Change, 20(4), 656–667. https://doi.org/10.1016/j.gloenvcha.2010.07.002	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	0.5. Psychological Distance + 0.5 Issue/Solution
20	Wiest, S. L., Raymond, L., & Clawson, R. A. (2015). Framing, partisan predispositions, and public opinion on climate change. Global Environmental Change, 31, 187–198. https://doi.org/10.1016/j.gloenvcha.2014.12.006	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Psychological Distance

21	Chatelain, G., Hille, S. L., Sander, D., Patel, M., Hahnel, U. J. J., & Brosch, T. (2018). Feel good, stay green: Positive affect promotes pro-environmental behaviors and mitigates compensatory "mental bookkeeping" effects. Journal of Environmental Psychology, 56, 3–11. https://doi.org/10.1016/j.jenvp.2018.02.002	Yes		No	Others	Population	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm
22	Linden, S. van der, Leiserowitz, A., & Maibach, E. (2018). Scientific agreement can neutralize politicization of facts. Nature Human Behaviour, 2(1), 2–3. https://doi.org/10.1038/s41562-017-0259-2	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Consensus/Uncertainty
23	Xu, X., Arpan, L. M., & Chen, C. (2015). The moderating role of individual differences in responses to benefit and temporal framing of messages promoting residential energy saving. Journal of Environmental Psychology, 44, 95–108. https://doi.org/10.1016/j.jenvp.2015.09.004	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	0.5 Moral/Value/Attribution/Norm + 0.5 Psychological Distance
24	Steinhorst, J., Klöckner, C. A., & Matthies, E. (2015). Saving electricity – For the money or the environment? Risks of limiting pro-environmental spillover when using monetary framing. Journal of Environmental Psychology, 43, 125–135. https://doi.org/10.1016/j.jenvp.2015.05.012	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm

25	Jang, S. M. (2013). Framing responsibility in climate change discourse: Ethnocentric attribution bias, perceived causes, and policy attitudes. Journal of Environmental Psychology, 36, 27–36. https://doi.org/10.1016/j.jenvp.2013.07.003	Yes	Yes	Yes	USonly	Population	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm
26	Rabinovich, A., Morton, T. A., & Birney, M. E. (2012). Communicating climate science: The role of perceived communicator's motives. Journal of Environmental Psychology, 32(1), 11–18. https://doi.org/10.1016/j.jenvp.2011.09.002	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm
27	Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2007). The effect of tailored information, goal setting, and tailored feedback on household energy use, energy-related behaviors, and behavioral antecedents. Journal of Environmental Psychology, 27(4), 265–276. https://doi.org/10.1016/j.jenvp.2007.08.002	Yes		No	Others	Convenient	Classic	Yes	Field	No	No	Moral/Value/Attribution/Norm
28	Boomsma, C., & Steg, L. (2014). The effect of information and values on acceptability of reduced street lighting. Journal of Environmental Psychology, 39, 22–31. https://doi.org/10.1016/j.jenvp.2013.11.004	Yes	Yes	No	Others	Convenient	Classic	No	Lab	No	No	Moral/Value/Attribution/Norm
29	van der Linden, S. (2015). Exploring Beliefs About Bottled Water and Intentions to Reduce Consumption: The Dual-Effect of Social Norm Activation and Persuasive	Yes		No	Others	Convenient	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm

	Information. Environment and Behavior, 47(5), 526–550. https://doi.org/10.1177/0013916513515239											
30	Scannell, L., & Gifford, R. (2013). Personally Relevant Climate Change: The Role of Place Attachment and Local Versus Global Message Framing in Engagement. Environment and Behavior, 45(1), 60–85. https://doi.org/10.1177/0013916511421196	Yes	Yes	Yes	Others	Convenient	Classic	No	Survey	No	No	Psychological Distance
31	Bakaki, Z., & Bernauer, T. (2016). Measuring and explaining the willingness to pay for forest conservation: Evidence from a survey experiment in Brazil. Environmental Research Letters, 11(11), 114001. https://doi.org/10.1088/1748-9326/11/11/114001	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Psychological Distance
32	Kaplowitz, S. A., & McCright, A. M. (2015). Effects of policy characteristics and justifications on acceptance of a gasoline tax increase. Energy Policy, 87, 370–381.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Issue/Solution
33	Shapiro, M. A., & Bolsen, T. (2019). Korean perceptions of transboundary air pollution and domestic coal development: Two framing experiments. Energy Policy, 126, 333–342. https://doi.org/10.1016/j.enpol.2018.11.013	Yes	Yes	No	Others	Convenient	Classic	No	Survey	Yes	No	0.5 Issue/Solution + 0.5 Moral/Value/ Attribution/Norm
34	Lockwood, M. (2011). Does the framing of climate policies make a difference to public support? Evidence from UK marginal constituencies. Climate Policy, 11(4), 1097–1112.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution

35	Christenson, D. P., Goldfarb, J. L., & Kriner, D. L. (2017). Costs, benefits, and the malleability of public support for "Fracking." Energy Policy, 105, 407–417. https://doi.org/10.1016/j.enpol.2017.03.002	Yes	Yes	No	USonly	Population	Classic	No	Survey	Yes	Yes	Issue/Solution
36	Griffioen, A. M., Handgraaf, M. J. J., & Antonides, G. (2019). Which construal level combinations generate the most effective interventions? A field experiment on energy conservation. PLOS ONE, 14(1), e0209469. https://doi.org/10.1371/journal.pone.0209469	Yes	Yes	No	Others	Convenient	Classic	No	Field	No	No	Psychological Distance
37	Hart, P. S., & Feldman, L. (2016). The Influence of Climate Change Efficacy Messages and Efficacy Beliefs on Intended Political Participation. PLOS ONE, 11(8), e0157658. https://doi.org/10.1371/journal.pone.0157658	Yes		No	USonly	Population	Classic	No	Survey	No	Yes	Issue/Solution
38	Deryugina, T., & Shurchkov, O. (2016). The Effect of Information Provision on Public Consensus about Climate Change. PLOS ONE, 11(4), e0151469. https://doi.org/10.1371/journal.pone.0151469	Yes	No	No	USonly	Population	Classic	Yes	Survey	No	Yes	Consensus/Uncertainty
39	Bolderdijk, J. W., Gorsira, M., Keizer, K., & Steg, L. (2013). Values Determine the (In)Effectiveness of Informational Interventions in Promoting Pro-Environmental Behavior. PLOS ONE, 8(12), e83911. https://doi.org/10.1371/journal.pone.0083911	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm

40	Linden, S. L. van der, Leiserowitz, A. A., Feinberg, G. D., & Maibach, E. W. (2015). The Scientific Consensus on Climate Change as a Gateway Belief: Experimental Evidence. PLOS ONE, 10(2), e0118489. https://doi.org/10.1371/journal.pone.0118489	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Consensus/Uncertainty
41	Singh, S. P., & Swanson, M. (2017). How issue frames shape beliefs about the importance of climate change policy across ideological and partisan groups. PLOS ONE, 12(7), e0181401. https://doi.org/10.1371/journal.pone.0181401	No	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	0.5 issue/solution + 0.5 Source Cue
42	Aasen, M., & Vatn, A. (2018). Public Attitudes Toward Climate Policies: The Effect of Institutional Contexts and Political Values. Ecological Economics, 146, 106–114. https://doi.org/10.1016/j.ecolecon.2017.10.008	Yes		No	Others	Convenient	Classic	No	Survey	No	No	Moral/Value/Attribution/Norm
43	Dharshing, S., Hille, S. L., & Wüstenhagen, R. (2017). The Influence of Political Orientation on the Strength and Temporal Persistence of Policy Framing Effects. Ecological Economics, 142, 295–305. https://doi.org/10.1016/j.ecolecon.2017.05.014	Yes	Yes	No	Others	Convenient	Classic	Yes	Survey	No	No	0.5 for Re-Labeling + 0.5 Issue/Solution
44	Alpízar, F., & Gsottbauer, E. (2015). Reputation and household recycling practices: Field experiments in Costa Rica. Ecological Economics, 120, 366–375. https://doi.org/10.1016/j.ecolecon.2015.04.003	Yes		No	Others	Convenient	Classic	No	Field	No	No	Moral/Value/Attribution/Norm

45	Whiting, A., Kecinski, M., Li, T., & Parker, J. (2019). The importance of selecting the right messenger: A framed field experiment on recycled water products. Ecological economics, 161, 1-8.	Yes		No	USonly	Convenient	Classic	No	Field	No	No	Source Cue
46	Seidl, R., Von Wirth, T., & Krütli, P. (2019). Social acceptance of distributed energy systems in Swiss, German, and Austrian energy transitions. Energy Research & Social Science, 54, 117-128.	No		Yes	Others	Population	Classic	No	Survey	No	No	Psychological Distance
47	Anspach, N. M., & Draguljić, G. (2019). Effective advocacy: the psychological mechanisms of environmental issue framing. Environmental Politics, 28(4), 615-638.	Yes		No	USonly	Convenient	Classic	No	Survey	No	Yes	0.5 Moral/Value/ Attribution/N orm + 0.5 Psychological Distance
48	Bakaki, Z., & Bernauer, T. (2017). Do global climate summits influence public awareness and policy preferences concerning climate change?. Environmental Politics, 26(1), 1-26.	Yes	Yes	No	USonly	Convenient	Classic	Yes	Survey	Yes	No	Issue/Solution
49	Zhou, J. (2016). Boomerangs versus javelins: how polarization constrains communication on climate change. Environmental Politics, 25(5), 788-811.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	0.5 Source Cue + 0.5 Issue/Solution
50	Benegal, S. D., & Scruggs, L. A. (2018). Correcting misinformation about climate change: The impact of partisanship in an experimental setting. Climatic change, 148(1-2), 61-80.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	Yes	Yes	0.5 Consensus/U ncertainty + 0.5 Source Cue
51	Levine, A. S., & Kline, R. (2017). A new approach for evaluating climate change communication. Climatic change, 142(1-2), 301-309.	Yes		No	USonly	Convenient	Classic	No	Survey and Field	No	No	Issue/Solution

52	Schuldt, J. P., & Pearson, A. R. (2016). The role of race and ethnicity in climate change polarization: evidence from a US national survey experiment. Climatic change, 136(3-4), 495-505.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	Re-Labelling
53	Bolsen, T., Kingsland, J., & Palm, R. (2018). The impact of frames highlighting coastal flooding in the USA on climate change beliefs. Climatic change, 147(1-2), 359-368.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	0.5 Re-Labelling + 0.5 Psychological Distance
54	Wolske, K. S., Raimi, K. T., Campbell-Arvai, V., & Hart, P. S. (2019). Public support for carbon dioxide removal strategies: the role of tampering with nature perceptions. Climatic change, 152(3-4), 345-361.	Yes	Yes	No	USonly	Population	Classic	No	Survey	Yes	No	Issue/Solution
55	Nolan, J. M., & Tobia, S. E. (2019). Public support for global warming policies: solution framing matters. Climatic Change, 154(3-4), 493-509.	Yes	No	No	USonly	Population	Classic	No	Survey and Lab	No	No	Issue/Solution
56	Villar, A., & Krosnick, J. A. (2011). Global warming vs. climate change, taxes vs. prices: Does word choice matter?. Climatic change, 105(1-2), 1-12.	No	Yes	Yes	USandOthers	Population	Classic	No	Survey	No	No	Re-Labelling
57	Schuldt, J. P., Enns, P. K., & Cavaliere, V. (2017). Does the label really matter? Evidence that the US public continues to doubt “global warming” more than “climate change”. Climatic Change, 143(1-2), 271-280.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Re-Labelling

58	Schuldt, J. P., Pearson, A. R., Romero-Canyas, R., & Larson-Konar, D. (2017). Brief exposure to Pope Francis heightens moral beliefs about climate change. Climatic Change, 141(2), 167-177.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Moral/Value/ Attribution/Norm
59	Myers, T. A., Nisbet, M. C., Maibach, E. W., & Leiserowitz, A. A. (2012). A public health frame arouses hopeful emotions about climate change. Climatic change, 113(3-4), 1105-1112.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Issue/Solution
60	Petrovic, N., Madrigano, J., & Zaval, L. (2014). Motivating mitigation: when health matters more than climate change. Climatic Change, 126(1-2), 245-254.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Issue/Solution
61	Braun, C., Merk, C., Pönitzsch, G., Rehdanz, K., & Schmidt, U. (2018). Public perception of climate engineering and carbon capture and storage in Germany: survey evidence. Climate Policy, 18(4), 471-484.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution
62	Kenny, J. (2018). The role of economic perceptions in influencing views on climate change: an experimental analysis with British respondents. Climate policy, 18(5), 581-592.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution
63	Chen, D., Cheng, C. Y., & Urpelainen, J. (2016). Support for renewable energy in China: A survey experiment with internet users. Journal of Cleaner Production, 112, 3750-3758.	Yes		No	Others	Population	Classic	No	Survey	Yes	No	Issue/Solution

64	Daziano, R. A., Waygood, E. O. D., Patterson, Z., & Kohlová, M. B. (2017). Increasing the influence of CO2 emissions information on car purchase. Journal of cleaner production, 164, 861-871.	Yes		No	USonly	Population	Classic	No	Survey	No	No	Re-Labelling
65	Huber, R. A., Anderson, B., & Bernauer, T. (2018). Can social norm interventions promote voluntary pro environmental action?. Environmental science & policy, 89, 231-246.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Moral/Value/ Attribution/Norm
66	Aklin, M., & Urpelainen, J. (2014). Perceptions of scientific dissent undermine public support for environmental policy. Environmental Science & Policy, 38, 173-177.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Consensus/Uncertainty
67	Bernauer, T., & Gampfer, R. (2015). How robust is public support for unilateral climate policy?. Environmental Science & Policy, 54, 316-330.	Yes		Yes	USandOthers	Population	Classic	No	Survey	No	No	Issue/Solution
68	Bimonte, S., Bosco, L., & Stabile, A. (2020). Nudging pro-environmental behavior: evidence from a web experiment on priming and WTP. Journal of Environmental Planning and Management, 63(4), 651-668.	Yes		No	Others	Convenient	Classic	No	Survey	No	No	Issue/Solution
69	Severson, A. W., & Coleman, E. A. (2015). Moral frames and climate change policy attitudes. Social Science Quarterly, 96(5), 1277-1290.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Moral/Value/ Attribution/Norm

70	Schuldt, J. P., Roh, S., & Schwarz, N. (2015). Questionnaire design effects in climate change surveys: Implications for the partisan divide. The ANNALS of the American Academy of Political and Social Science, 658(1), 67-85.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Re-Labelling
71	Bolsen, T., Leeper, T. J., & Shapiro, M. A. (2014). Doing what others do: Norms, science, and collective action on global warming. American Politics Research, 42(1), 65-89.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	0.5 Moral/Value/ Attribution/Norm + 0.5 Consensus/Uncertainty
72	Feinberg, M., & Willer, R. (2011). Apocalypse soon? Dire messages reduce belief in global warming by contradicting just-world beliefs. Psychological science, 22(1), 34-38.	Yes	Yes	NO	USonly	Convenient	Classic	Yes	Survey and Lab	No	No	Moral/Value/ Attribution/Norm
73	Saunders, K. L. (2017). The impact of elite frames and motivated reasoning on beliefs in a global warming conspiracy: The promise and limits of trust. Research & Politics, 4(3), 2053168017717602.		Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Re-Labelling
74	Hardisty, D. J., Johnson, E. J., & Weber, E. U. (2010). A dirty word or a dirty world? Attribute framing, political affiliation, and query theory. Psychological Science, 21(1), 86-92.	No	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	Re-Labelling
75	Parag, Y., Capstick, S., & Poortinga, W. (2011). Policy attribute framing: A comparison between three policy instruments for personal emissions reduction. Journal of Policy Analysis and Management, 30(4), 889-905.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Re-Labelling

76	Vainio, A., Irz, X., & Hartikainen, H. (2018). How effective are messages and their characteristics in changing behavioural intentions to substitute plant-based foods for red meat? The mediating role of prior beliefs. Appetite, 125, 217-224.	Yes	Yes	No	Others	Population	Classic	No	Survey	Yes	No	Issue/Solution
77	Bernauer, T., Gampfer, R., & Kachi, A. (2014). European unilateralism and involuntary burden-sharing in global climate politics: A public opinion perspective from the other side. European Union Politics, 15(1), 132-151.	Yes		Yes	USandOthers	Population	Classic	No	Survey	Yes	No	Issue/Solution
78	Wolsko, C., Ariceaga, H., & Seiden, J. (2016). Red, white, and blue enough to be green: Effects of moral framing on climate change attitudes and conservation behaviors. Journal of Experimental Social Psychology, 65, 7-19.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Moral/Value/ Attribution/Norm
79	Bolsen, T., Druckman, J. N., & Cook, F. L. (2014). Communication and collective actions: a survey experiment on motivating energy conservation in the US. Journal of Experimental Political Science, 1(1), 24-38.	Yes		No	USonly	Population	Classic	No	Survey	No	No	0.5 Moral/Value/ Attribution/Norm + 0.5 Issue/Solution
80	Baumer, E. P., Polletta, F., Pierski, N., & Gay, G. K. (2017). A simple intervention to reduce framing effects in perceptions of global climate change. Environmental Communication, 11(3), 289-310.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Re-Labelling

81	Hart, P. S., & Nisbet, E. C. (2012). Boomerang effects in science communication: How motivated reasoning and identity cues amplify opinion polarization about climate mitigation policies. Communication research, 39(6), 701-723.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Psychological Distance
82	Van der Linden, S. (2015). The conspiracy-effect: Exposure to conspiracy theories (about global warming) decreases pro-social behavior and science acceptance. Personality and Individual Differences, 87, 171-173.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Issue/Solution
83	Bolsen, T., & Druckman, J. N. (2018). Do partisanship and politicization undermine the impact of a scientific consensus message about climate change?. Group Processes & Intergroup Relations, 21(3), 389-402.	Yes	Yes	No	USonly	Population	Classic	No	Survey	Yes	Yes	Consensus/Uncertainty
84	Kahan, D. M., Jenkins-Smith, H., Tarantola, T., Silva, C. L., & Braman, D. (2015). Geoengineering and climate change polarization: Testing a two-channel model of science communication. The ANNALS of the American Academy of Political and Social Science, 658(1), 192-222.	Yes	Yes	Yes	USandOthers	Population	Classic	No	Survey	No	No	Issue/Solution
85	Mildenberger, M., & Tingley, D. (2019). Beliefs about climate beliefs: the importance of second-order opinions for climate politics. British Journal of Political Science, 49(4), 1279-1307.	Yes		No	USonly	Population	Classic	No	Survey	No	Yes	Consensus/Uncertainty

86	Schuldt, J. P., Konrath, S. H., & Schwarz, N. (2011). "Global warming" or "climate change"? Whether the planet is warming depends on question wording. Public opinion quarterly, 75(1), 115-124.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Re-Labelling
87	Myers, T. A., Maibach, E., Peters, E., & Leiserowitz, A. (2015). Simple messages help set the record straight about scientific agreement on human-caused climate change: The results of two experiments. PloS one, 10(3).	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	Re-Labelling
88	Dickinson, J. L., Crain, R., Yalowitz, S., & Cherry, T. M. (2013). How framing climate change influences citizen scientists' intentions to do something about it. The Journal of Environmental Education, 44(3), 145-158.	Yes	No	No	USonly	Population	Classic	No	Survey	No	No	Issue/Solution
89	Hart, P. S., & Feldman, L. (2016). The impact of climate change–related imagery and text on public opinion and behavior change. Science Communication, 38(4), 415-441.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Re-Labelling
90	Jones, M. D., & Song, G. (2014). Making sense of climate change: How story frames shape cognition. Political Psychology, 35(4), 447-476.	Yes	Yes	No	USonly	Convenient	Classic	Yes	Survey	No	No	0.5 Moral/Value/ Attribution/N orm + 0.5 Issue/Solution
91	Nisbet, E. C., Hart, P. S., Myers, T., & Ellithorpe, M. (2013). Attitude change in competitive framing environments? Open-/closed-mindedness, framing effects, and climate change. Journal of Communication, 63(4), 766-785.	Yes	Yes	No	USonly	Population	Classic	No	Survey	Yes	No	Issue/Solution

92	Sapiains, R., Beeton, R. J., & Walker, I. A. (2016). Individual responses to climate change: Framing effects on pro-environmental behaviors. Journal of Applied Social Psychology, 46(8), 483-493.	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Issue/Solution
93	Aklin, M., Cheng, C. Y., & Urpelainen, J. (2018). Social acceptance of new energy technology in developing countries: A framing experiment in rural India. Energy Policy, 113, 466-477.	Yes	No	Yes	Others	Population	Classic	No	Survey	No	No	Issue/Solution
94	Spence, A., Leygue, C., Bedwell, B., & O'Malley, C. (2014). Engaging with energy reduction: Does a climate change frame have the potential for achieving broader sustainable behaviour?. Journal of Environmental Psychology, 38, 17-28.	Yes	No	No	Others	Convenient	Classic	No	Survey	No	No	Issue/Solution
95	Gifford, R., & Comeau, L. A. (2011). Message framing influences perceived climate change competence, engagement, and behavioral intentions. Global Environmental Change, 21(4), 1301-1307.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution
96	Schoenefeld, J. J., & McCauley, M. R. (2016). Local is not always better: the impact of climate information on values, behavior and policy support. Journal of Environmental Studies and Sciences, 6(4), 724-732.	Yes	No	No	USonly	Convenient	Classic	No	Survey	No	No	Psychological Distance

97	Attari, S. Z., Krantz, D. H., & Weber, E. U. (2019). Climate change communicators' carbon footprints affect their audience's policy support. Climatic Change, 154(3-4), 529-545.	Yes	No	No	USonly	Convenient	Classic	No	Survey	No	Yes	Moral/Value/ Attribution/Norm
98	Rinscheid, A., Pianta, S., & Weber, E. U. (2020). What shapes public support for climate change mitigation policies? The role of descriptive social norms and elite cues. Behavioural Public Policy, 1-25.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	0.5 Moral/Value/ Attribution/Norm + 0.5 Source Cue
99	Schuldt, J. P., & Roh, S. (2014). Of accessibility and applicability: how heat-related cues affect belief in "global warming" versus "climate change". Social Cognition, 32(3), 217-238.	Yes	Yes	Yes	USonly	Convenient	Classic	No	Field	No	No	Re-Labelling
100	Shwom, R., Dan, A., & Dietz, T. (2008). The effects of information and state of residence on climate change policy preferences. Climatic Change, 90(4), 343.	No	Yes	Yes	USonly	Convenient	Classic	No	Survey	No	No	Psychological Distance
101	Brügger, A., Morton, T. A., & Dessai, S. (2016). "Proximising" climate change reconsidered: A construal level theory perspective. Journal of Environmental Psychology, 46, 125-142.	No	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Psychological Distance
102	Lachapelle, E., Montpetit, É., & Gauvin, J. P. (2014). Public perceptions of expert credibility on policy issues: The role of expert framing and political worldviews. Policy Studies Journal, 42(4), 674-697.	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Consensus/Uncertainty

103	Dür, A. (2019). How interest groups influence public opinion: Arguments matter more than the sources. European journal of political research, 58(2), 514-535.	Yes	Yes	Yes	USandOthers	Population	Classic	No	Survey	Yes	Yes	Source Cue
104	Wong-Parodi, G., & Fischhoff, B. (2015). The impacts of political cues and practical information on climate change decisions. Environmental Research Letters, 10(3), 034004.	Yes	Yes	No	USonly	Convenient	Classic	Yes	Survey	No	No	0.5 Issue/Solution + 0.5 Psychological Distance
105	R. A. Huber, L. Fesenfeld, T. Bernauer (2020), Political Populism, Responsiveness, and Public Support for Climate Mitigation. Clim. Policy .	Yes		No	USonly	Population	Classic	No	Survey	No	Yes	Moral/Value/ Attribution/Norm
106	Hurlstone MJ, Lewandowsky S, Newell BR, Sewell B (2014) The Effect of Framing and Normative Messages in Building Support for Climate Policies. PLoS ONE 9(12): e114335. https://doi.org/10.1371/journal.pone.0114335	Yes		No	Others	Convenient	Classic	No	Survey	No	Yes	0.5 Moral/Value/ Attribution/Norm + Issue/Solution
107	Gregg Sparkman and Shahzeen Z. Attari (2020) Credibility, communication, and climate change: How lifestyle inconsistency and do-gooder derogation impact decarbonization advocacy. Energy Research & Social Science, 59. https://doi.org/10.1016/j.erss.2019.101290	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	Source Cue

108	Jillian L.Goldfarb, Marric Buessing and Douglas L.Kriner (2016): Geographic proximity to coal plants and U.S. public support for extending the Production Tax Credit. Energy Policy. https://doi.org/10.1016/j.enpol.2016.03.029	No	Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Issue/Solution
109	M.V. Mossler, A. Bostrom, R.P. Kelly, K.M. Crosman, P. Moy. How does framing affect policy support for emissions mitigation? Testing the effects of ocean acidification and other carbon emissions frames. Glob. Environ. Change, 45 (2017), pp. 63-78	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	No	Issue/Solution
110	Bertolotti, Mauro, Patrizia Catellani. 2014. 'Effects of message framing in policy communication on climate Change'. European Journal of Social Psychology 44(5): 474-486. https://doi.org/10.1002/ejsp.2033	Yes	Yes	No	Others	Convenient	Classic	No	Survey	No	No	Issue/Solution
111	Bertolotti, Mauro, Patrizia Catellani. 2015. 'Agreement with climate change policies: Framing the future and national versus supranational identity'. European Journal of Social Psychology 45(7): 847-857.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	Issue/Solution
112	P. Sol Hart, Lauren Feldman. 2018. 'Would it be better to not talk about climate change? The impact of climate change and air pollution frames on support for regulating power plant emissions' Journal of Environmental Psychology 60: 1-8. https://doi.org/10.1016/j.jenvp.2018.08.013.	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	No	Issue/Solution

113	Dean, Angela J., Kelly S. Fielding, Kerrie A. Wilson. 2019. 'Building community support for coastal management — What types of messages are most effective?' Environmental Science & Policy 92: 161-169. https://doi.org/10.1016/j.envsci.2018.11.026.	Yes	Yes	No	Others	Population	Classic	No	Survey	No	No	0.5 Moral/Value/ Attribution/Norm + Issue/Solution
114	Walker, B. J. A., Kurz, T., & Russel, D. 2018. Towards an understanding of when non-climate frames can generate public support for climate change policy. Environment and Behavior, 50(7), 781–806. https://doi.org/10.1177/0013916517713299	Yes	No	No	Others	Convenient	Classic	No	Survey	No	No	Issue/Solution
115	DeGolia AH, Hiroyasu EHT, Anderson SE (2019) Economic losses or environmental gains? Framing effects on public support for environmental management. PLoS ONE 14(7): e0220320. https://doi.org/10.1371/journal.pone.0220320	Yes	Yes	No	USonly	Population	Classic	No	Survey	No	Yes	Issue/Solution
116	A.M. McCright, M. Charters, K. Dentzman, T. Dietz. 2016. 'Examining the effectiveness of climate change frames in the face of a climate change denial counter-frame'. Topics in Cognitive Science 8: 76-97.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	Yes	No	Issue/Solution
117	Morton, Thomas A., Anna Rabinovich, Dan Marshall, Pamela Bretschneider. 2011 'The future that may (or may not) come: How framing changes responses to uncertainty in climate change communications', Global Environmental Change, bind 21, nr. 1, s. 103-109.	Yes		No	Others	Convenient	Classic	No	Survey	No	No	0.5 Psychological Distance + 0.5 Issue/Solution

118	Benjamin J.A.Walker, Bouke Wiersma & Etienne Bailey. 2014. 'Community benefits, framing and the social acceptance of offshore wind farms: An experimental study in England'. Energy Research & Social Science: 3. https://doi.org/10.1016/j.erss.2014.07.003	Yes		No	Others	Population	Classic	No	Survey	Yes	No	Issue/Solution
119	Hornsey, Matthew J., Kelly S. Fielding, Ryan McStay, Joseph P. Reser, Graham L. Bradley, Katharine H. Greenaway. 2015. 'Evidence for motivated control: Understanding the paradoxical link between threat and efficacy beliefs about climate change' Journal of Environmental Psychology 42: 57-65.E117 https://doi.org/10.1016/j.jenvp.2015.02.003.	Yes		No	USonly	Population	Classic	No	Survey	No	No	Psychological Distance
120	Hardisty, David J., Alec T. Beall, Ruben Lubowski, Annie Petsonk, Rainer Romero-Canyas. 2019. "A carbon price by another name may seem sweeter: Consumers prefer upstream offsets to downstream taxes" Journal of Environmental Psychology: 66. https://doi.org/10.1016/j.jenvp.2019.101342.	Yes	Yes	No	USonly	Convenient	Classic	No	Survey	No	Yes	Re-Labelling
121	Ahn, S. J. (Grace), Fox, J., Dale, K. R., & Avant, J. A. (2015). Framing Virtual Experiences: Effects on Environmental Efficacy and Behavior Over Time. Communication Research, 42(6), 839–863.	Yes	No	No	USonly	Convenient	Classic	Yes	Lab	No	No	0.5 Psychological Distance + 0.5 Issue/Solution

SI-Section IV: Results LASSOplus re-analysis

SI-Table 3: ID17: (Stokes and Warshaw 2017)

	Mean	50%	2.5%	97.5%	outcome
Democrat	0.228	0.234	0	0.332	billsup
age	-0.006	-0.006	-0.009	-0.004	billsup
edu	0.049	0.053	0	0.081	billsup
Randomization2b: Control	0.143	0.164	0	0.275	billsup
Randomization2b: Increase costs $10 per month	-0.101	-0.125	-0.257	0	billsup

SI-Table 4: ID35 (Christenson and Goldfarb 2017)

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.492	-0.491	-0.7	-0.29	DVfrackingsupport
Democrat	0.725	0.725	0.513	0.945	DVfrackingsupport
white	-0.372	-0.37	-0.514	-0.232	DVfrackingsupport
male	0.105	0.118	0	0.281	DVfrackingsupport
treat: benefits	0.124	0.132	0	0.342	DVfrackingsupport

	Mean	50%	2.5%	97.5%	outcome
Democrat	0.276	0.277	0.197	0.348	DVfrackingsupport2
age	0.002	0.002	0	0.003	DVfrackingsupport2
male	0.118	0.118	0.079	0.159	DVfrackingsupport2
treat: benefits	0.101	0.104	0	0.155	DVfrackingsupport2

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.285	-0.285	-0.404	-0.155	DVfrackingsupport3
Democrat	0.405	0.404	0.277	0.539	DVfrackingsupport3
white	-0.211	-0.211	-0.297	-0.122	DVfrackingsupport3
male	0.079	0.094	0	0.185	DVfrackingsupport3
treat: benefits	0.139	0.156	0	0.246	DVfrackingsupport3

SI-Table 5: ID41 (Singh and Swanson 2017)

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.482	-0.543	-1.223	0	importance_climate
ideology	-0.389	-0.39	-0.465	-0.316	importance_climate

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.271	-0.279	-0.764	0	rank_climate_rev
ideology	-0.213	-0.213	-0.263	-0.164	rank_climate_rev

SI-Table 6: ID57 (Schuldt, Enns and Cavaliere 2017)

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.137	-0.147	-0.268	0	ccgwhappeningbin
Democrat	0.092	0.085	0	0.253	ccgwhappeningbin

SI-Table 7: ID71:[1] (Bolsen, Leeper and Shapiro 2014)

	Mean	50%	2.5%	97.5%	outcome
treat: condescriptive	-0.062	-0.015	-0.215	0	ce_ppi

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.289	-0.295	-0.451	0	global_warming

[1] No non-zero estimates found for the outcome: ce_er

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.236	-0.248	-0.4	0	human_induced

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.209	-0.223	-0.378	0	smallercar

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.231	-0.242	-0.391	0	support_cap

	Mean	50%	2.5%	97.5%	outcome
age	0.011	0.011	0	0.017	EmissionCap
liberal	0.181	0.18	0.126	0.235	EmissionCap

	Mean	50%	2.5%	97.5%	outcome
liberal	0.148	0.148	0.092	0.208	GWBelief

	Mean	50%	2.5%	97.5%	outcome
liberal	0.111	0.115	0	0.178	GWHuman

	Mean	50%	2.5%	97.5%	outcome
Republican	-0.058	-0.024	-0.178	0	PersonalAction
age	0.01	0.011	0	0.017	PersonalAction
female	0.113	0.115	0.05	0.167	PersonalAction
liberal	0.087	0.095	0	0.153	PersonalAction

SI-Table 8: ID73: (Saunders 2017)

	Mean	50%	2.5%	97.5%	outcome
Republican	0.442	0.434	0.182	0.76	ccgwishoax
Democrat	-0.45	-0.459	-0.704	-0.164	ccgwishoax
age	0.003	0.004	0	0.006	ccgwishoax
educ: alt	-0.168	-0.18	-0.298	0	ccgwishoax
age x treat: ClimateChange	-0.005	-0.006	-0.012	0	ccgwishoax

SI-Table 9: ID74:[2] (Hardisty, Johnson and Weber 2010)

	Mean	50%	2.5%	97.5%	outcome
treat: tax	-0.161	-0.164	-0.264	0	co_avg

	Mean	50%	2.5%	97.5%	outcome
Democrat	0.412	0.397	0	1.238	mm_avg
Republican	-0.376	-0.253	-1.25	0	mm_avg
treat: tax	-0.817	-0.824	-1.288	-0.271	mm_avg
AGE x treat: tax	0.028	0.029	0	0.069	mm_avg

	Mean	50%	2.5%	97.5%	outcome
treat: tax	-0.509	-0.518	-0.826	-0.13	ps_avg

	Mean	50%	2.5%	97.5%	outcome
treat: tax	-0.063	-0.041	-0.209	0	choice

[2] No non-zero estimates found for the outcomes: cr_avg

	Mean	50%	2.5%	97.5%	outcome
treat: tax	-0.305	-0.277	-0.938	0	mand

	Mean	50%	2.5%	97.5%	outcome
treat: tax	-0.317	-0.279	-0.967	0	pref

SI-Table 10: ID83 (Bolsen and Druckmann 2018)

	Mean	50%	2.5%	97.5%	outcome
Democrat	1.417	1.415	1.248	1.584	ccexphuman
knowdummy	0.229	0.251	0	0.459	ccexphuman

	Mean	50%	2.5%	97.5%	outcome
Democrat	0.275	0.275	0.241	0.31	policy

	Mean	50%	2.5%	97.5%	outcome
Democrat	0.233	0.234	0.168	0.3	scienceagree
knowdummy	0.111	0.116	0	0.183	scienceagree
inform	0.062	0.055	0	0.186	scienceagree

SI-Table 11: ID86 (Schuldt, Konrath and Schwarz 2011)

	Mean	50%	2.5%	97.5%	outcome
Democrat	0.526	0.527	0.288	0.773	gwcchappen
Republican	-1.071	-1.071	-1.311	-0.836	gwcchappen
female	0.12	0.131	0	0.321	gwcchappen
educ	0.218	0.218	0.149	0.289	gwcchappen
treat: climatechange	0.222	0.235	0	0.382	gwcchappen
Republican x treat: climatechange	0.329	0.377	0	0.809	gwcchappen

SI-Table 12: ID115 (DeGolia and Hiroyaus)

No non-zero estimates.

SI-Section V: Survey with authors of reviewed framing experiments

Start of Block: 1. Section: Introduction/consent form

Dear participant,

Welcome to the survey. We appreciate your contribution very much. This survey will only take less than three minutes and contains five brief questions about your experience with running framing experiments with respect to climate and environmental issues. It is being carried out for a research project at ETH Zurich.

Please read the following consent statement carefully. If you choose to participate in this survey, please check the box “I have read and understood the consent form and agree to participate in this survey.” If you choose not to participate, please click on the “Cancel” button at the bottom of this page and leave the survey.

Consent statement: "The survey is solely for scientific purposes. It has no commercial or government-related purpose. There are no known risks for participants in this survey, nor any costs. The information you provide in this survey will not be stored or used in any way that could reveal your personal identity."

- ○ I have read and understood the consent form and agree to participate in this survey
- ○ Cancel

Page Break

End of Block: 1. Section: Introduction consent form

Start of Block: 2. Section: Experience

Have you ever conducted (emphasis) framing experiments with respect to climate and environmental issues that identified non-significant effects?

- ○ No
- ○ Yes

Page Break

Have you ever submitted experimental (emphasis) framing studies that you conducted with respect to climate and environmental issues to peer-reviewed journals that identified non-significant effects?

- ○ No
- ○ Yes

Page Break

Approximately how many of all experimental (emphasis) framing studies that you have conducted with respect to climate and environmental issues and that identified non-significant effects did/did not get published in peer-reviewed journals?

- ○ Approximate number of studies showing non-significant effects that did get published in peer-reviewed journals _____
- ○ Approximate number of studies showing non-significant effects that did not get published in peer-reviewed journals _____

Page Break

End of Block: 2. Section: Experience

Start of Block: 3. Section: General Information

We would be grateful if you could briefly share with us your general experience with publishing (emphasis) framing experiments with respect to environmental and climate issues. We are especially interested into your experience about publishing non-significant effects.

_____
_____
_____
_____
_____

Page Break

What is your current academic position?

- ○ Full Professor
- ○ Associate Professor
- ○ Assistant Professor
- ○ Senior Researcher
- ○ Postdoc
- ○ PhD student
- ○ Other

Page Break

Thank you very much for answering the short questionnaire! We appreciate your support a lot. Please click once more to leave the survey.

Figures

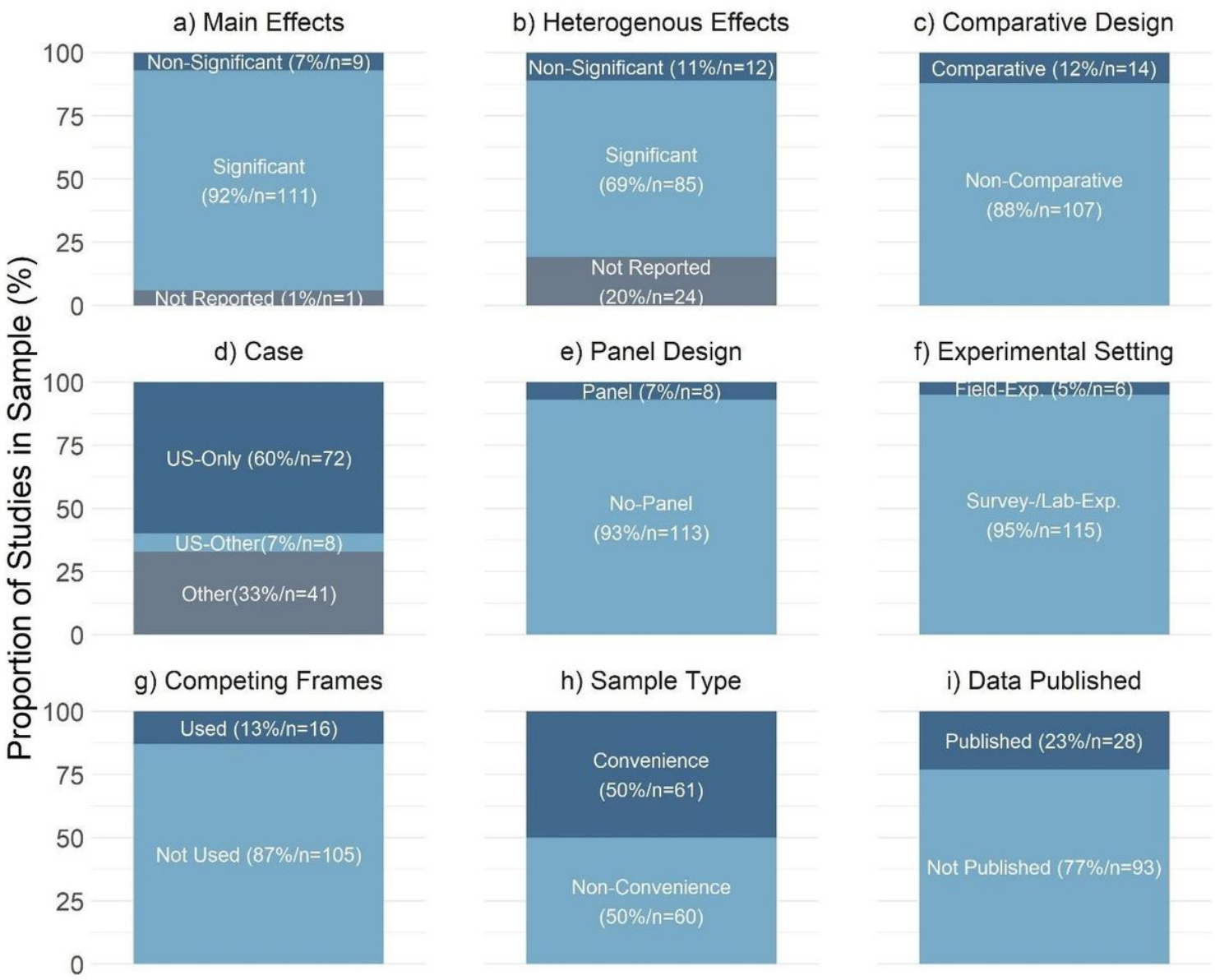


Figure 1

Overview of 121 framing experimental studies in the field of climate and environmental politics, economics and psychology published between 2007 and 2020.

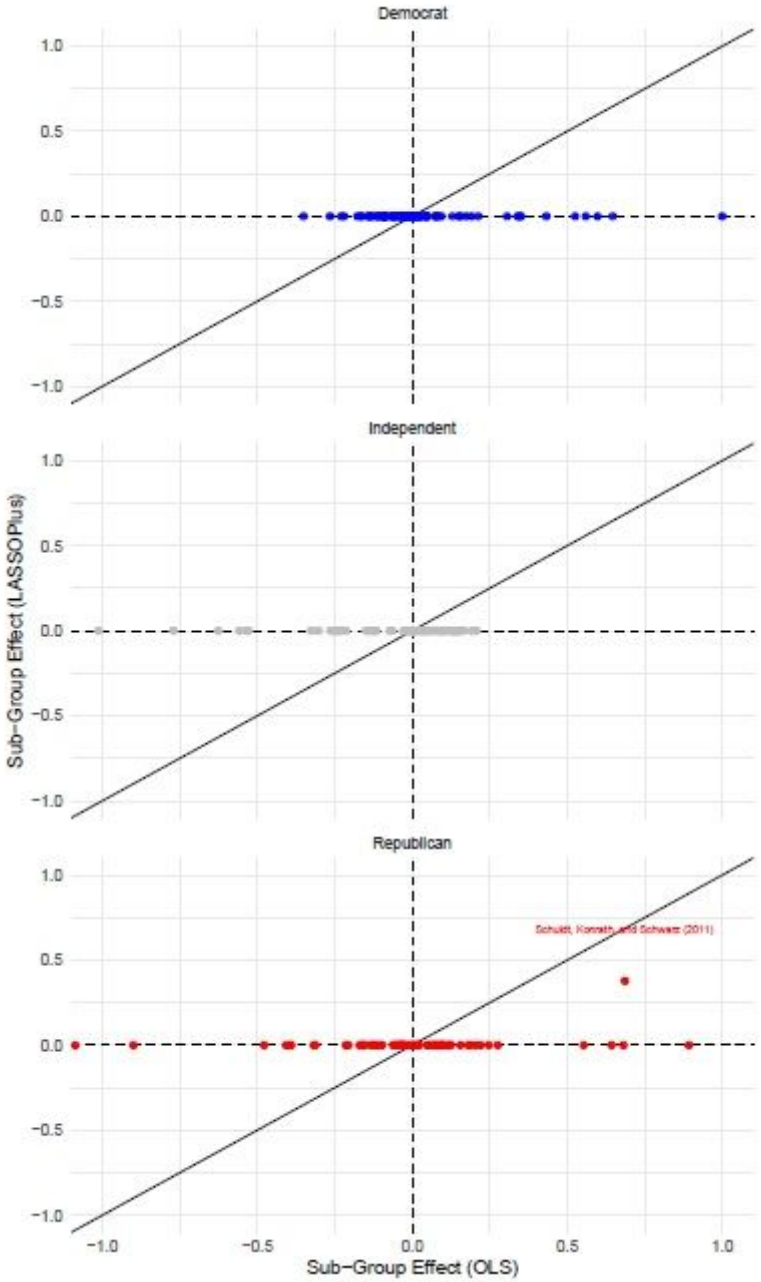


Figure 2

Partisan Sub-Group effects are not robust. Points indicate estimated treatment effects for sub-group framing effects by partisanship. The y-axis displays the estimated sub-group treatment effects estimated using LASSOplus that allows for all possible covariate interactions. The x-axis displays the estimated sub-group effects when estimated using OLS and not allowing for covariate interactions, equivalent to a difference-in-means tests. The solid black line displays the 45 degree line, with points falling on this indicating identical estimates for the different methods of estimating sub-group effects.