Reasoning about Climate Change

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Reasoning about climate change

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Abstract

Why is disbelief in anthropogenic climate change widespread despite broad scientific consensus to the contrary? A widely-held explanation involves politically motivated (“system 2”) reasoning: Rather than helping uncover truth, people use their reasoning abilities to protect their partisan identities and reject beliefs that threaten those identities. Despite the popularity of this account, the evidence supporting it (i) does not account for the fact that partisanship is confounded with prior factual beliefs, and (ii) is entirely correlational with respect to the effect of reasoning. Here, we address these shortcomings by (i) measuring prior factual beliefs and (ii) experimentally manipulating participants’ extent of reasoning using cognitive load and time pressure while they evaluate arguments for or against anthropogenic global warming. The results challenge the politically motivated system 2 reasoning account: Rather than exacerbating the impact of partisanship per se, engaging in more reasoning led people to have greater coherence between judgments and their prior factual beliefs about climate change - a process that can be consistent with rational (unbiased) Bayesian reasoning. Thus, we challenge the dominant cognitive account of climate disbelief, and suggest that interventions aimed at providing accurate information about climate change may be effective in the long run.

Skepticism amongst the public about climate change and its human origins represents a major impediment to the adoption of sensible policy ¹⁻³. One of the most commonly cited reasons for climate change denial is political partisanship or ideologies ⁴. In the US, for example, people on the political right are more likely to believe that climate change is a hoax or that it is not caused by human activities ^{2,5-8}. What is more, people with greater numerical ability and cognitive sophistication show *increased* partisan differences in climate change beliefs, rather than greater agreement with the scientific consensus ⁹⁻¹³. That is, having stronger cognitive ability appears to not protect against climate misperceptions; rather it may serve to bolster views that align with one's political identities.

The most popular explanation of this result is provided by the identity-protective cognition framework ^{11,14-16}. This framework employs a dual process perspective ¹⁷⁻¹⁹, which distinguishes between two types of reasoning process: intuition ("System 1") and deliberation ("System 2"). While intuition is considered a low-effort, quick, automatic response to stimuli, deliberation is a more effortful, time-consuming process. The identity-protective cognition framework asserts that cognitive abilities are linked to greater polarization because deliberation facilitates motivated reasoning: When faced with new evidence, engaging in deliberation better allows one to discredit the evidence if it is not congenial to one's identity and partisan commitments. As a result, there are large partisan differences in what evidence is deemed credible, eventually leading to substantial polarization in beliefs. In the language of dual-process theory, deliberative reasoning processes are triggered to rationalize or justify identity-consistent intuitive impulses. In the context of climate change, this would mean that deliberation leads Republicans to reject evidence in favor of climate change (to protect their partisan identity), while deliberation leads Democrats to reject evidence questioning climate change ^{10,11,20-23}. If more cognitively sophisticated people engage in more deliberation, they will be better at aligning their judgments of evidence about climate change with their respective political identities.

This theory has enormous practical importance because, if it is true, common strategies such as educating people, or making them more reflective, will not be effective against climate change denial. In fact, such strategies will only serve to *increase* partisan differences ^{10,23,24} (although there is evidence questioning this assumption^{25,26}). Furthermore, from a theoretical perspective, this "motivated system 2 reasoning" account stands in stark contrast to the typical dual-process perspective - the "classical reasoning" view - whereby System 2 reasoning typically helps facilitate accuracy in a variety of decision-making tasks ^{18,27}. Put differently, the classical reasoning account posits that when people engage in deliberation, they tend to form more accurate beliefs, regardless of the partisan- or identity-alignment of the propositions they are deliberating about ²⁸.

However, there are two serious limitations of the prior empirical research that has been used to support the identity-protective motivated system 2 reasoning account. First, this work does not actually allow for the identification of politically motivated reasoning without making strong assumptions, because political identity is confounded with - but meaningfully

separable from - people's prior factual beliefs about climate change ²⁹. In particular, Democrats are much more likely to believe that climate change is caused by human activity than Republicans, such that partisanship and prior factual beliefs are correlated - yet many (even most) Republicans do believe in anthropogenic climate change, and some Democrats do not, such that partisanship and priors are meaningfully distinct. For example, a recent Pew survey found that 53% of conservative Republicans believe that human activity contributes to global warming to at least some degree, while 8% of moderate Democrats think it does not ⁵. Yet most studies claiming to provide evidence of politically motivated reasoning have not measured these prior factual beliefs. This is highly problematic ²⁹⁻³¹, as convincing evidence of politically motivated reasoning must show that partisanship *per se* influences information evaluation, above and beyond the influence of prior factual beliefs about the specific topic. Although partisanship might influence prior factual beliefs, many other factors also contribute to factual beliefs, such as who people judge trustworthy as well as family environment or life experiences ¹²; and prior factual beliefs may also influence partisanship. Thus effects driven by prior factual beliefs do not provide compelling evidence for politically motivated reasoning.

Indeed, Tappin et al. ²⁹ find that controlling for prior beliefs related to climate change nullifies the correlation between cognitive sophistication and partisan bias in one very influential paradigm for studying motivated system two reasoning and climate change. Instead, increased cognitive reflection was associated with placing greater emphasis on prior factual beliefs when evaluating new information. While evaluating new evidence in light of prior beliefs is sometimes called "confirmation bias", in fact such evaluation can be entirely rational and unbiased from a Bayesian perspective when there is uncertainty about the reliability of sources ³²⁻³⁵: When considering evidence that is inconsistent with your prior factual beliefs, it can be rational to conclude that it is more likely that (i) the information source is unreliable than that (ii) the accumulation of all your prior knowledge is wrong. For example, if a stranger tells you that he was abducted by aliens, is it not irrational to conclude that that information is probably unreliable. Thus, it is essential to account for prior factual beliefs when attempting to test for politically motivated reasoning.

Second, past research on motivated system 2 reasoning has relied upon correlating individual differences in cognitive sophistication (e.g. cognitive reflection, numeracy, education) with the extent of partisan differences on politicized issues ^{9,11,36}. Although it is generally thought that people scoring higher on cognitive sophistication scales are better at deliberation than people scoring lower on these scales, they also tend to differ in many other aspects. For example, they tend to generate different intuitions on many reasoning tasks ^{37,38}. Thus, because this approach is correlational, it does not allow for the direct identification of causal effects of deliberation on polarization versus accuracy.

Current research

In the current research, we address both of these limitations. We measure prior factual beliefs about climate change by asking how serious a risk participants believe climate change to be, and how much they agree that human activity causes climate change. And we provide a causal test of the role of intuition and deliberation on how people evaluate pro- and contra-arguments regarding climate change by forcing some participants to make judgments under cognitive load and time pressure.

This allows us to shed new light on competing accounts of the role of deliberation in argument evaluation surrounding climate change: Does deliberation magnify partisan bias, consistent with the identity protective cognition ¹¹? Or does it facilitate accurate assessments or normatively rational evidence evaluation, consistent with a more classical perspective on reasoning ^{28,29,35}? Furthermore, we specify the classical reasoning account more precisely than in prior work. Previous research (e.g. studying blatantly false political news posts; ²⁸) has argued that the classical reasoning approach simply predicts that more deliberation will lead to increased objective accuracy, defined here as holding a position more consistent with the scientific consensus on climate change. However, most people do not actually have direct access to the information needed to know the objectively accurate answer, particularly in the context of extremely complicated technical issues like climate change. Thus, the classical reasoning account would not necessarily predict that deliberation leads to more objectively accurate views. Instead, accuracy-motivated deliberation may lead to improved coherence between one's existing directly relevant factual beliefs and the stimuli being presented. That is, deliberation may increase the extent to which one evaluates whether new information makes sense in light of the relevant factual belief that one has developed based on all previous information one has encountered (a process that, as discussed above, can be consistent with unbiased, rational Bayesian updating ³²⁻³⁵). In this case, deliberation should magnify differences based on prior factual beliefs - but *not* differences based on political identities *per se*. This is an essential distinction, because although partisanship and prior factual beliefs are correlated, they are still quite distinct. As reported in more detail below, for example, in our dataset a majority of Republicans do believe in anthropogenic climate change, and some Democrats do not. Thus, it is essential to disentangle the impact of factual prior beliefs from partisanship ³¹.

In our experiment, we asked participants to indicate how much they agreed with politically neutral arguments about climate change (meaning that there were no references in them to specific policies or to politics in any way). Arguments were content counter-balanced, such that for each statement we created a pro and contra version, one of which was randomly assigned to a given participant; participants never saw both the pro and contra version of the same argument. Table 1 shows a pro and contra version of an example item from our experiment (for a complete set of statements, see Supplementary Materials Section A).

Table 1. Table shows an example of the argument items we used in this experiment.

Pro climate change	Contrary to climate change
<p>Average temperatures on earth have increased at a rate far faster than can be explained by natural climate changes. A 2008 study compared data from tree rings, ice cores, and corals over the past millennium with recent temperature records. The study created the famous "hockey stick" graph, showing that the rise in earth's temperature over the preceding decade had occurred at a rate faster than any warming period over the last 1,700 years. In 2012 the Berkeley scientists found that the average temperature of the earth's land increased 2.5°F over 250 years (1750-2000), with 1.5°F of that increase in the last 50 years.</p> <p>Lead researcher Richard A. Muller, PhD, said "it appears likely that essentially all of this increase [in temperature] results from the human emission of greenhouse gases." In 2013, a surface temperature study published in Science found that global warming over the past 100 years has proceeded at a rate faster than at any time in the past 11,300 years. According to the IPCC's 2014 Synthesis Report, human actions are "extremely likely" (95-100% confidence) to have been the main cause of 20th century global warming, and the surface temperature warming since the 1950s is "unprecedented over decades to millennia."</p>	<p>Earth's climate has always warmed and cooled, and the 20th century rise in global temperature is within the bounds of natural temperature fluctuations over the past 3,000 years. Although the planet has warmed 1-1.4°F over the 20th century, it is within the +/- 5°F range of the past 3,000 years. A 2003 study by researchers at the Harvard-Smithsonian Center for Astrophysics found that "many records reveal that the 20th century is probably not the warmest nor a uniquely extreme climatic period of the last millennium."</p> <p>A 2005 study published in Nature found that "high temperatures - similar to those observed in the twentieth century before 1990 - occurred around AD 1000 to 1100" in the Northern Hemisphere. A 2013 study published in Boreas found that summer temperatures during the Roman Empire and Medieval periods were "consistently higher" than temperatures during the 20th century. According to a 2010 study in the Chinese Science Bulletin, the recent global warming period of the 20th century is the result of a natural 21-year temperature oscillation, and will give way to a "new cool period in the 2030s."</p>

Since this is a novel way to measure belief in climate change, we started by conceptually replicating prior correlational results regarding cognitive sophistication (the extent to which people are able and willing to engage in deliberation, as measured by the Cognitive Reflection Test) and belief in climate change (see SI Section B). Consistent with prior work (Tappin et al., 2020a), we found that (i) cognitive sophistication is associated with politically polarized evaluations of our climate change measures, but (ii) accounting for differences in prior factual beliefs about climate change nullifies this interaction between cognitive sophistication and political partisanship, and instead more cognitive sophisticated participants actually condition their judgments on coherence with prior factual beliefs rather than partisanship per se.

In our main experiment, we recruited 1157 American participants from Lucid (quota matched to the national distribution on age, gender, ethnicity and geographic region) and experimentally induced intuitive responding for randomly selected participants to provide a *causal* test of the role of intuition versus deliberation on climate argument evaluation. We used a two response paradigm in which participants were presented with the same argument twice. First, they were asked to give a quick and intuitive response. Deliberation is highly dependent on available working memory capacities, and tends to take more time (compared to intuitive responses^{17,39}). Hence, to minimize the extent of deliberation, we applied a working memory load and a strict response deadline (28 sec)¹. After participants gave a response, they were re-presented with the argument and asked to rate it again - this time under no cognitive or time constraints. We also compared both responses on this paradigm to

¹ To define the response deadline, we conducted a reading pre-test experiment, in which we simply asked participants to read the material. The response deadline is the average of the reading times in this pre-test.

a baseline condition in which participants were presented to the arguments only once, without any constraint (and hence were free to deliberate). For details, see Methods.

According to the identity-protective cognition account, when people are able to engage in deliberation (one-response condition) they should be more likely to have increased agreement with the arguments that are concordant to their political ideology. Most critically, it expects Republicans to have increased belief in contra arguments, and decreased belief in pro arguments, after deliberation.

If deliberation simply facilitates accurate beliefs (defined in this case as beliefs that are more consistent with the scientific consensus), people will increase belief in contra arguments and decrease belief in contra arguments after deliberation.

Finally, if deliberation facilitates the coherence between one's prior factual beliefs and the new information, we should find that when prior beliefs are accounted for, political partisanship has no impact on the effect of deliberation. Instead, deliberation should increase belief in arguments that are consistent with the participant's prior factual beliefs about climate change while decreasing belief in arguments that are inconsistent with the participant's prior factual beliefs.

To test these various predictions we used mixed effect linear models including the most complex random effect term that converged. For the specification of random effects used in the various models, see Table 2. Our models take belief ratings as the dependent variable, and as independent variables we include prior belief in climate change, partisanship, argument type (pro or contra) and response type (initial response, final response or one response baseline, depending on the test). The identity protective deliberation account predicts a three-way interaction between partisanship, response type and argument type, while the specific prior beliefs account predicts an interaction between specific prior beliefs, argument type and response type. If deliberation facilitates accurate beliefs per se, we should find a two-way interaction between response type and argument type.

Results

Separability of partisanship and prior factual beliefs about climate change

We begin by documenting a motivation for our work - the disconnect between partisanship and prior factual beliefs. Although there is a moderate correlation between our measures of prior factual beliefs and partisanship $r = 0.45$, $p < 0.0001$, it is clear that these measures are meaningfully independent from each other. As shown in Figure 1, a majority of participants from both parties believed in human-caused climate change. Thus, being Republican is a poor proxy for being a climate denier.

Figure 1. Distribution of specific prior belief (i.e. people who believe vs who deny climate change and its consequences) plotted as a function of partisanship. Although the two measures are moderately correlated, they are meaningfully distinct.

Main experiment

First, we compared baseline responses to the initial (intuitive) responses from the two-response condition - this is analogous to the analysis in a standard between-condition cognitive load/time pressure experiment. Contrary to the motivated system two reasoning account, there was no significant three-way interaction between partisanship, argument type and condition, $b = -0.75$, $p = 0.87$ (Figure 2). We also find no two-way interaction between response type and argument type, $b = 3.67$, $p = 0.29$, and hence, no support for the idea that deliberation simply facilitates accurate beliefs per se.

Instead, prior beliefs significantly interacted with argument type and condition, three-way interaction $b = -14.37$, $p = 0.0006$ (Figure 3).² This provides support for the belief-coherence

² To avoid any potential selection bias, we replicated this analysis by replacing the missed initial responses (in which case there was no response recorded) with their corresponding final response. This analysis yielded qualitatively equivalent results, with a significant interaction between prior belief, argument type and response type, $b = -14.71$, $p = 0.0002$, no significant interaction between partisanship, argument type and response type, $b = -0.35$, $p = 0.94$, and no significant interaction between argument type and response type, $b = 4.4$, $p = 0.18$.

deliberation account. To further understand this interaction, we compared baseline and intuitive responses separately for believers versus deniers (median split on prior factual beliefs) on each argument type. We found that on the contrary arguments, “believers” were more likely to decrease belief, $b = -8.5$, $p < 0.0001$, while “deniers” were more likely to increase belief after deliberation, $b = 10.2$, $p = 0.03$. On the pro arguments, neither believers, $b = 0.07$, $p = 0.96$, nor deniers, $b = 0.32$, $p = 0.95$, significantly changed their beliefs after deliberation.

Interestingly, when we compare initial and final responses within the two-response condition, we find somewhat different results. In this analysis, both of the three way interactions are significant; the three-way interaction with political partisanship, $b = -4.7$, $p = 0.03$, and the three way interaction with prior beliefs, $b = -3.9$, $p = 0.04$ (although still no two way interaction between argument and response type, $b = 0.33$, $p = 0.84$). One possibility for this difference in results for the between-condition analysis (reported in the previous paragraphs) and the within-condition analysis (reported here) is that in the two-response condition, there may be an anchoring effect: That is, given that people had to explicitly give an initial response before they were allowed to give a final response, this might have anchored their thinking to their initial response. To evaluate this possibility, we compare the baseline condition to final responses in the two-response condition. If no anchoring is occurring in the two-response condition, we should not find any significant differences between the baseline and the final response. However, we do find a significant interaction between prior beliefs, argument type and condition, $b = 11.1$, $p = 0.01$, suggesting that anchoring is indeed occurring for the final responses in the two-response condition (we also note that the three-way interaction among partisanship, argument type and condition was not significant, $b = -3.38$, $p = 0.49$, neither was the two way interaction between response and argument type, $b = -4.1$, $p = 0.25$). Thus, the initial response versus baseline comparison (in which there is no significant interaction with partisanship) is the cleaner test.

Figure 2. Agreement scorers as a function of party affiliation, response condition (initial = intuitive response, final response, one-response baseline), and argument type. Dots in the middle of the half-violin plots are averages. Positive trends mean increase in belief after deliberation, while negative trends mean a decrease in belief after deliberation.

Figure 3. Agreement scores as a function of prior beliefs, response condition (initial = intuitive response, final response, one-response baseline), and argument type. Dots in the middle of the half-violin plots are averages. Positive trends mean increase in belief after deliberation, while negative trends mean a decrease in belief after deliberation.

Demonstrating the replicability of our experimental results, Supplementary Materials Section C describes another experiment we ran with a nearly identical design, except that participants' prior factual beliefs about climate change and partisanship were measured after the argument evaluation task rather than at the outset of experiment; and prior factual belief about climate change was measured with a single item. The results are qualitatively equivalent to the experiment reported here (in that study both initial vs baseline and initial vs final response analysis gives us the same conclusion), contradicting the motivated system two reasoning account and supporting the belief-coherence account.

Discussion

Here we investigated the role of reasoning in climate change (dis)belief, addressing two major limitations of prior work: We accounted for prior factual beliefs (which we demonstrate are clearly dissociable from partisanship *per se*), and we experimentally manipulated extent of reasoning rather than relying on correlations with individual differences in reasoning. Our results showed that - contrary to the widely accepted motivated system two reasoning / identity protective cognition account - deliberation did not increase reliance on partisan alignment *per se* (e.g. reasoning did not lead most Republicans to reject climate change). Interestingly, deliberation also did not increase agreement with the scientific consensus (objective accuracy).

Instead, deliberation increased coherence between evaluation of novel climate arguments and one's pre-existing factual beliefs about climate change. While evaluating current evidence in light of prior beliefs is sometimes called "confirmation bias", in fact such evaluation can be entirely rational and unbiased from a Bayesian perspective^{32,33,35}. Of course, our experiment does not allow us to identify what caused the differential factual priors that climate believers versus deniers brought into our study. It seems likely that exposure to differential information streams (e.g. right- versus left-leaning news channels) is a major contributor; and it is possible that political motivations influenced belief formation or updating at an earlier stage (that is, that factual prior beliefs mediate the effect of partisanship). Shedding light on how partisan differences in priors emerge is an extremely important direction for future work - but regardless of how they may have arisen, our results show that engaging in reasoning does in and of itself lead to an increased direct effect of partisan alignment on climate change beliefs.

While the behavior we observe may be rational, as we see in our data, being "rational" does not mean that deliberation will necessarily lead to greater belief in climate change. Our results therefore suggest that simply getting people to think more carefully will not in and of itself make people more likely to believe in the threat of climate change. But our results also suggest that things are not as bleak as suggested by the identity-protective cognition account. If people are engaging in a good-faith effort to assess new information accurately, and relying on their prior factual beliefs to guide such judgments, then educational interventions could - in the long run - move people's priors and increase agreement with the scientific consensus.

Accordingly, informing people about climate change showed to be an effective technique^{25,26,40,41} to increase knowledge about issues surrounding climate change - that is, to shift people's prior factual beliefs. Our results suggest that this knowledge is obtained, inducing deliberation could help people resist climate misinformation and reduce their likelihood of engaging in science denial.

Interestingly, and unexpectedly, we found an asymmetry between how pro and contra climate change arguments are processed. We found no deliberation effect on pro arguments, but there was a very strong intuition effect (differences between believers and deniers at the initial response stage); on the other hand, on contrary arguments there was a stronger deliberation effect, while the intuition effect was much smaller than what was observed on pro arguments. We have no clear explanation for this, however, we hypothesize that it may be that most participants had already been exposed to the pro-climate arguments - and therefore already formed their opinions about those arguments and not needed time to deliberate when evaluating them. Conversely, the contra-climate arguments were likely to have been more novel, such evaluating them required more effort. Future work should investigate this issue in more detail.

There are limitations of our work that it is important to acknowledge. First, we only used participants recruited online. Although Lucid uses quota matching on age, gender, ethnicity, and geographic region, our sample should not be considered fully representative of the US population. It should be noted, however, that our sample *is* ideologically balanced - there was an almost identical number of Republicans and Democrats, and our estimate of prior belief in anthropogenic climate change is close to the national average: According to US-wide nationally representative surveys⁵, 20% of americans believe that humans play no or very little role in global warming, which is fairly close to our estimate of 16.5%. Relatedly, we only recruited participants from the US, while climate change is obviously a global issue. Thus, it is important for future work to examine how our results generalize to other countries with differing political cultures. Another limitation involves the abstracted context (a survey experiment) in which we presented the pro and contra arguments. It would be fruitful for future work to examine how richer social contexts influence reasoning, such as the messenger who delivers the argument. Finally, we only examined prior factual beliefs about climate change. Future work should also examine other relevant factual beliefs, such as beliefs about the reliability of science and the trustworthiness of scientists.

In sum, the data presented here challenge the dominant identity-protective cognition account of climate misbelief. Rather than being blinded by partisanship, our results suggest that climate deniers may in fact be making a good-faith effort to form accurate beliefs. The blame for climate denial would then rest on the producers and distributors of climate misinformation. This emphasizes the key role of effective climate communication - disseminating accurate information about climate change in an engaging manner is essential for winning the battle against climate denial.

Methods

Participants. In total, 1157 participants were recruited from Lucid who passed our first screening question and was allowed to take part. In the two response paradigm, 683 participants (357 females, 320 males and 6 others, Mean age = 44.5 years, SD = 17.2 years) took part, while in the one response study 474 people (234 females, 239 males and 1 others, Mean age = 45.5 years, SD = 17 years) participated. In the two response condition, 389 people were Democrats, and 288 were Republicans, and in the one response test, 291 were Democrats and 182 were Republicans.

Pre-registration for this study can be found at: <https://osf.io/4axr6/>

Materials and procedures

Climate arguments. Altogether, participants were presented with 6 arguments in a randomised order. All the arguments we used in this study were taken from *procon.org* and can be seen in the Supplementary Material section A. Half of these arguments were supporting arguments for anthropogenic climate change. These were scientific arguments, mostly explaining how climate change affects our environment, or how human activity causes climate change, all related to climate change, while the other half of the arguments argued against that humans causing climate change or that it would have bad consequences. All of these arguments were presented in a non-partisan manner, there were no party cues, or politicians mentioned whatsoever. Arguments were content-counterbalanced, and participants never saw the pro and contra version of a given content. Participants were presented with only one of the two versions of one argument, but were always presented with 3 pro and 3 contra arguments. After each argument, we asked people “How much do you agree with this argument? (0=completely disagree, 100=completely agree)”. Participants could give a response on a slider. To make sure that the position of the handler on the slide does not bias participants, the handler was not shown until participants first clicked on the slide.

Dot matrix task. As we wanted to minimize the impact of System 2 deliberation in the initial response stage of the two response experiment, participants were presented with a cognitive load. The rationale here is simple: Insofar as System 2 deliberation depends upon working memory to operate¹⁷, restricting working memory capacity should increase reliance on System 1 intuitions (which do not depend upon working memory). As in other two response paradigm experiments (e.g.,⁴² we used a dot matrix task⁴³ which has been shown to decrease analytical engagement in many tasks including probabilistic reasoning⁴⁴ and moral reasoning⁴⁵. In this task, before the argument is presented, participants are presented with a 4X4 matrix, with 5 dots in it, and they are instructed to memorise the dot pattern. After the initial response stage, participants are presented with a set of 4 matrices and they were asked to select the matrix that was presented to them in the beginning. After they made a decision, they were given a feedback if they selected the correct one or not. In cases where the participant failed

to select the correct option, they were asked to pay more attention on the subsequent trials. Load was not applied during the final response stage.

Response deadline and reading pre-test. To further assure the intuitive nature of the initial response, participants had to indicate their answer under a strict response deadline^{42,46,47}. The rationale here is that System 2 is argued to be relatively slower to produce a response than System 1 processing. Hence, by presenting participants with a deadline, we decrease the probability of System 2 engagement. To help us define the deadline we run a reading pre-test with N = 101 participants (35 females, 66 males, Mean age = 35.24 years, SD = 12 years) on MTurk. Participants were presented with the same arguments as in the actual experiment. They were instructed to simply read the material and then click on the “Next” button. We then logarithmically transformed RT data and back-transformed the data, thereby calculating the geometric mean. We found that, on average, people took 27.3 seconds (SD = 34.02) to read the headlines [after excluding all trials three times the standard deviation above or below the mean]. Hence, we decided to set the response deadline to the closest integer of the average reading time: 28 seconds.

Two response paradigm procedure. Before the instructions, participants were presented two screening questions to screen careless respondents. Then, participants were asked a series of questions regarding their prior beliefs and political partisan identities.

Most importantly, we measured participants’ political partisanship with a single question: “Which of the following best describes your political preference?” (1 - Strongly Democratic, 6 - Strongly Republican). To measure specific prior beliefs about climate change, we asked people two questions: “How much do you agree with the idea that human activity causes global changes in climate? (Completely agree, Somewhat agree, Somewhat disagree, Completely disagree)” and “How significant is the risk climate change pose on humanity? (Very significant, Somewhat significant, somewhat insignificant, Very insignificant)”. We calculate the average of these two measures for every participant to create a “prior belief” score which we will later apply in the analysis.

Participants were then told that they are going to be presented with argument twice. The literal instructions were:

“Welcome to the experiment!”

Please read these instructions carefully!

This experiment is composed of 6 questions and a couple of practice questions. It will take about 15 minutes to complete and it demands your full attention. You can only do this experiment once.

In this experiment, you will be presented with different arguments regarding climate change and its potential effects. You will be asked you to indicate how much you agree with the argument on a scale from 0 = completely disagree to 100 = completely agree. We want to know what your initial, intuitive decision is and how you respond after you have thought about the problem for some more time. Hence, as soon as the problem is presented, we will ask you to enter your initial response. We want you to respond with the very first answer

that comes to mind. You don't need to think about it. Just give the first answer that intuitively comes to mind as quickly as possible. Next, the argument will be presented again and you can take all the time you want to actively reflect on it. Once you have made up your mind you can enter your final response. You will have as much time as you need to indicate your second response.

To assure that the initial response is really intuitive, you will have 28 seconds to give a response. 3 second before the deadline passes, the background will turn yellow to warn you.

In sum, keep in mind that it is really crucial that you give your first, initial response as fast as possible. Afterwards, you can take as much time as you want to reflect on the problem and select your final response.

Please confirm below that you read these instructions carefully and then press the "Next" button. We will start with a couple of practice problems.”

After the instructions, participants were presented with a practice problems. After this, they were presented with a dot matrix practice problems in which they were only asked to memorize the dot pattern and try to select the correct one out of the four matrices presented afterwards. Then, they were presented with a new practice problem, in which they had to give an initial response under load. Each trial started with a presentation of a fixation cross which stayed on screen for 1000 ms. After it disappeared, the dot matrix was presented for 2000 ms. Then, the argument was presented and participants had 28 seconds to give a response; 3 seconds before the deadline, the background turned yellow, to warn participants of the approaching deadline. In case they did not manage to give a response before the deadline passed, they received a message saying *“You did not enter your response before the deadline. Try to respond within the deadline on the next trials. No big deal if you're not totally sure. Just enter your very first intuitive answer. You get more time to reflect on your answer afterwards.”* After the initial response or the message, they were presented with the dot matrix question and had to select the pattern they were presented with. They received feedback on whether or not they selected the correct pattern. In case they did not, they were warned to try to focus on recalling the correct pattern in subsequent rounds. After the feedback, they were presented with the same argument again and were asked to give a final response.

Next, participants were asked to complete a six item version of the Cognitive Reflection Test: first, they were presented with content-modified versions²⁸ of the original three CRT items⁴⁸ after which they were presented with a newer three-item non-numerical CRT⁴⁹.

One response paradigm procedure. In this condition, participants were presented with each argument only once. These are the literal instructions participants received at the beginning of this experiment:

“Welcome to this experiment!

In this experiment, you will be presented with different arguments regarding climate change and its potential effects. You will be asked you to indicate how much you agree with the argument on a scale from 0 =

completely disagree to 100 = completely agree. Then, you will be presented with the same problem again and we will ask you three other questions. Please carefully read through the arguments before responding.

You will be presented with 6 arguments. The experiment will take about 15 minutes to complete, and will demand your full attention.

Press 'Next' to continue!”

In each trial, after a brief fixation cross period (1 sec) the argument appeared and they were asked to give a response without any (load or deadline) constraints. In short, participants in this condition were simply given the “final response” portion of the 2-response paradigm. At the end of this experiment, participants were presented with the same CRT, science knowledge and demographic questionnaires as in the two response version.

Exclusion. We first excluded participants who did not pass our screening questions; from the two response experiment we excluded 127 people and from the one response version we excluded 116 participants. As stated in the pre-registration, we excluded all trials in which participants did not manage to give an initial response in time (hence, there was no data recorded). Only exception is when we compared baseline and final responses in which analysis we included all the data. Some participants also did not finish the experiment, and quit after giving an initial response. These data were also excluded from the initial vs final analysis but not from the rest. Altogether, 11.6% of trials were excluded from analysis for missing data.

Statistical analysis. The maximal model converged in none of the cases. In all models, we included argument condition (0.5 - contra, -0.5 - pro) and condition (initial, final, baseline). As stated in the pre-registration, belief was coded as a numeric variable from -1 (strong disbelief) to 1 (strong belief) and partisanship similarly as a numeric, from -1 (strongly Republican) to 1 (strongly Republican). We compared conditions to each other, always including only two of them in the models (e.g., initial vs final, etc). Table 2 shows all the fixed and random effects that were included in the separate models. In all models, the intercept was allowed to vary over subjects and item contents.

Table 2. Table shows all the fixed and random effects that were included in the models in the main experiment.. In all models, the intercept was allowed to vary over subjects and item contents.

	Fixed	Random slope over Subjects	Random slope over item contents
Initial vs Final	Argument type, Condition (0 - initial, 1 - final), Partisanship, Belief	Argument type, Belief	Argument type

Initial vs Baseline	Argument type, Condition (1 - initial, 1 - baseline), Partisanship, Belief	Argument type, Belief	Argument type
Baseline vs Final	Argument type, Condition (1 - baseline, 0 - final), Partisanship, Belief	Argument type	Argument type, Belief

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Competing Interests Statement

We declare no competing interests.

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Figures

Figure 1

Distribution of specific prior belief (i.e. people who believe vs who deny climate change and its consequences) plotted as a function of partisanship. Although the two measures are moderately correlated, they are meaningfully distinct.

Figure 2

Agreement scorers as a function of party affiliation, response condition (initial =intuitive response, final response, one-response baseline), and argument type. Dots in the middle of the half-violin plots are averages. Positive trends mean increase in belief after deliberation, while negative trends mean a decrease in belief after deliberation.

Figure 3

Agreement scores as a function of prior beliefs, response condition (initial =intuitive response, final response, one-response baseline), and argument type. Dots in the middle of the half-violin plots are

averages. Positive trends mean increase in belief after deliberation, while negative trends mean a decrease in belief after deliberation.

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