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Explanatory Refutation Texts Increase Epistemic Trust in Climate Scientists and Anthropogenic Global Warming Acceptance

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Abstract: Trust is fundamental to the non-experiential learning of complex scientific knowledge that informs societal decision-making (e.g., about climate change). Global warming (GW) beliefs and attitudes often reflect one's trust in climate scientists as reliable information sources, so fostering GW knowledge includes addressing misconceptions that can inhibit such trust. Using a pretest-posttest control group design (with an extra posttest-only treatment group that eliminated experimenter-demand concerns), we herein showed that two (long/short) brief explanatory, persuasive, refutation texts addressing climatologists' research practices increased learners' (a) trust in climate scientists (and scientists overall) and (b) acceptance that anthropogenic GW is occurring and concerning. Our experiment's results support prior findings that people revise their GW beliefs—without polarization—upon encountering crucial, valid, and germane, information. These findings expand empirical evidence demonstrating the utility of directly confronting epistemic misconceptions (e.g., about scientists'—especially climatologists'—reward structures) using explanatory, persuasive, refutation texts.

Introduction

Confidence in scientists among the US public is typically high and on par with their confidence in their military (Funk et al., 2019): 86% of residents have "a great deal" (35%) or "a fair amount" (51%) of confidence that scientists act in the public's best interests. However, trust in scientists varies by scientific field, and this variability is prominent for socio-scientific issues (SSIs), such as pandemics (Evans & Hargittai, 2020), evolution, and global climate change (e.g., Ranney, 2012; Ranney & Clark, 2016). About 25% of Americans "somewhat" or "strongly" distrust scientists as sources of global warming (GW) information (Leiserowitz et al., 2011). Given this landscape and the need for well-informed citizens/consumers, communicators have analyzed the factors—in a message, a messenger, and a recipient—that influence trust. Various strategies improve the effectiveness of climate change communication (Nisbet, 2009), including increasing people's trust in scientists (e.g., Goodwin & Dahlstrom, 2014). The following two subsections briefly survey literatures that informed the current experiment's design, especially those involving (a) epistemic trust and (b) kinds of texts that change minds and counter misinformation.

Elements of trust and epistemic trust

Mayer et al. (1995) define trust as "a function of the trustee's perceived ability, benevolence, and integrity, and of the trustor's propensity to trust," with (a) *ability* being the trustee's domain competence/expertise, (b) *benevolence* being the extent to which a trustee is seen to act in the trustor's best interest (beyond the trustee's personal benefit), and (c) *integrity* referring to the trustor's sense that the trustee follows principles acceptable to the trustor. Origgi (2004) describes *epistemic trust* as trust in a source's knowledge-reliability in a specific domain (vs. trusting someone to keep a secret or watch your laptop). Extending epistemic trust to science/scientists, Hendriks et al. (2016) characterize it as "trust in the knowledge that has been produced or provided by scientists." Epistemic trust permeates the acquisition of vicarious knowledge because it is difficult for non-experts to gain a first-principles understanding of many scientific phenomena. To make well-informed decisions about SSIs, laypeople should establish the trustworthiness of various knowledge sources (scientists, journalists, etc.); thus, their scientific beliefs about a field are often closely tied to their trust in that field's science/scientists.

Trust in scientists' competence, integrity, methods, and motives crucially shapes public opinions on climate action (MacInnis & Krosnick, 2016). Anthropogenic global warming (AGW) *acceptance* (a) significantly correlates with *trust in climate scientists* (Hmielowski et al., 2014) and (b) is causally related to *awareness of AGW's scientific consensus* (van der Linden et al., 2015). Indeed, one's trust in scientists moderates the relationship between knowledge of, and concern about, GW: Malka et al. (2009) report that knowledge is positively associated with concern among people who at least moderately trust scientists, yet knowledge is *uncorrelated* with concern about GW among those who are distrustful of what scientists say about the environment. Climate change skeptics—and many groups with vested fossil fuel industry interests—often claim that climate scientists push AGW narratives to get funding (Boussalis & Coan, 2016; Mann & Toles, 2016). Further, Funk and Kennedy (2016) note that 31% of US adults believe that climate scientists understand global climate change's causes "not too well" or "not at all." More saliently for the present study, they also note that only 23% of US adults—and only a tiny 7% of conservative Republicans—believe that climate change research findings are influenced by *concern for the public's best interests* "most of the time." These data show Americans' nontrivial distrust of climate scientists over all three aspects of epistemic trust: expertise, integrity, and benevolence. Therefore, items comprising our experiment's trust instruments cover all three aspects.

Using texts for conceptual/epistemic/attitude change and countering misinformation

Enhancing public understanding of, and engagement with, SSIs often entails (a) conceptual change in understanding a scientific phenomenon, (b) attitude change about the emotion or valence an SSI evokes, and (c) epistemic change about the nature of science knowledge and practice (Sinatra et al., 2014). Consider how different kinds of texts can shift knowledge and attitudes. *Refutation texts* are a text-genre in *misconceptions-based learning* that are designed to spur conceptual change. These texts state the learner's (presumed or actual) incorrect belief about a concept to make them cognizant of that belief—and then contrast it with more plausible, scientific alternatives (Tippett, 2010). Refutation texts can artfully counter readers' prior beliefs non-threateningly and invite attentive processing: in a meta-analysis of text-based, instructional strategies, Guzzetti et al. (1992) found refutational expository texts to be more effective than traditional expository tests (with a mean effect size of 0.22). *Persuasive texts* are designed to alter readers' *attitudes* about an issue (often emphasizing such alterations over knowledge changes), typically having a claim, then evidence supporting the claim, and a warrant linking the claim to the evidence. Persuasive texts tend to be effective if they counter readers' initial beliefs, promote mindful processing, and motivate readers to revise their beliefs (Chambliss & Garner, 1996).

This experiment also draws on work on communication strategies designed to combat misinformation. Such *agnotology-based learning* involves teaching techniques to examine and critique misinformation (Cook, 2019). Lewandowsky et al. (2012) showed that disconfirming misinformation alone may not end its influence: it is crucial to fill the coherence gap left by the disconfirmed beliefs with a plausible, alternative narrative. As noted, many who deny GW cast doubt on climate scientists' motives and findings (Oreskes & Conway, 2011). Cook (2019) classified such "attacks on the integrity of climate scientists" as a climate misinformation rhetorical strategy. Our experiment's texts directly counter flaws in claims about climatologists' purported over-devotion to financial or social-acceptance goals—which, among other things, helps readers empathize with climate scientists.

Inoculation-messages can also counter misinformation (Cook et al., 2017). When shown flawed logic or specific misinformation instances (e.g., *fake experts* feigning a lack of scientific consensus on GW), people are cognitively inoculated against similar deceptive tactics they may see in the future. Explicitly debunking misinformation (e.g., countering misleading claims based on cherry-picked information) is effective when designed aptly and repeated often. If misused or poorly constructed, trying to debunk may worsen matters (Farmer & Cook, 2013)—for instance, it may cause a *backfire effect* (i.e., should a false idea become more accepted than the facts that counter it). Beyond correcting the money-libel and clan-appeasing aspersions, our intervention text may also inoculate against other forms of misinformation that target climate scientists' integrity.

Refutation texts and persuasive texts have shifted climate change attitudes (Thacker et al., 2020) and aided climate change conceptual changes (Nussbaum et al., 2017). Other explanatory texts have increased both GW knowledge and concern (e.g., Velautham et al., 2019; Ranney & Velautham, 2021). Refutation-based interventions (Chang et al., 2018) have focused on climate change's causes and misconceptions, but intervention texts targeting misconceptions that contribute to climate change denial have not directly addressed scientific research's reward system. Individual scientists have tried to dispel the mere-greed myth by detailing their funding (Mandia, 2010). Others have emphasized science's incentive for proving one's peers wrong (Mann & Toles, 2016), which our intervention subsumes (among other elements). In full, our experiment's intervention text is designed to persuade readers that GW is real and man-made—mostly by refuting the (largely false) idea that climate scientists exaggerate AGW for personal gain (Boussalis & Coan, 2016; Oreskes & Conway, 2011).

Experiment

We herein assessed the utility of two brief intervention texts (long and short) in yielding (a) conceptual-and-attitudinal changes (as measured by readers' anthropogenic Global Warming Acceptance [GWA]), and (b) epistemic change (as measured by readers' Trust in Scientists [TiS] and Trust in Climate Scientists [TiCS]). Our three primary hypotheses (H1-H3) were: that the (a) long and (b) short texts would increase readers' TiS (H1), TiCS (H2), and GWA (H3). H1 and H2 reflect predictions that trust in (general and climate) scientists will increase due to crucial new epistemic information refuting misconceptions about climatologists' motivations. H3 reflects the idea that GWA and TiCS increases ought to co-occur, because trusting climatologists means that their AGW claims gain credence. A secondary hypothesis (H4) is that our texts succeed with liberal *and conservative* participants (i.e., with no polarization—as Ranney et al., 2019, etc., have found for other brief GW interventions).

Participants
A diverse set of 419 online (*Qualtrics Panels)* adult US participants were pre-selected to roughly reflect three US distributions that were counterbalanced across all conditions: age, education, and political affiliation. It was thus a more balanced/diverse sample than is typical of most studies (e.g., those using Mechanical Turk, whose samples tend to be younger, more liberal, and more educated than US adults). Our median participant was middle-aged with some college credit (but no post-high-school degree). Political affiliations reflected the US's (somewhat labile) proportions, with 36.3% Democrats, 35.6% Independents, 27.4% Republicans, and 0.7% Green/Libertarian/Other participants. Our campus's institutional review board approved this study. Qualtrics received $4.50 per not-excluded participant, half of which went to individuals—with the actual value (whether cash, gift card, or other cash-substitute) being proprietarily determined by Qualtrics and its panel provider(s).

Design
Participants were randomly assigned to one of four conditions: (a) a Pretest, Long intervention-text, plus Posttest (PLP) group, (b) a Pretest, Short intervention-text, plus Posttest (PSP) group, (c) a No-Pretest, Long intervention, plus Posttest (NPLP) group, or (d) a control-text group. We hypothesized (H1-H3 above) that PLP (H1a-H3a) and PSP (H1b-H3b) groups would show pretest-to-posttest gains for all outcome variables (TiS, TiCS, and GWA), relative to the control group. The PSP group effectively assesses a dosage hypothesis regarding whether roughly halving the text's words (vs. PLP) would still yield such gains. The NPLP group served to detect any pretest sensitization suggesting (in the PLP or PSP groups) either an experimenter demand or a consistency bias. Such a pretest-treatment interaction would mean that a pretest increased or decreased participants' sensitivity to an experimental text (i.e., people getting pretests sometimes show more or less gain compared to a no-pretest group). Spurious gains to please experimenters were greater threats to our experiment's validity than reduced gains, so we hypothesized (H5) that the NPLP posttest scores would not be significantly below the PLP posttest scores, indicating no experimenter demand effect. The NPLP condition also allowed replication of a longer-text treatment effect beyond the PLP group: we hypothesized (H6) that the NPLP posttest scores would exceed the other groups' pretest scores, which would indicate yet another treatment main effect for the (long) intervention text.

Procedure
Participants gave informed consent before receiving material for their randomly assigned group from a Qualtrics link. Each pretest and posttest included 30 items over four online presentation-pages. Participants failing to complete the experiment or pass quality checks were replaced from the panel pool. Those who responded correctly to at least one out of two items in each of these were retained: a) two attention-check items mingled into pretest items, b) two attention-check items mingled into posttest items, and c) two comprehension check queries right after the (control or intervention) text. Speeding checks on the total time spent were also enforced: those spending less than half the median time for their assigned condition were excluded. Finally, anomalous indicators—such as (1) page latencies (i.e., local speeding), (2) very low within-participant variance, and (3) internal incoherence among responses to similarly-worded or negatively-phrased items—were examined to remove random, *straightliner*, and inattentive responders. Demographic information was solicited after the posttest.

Materials (texts and instruments)
Two intervention-text versions with the same brief, core, message were used: the PSP group's Short (i.e., roughly condensed) 253-word version—and the PLP and NPLP groups' Long 483-word version. (The control text was a similarly engaging 500-word summary of the film *Mary Poppins*.) The intervention texts countered hoax-ideas that are common in some subpopulations—such as that climatologists bolster their field's status quo to get grants/accolades—by highlighting that *real* scientists' fame reflects the field-altering shock of their findings. A part of the short version highlights this: "Scientists also don't just accept global warming because they want to get along with other scientists. That's mostly the opposite of how scientific rewards work. Scientists treasure any chance to show that the vast majority of their peers are incorrect: that's how Einstein-types achieve fame. [...] About 98% of climate scientists accept human-caused global warming even while wishing it were false—and having incentives to disprove it. This reflects the very high probability that climate change is truly happening."

A scientist can earn trust and engage doubtful audiences by showing vulnerability and highlighting a willingness to sacrifice (Goodwin & Dahlstrom, 2014)—for instance, through a commitment that clearly shows that the scientist has something to lose. Our texts do so by (beyond their other features) describing a scientist (this piece's third author) who often publicly pledges to quit all climate-related activities and return all climate-related funds he has received if "someone could please" disabuse him of his beliefs that GW is occurring and human-caused; he developed the texts' prose over dozens of lectures with sometimes-dubious audiences (e.g., one in a bar in Texas, USA). The texts quote him, including: "Indeed, virtually all climate scientists absolutely wish that global warming were not happening—especially if they're parents!" He elaborates that anyone who *can* disconfirm GW *would*, as the person would win a Nobel prize, become the "most famous scientist ever," and get "wildly rich" (from fossil-fuel companies, etc.). The texts are available on our group's academic site (at https://convinceme.com/downloads/papers/SenthilkumaranVelauthamRanney2023-ICLS-ExtraMaterial.pdf) and our group's public-outreach site (at https://www.howglobalwarmingworks.org/trust-in-scientists.html—along with some of our other brief materials that have been shown to increase global warming acceptance/concern).

An eight-item TiS instrument and an eight-item TiCS instrument were developed (with items adapted from Nadelson et al., 2014) and validated prior to this study. Both were highly reliable (Cronbach's $\alpha = 0.75$ and 0.90, respectively), and their sum-scores correlated (r = 0.69 and 0.87, respectively) with those from an eight-item GW Acceptance instrument from our prior experiments (e.g., Velautham et al., 2019), further supporting their validity. The GWA instrument measures how much people believe that (a) GW is occurring and largely human-caused, (b) GW's effects are a serious threat, and (c) GW's effects are concerning. All items were rated on a 1-9 scale from "extremely disagree" to "extremely agree" (with verbal labels at each number). An example of a TiS item is: "Scientists honestly look for flaws in the methods and findings of other scientists." A *negatively*-phrased example of a TiCS item is: "Climate scientists do not accurately convey their findings." An example of a GWA item is: "I am confident that human-caused global warming is taking place."

Statistical-analysis rationale

Because univariate effects were of central interest in comparing changes among experimental groups for our pretest-posttest design, we bypassed a MANOVA to directly use univariate ANOVAs on each outcome variable. Intercorrelations among the outcome variables on the pre-tests (covering Control, PLP, and PSP groups' data) ranged from .65 to .82 and on the *post*-tests (covering all four groups' data) from .69 to .84. We used (per Smolkowski, 2019) a change (posttest minus pretest) score approach over an ANCOVA on posttest scores or a repeated-measures ANOVA. We used the Holm-Bonferroni correction, given multiple-comparisons and Type 1 error, such that the experiment-wise α was .05. We first performed one-way ANOVAs on each outcome variable; for ANOVAs revealing a statistically significant between-groups difference, we performed post-hoc Dunnett's tests. For the NPLP group, we compared its posttest scores to (i) the PLP group's posttest scores (to rule out experimenter demand), and (ii) the other groups' (PLP+PSP+Control combined) pretest scores (for replication).

Results

Gains for both trust-text treatments for all within-participant measures

Table 1 shows pretest (if applicable) and posttest group means (out of 72) for GWA, TiS, and TiCS. (Each group's data for all outcome variables were reasonably symmetrically distributed—with few outliers on one or both tails.) As hypothesized, the PLP (H1a-H3a) and PSP (H1b-H3b) groups showed posttest gains for all three outcome variables. Focusing on Table 1's *changes*, Table 2 shows means and *SDs* of the change scores for the three GW and trust measures from groups who had a pretest (control, PLP, PSP). The PLP group, with its longer-than-PSP text, tended to yield the largest gains on the measures, and the control group showed basically no changes.

Table 1
Pretest and Posttest Means and (italicized) Standard Deviations of Outcome Variables by Condition

Group	n	GWA Pre		GWA Post		TiS Pre		TiS Post		TiCS Pre		TiCS Post	
		M	*SD*	M	*SD*	M	*SD*	M	*SD*	M	*SD*	M	*SD*
Control	113	52.4	*14.7*	51.7	*15.1*	49.7	*9.3*	49.8	*8.8*	49.1	*11.5*	49.6	*12.6*
NPLP	91	-	-	56.5	*12.8*	-	-	53.0	*9.2*	-	-	53.7	*10.7*
PLP	104	47.5	*16.0*	50.5	*16.2*	48.9	*10.1*	51.0	*10.4*	46.0	*13.5*	50.7	*13.5*
PSP	111	49.7	*17.1*	51.6	*16.6*	49.2	*9.3*	51.7	*10.3*	47.1	*14.0*	51.3	*13.8*

Note: Max. possible score on each of these measures was 72 (i.e., 8 items each on 1-9 scales); - = no pretest

Dunnett's test (df = 325) showed that the PLP (p < 0.00001, Cohen's d = 0.77) *and* PSP groups' GWA gains (p = 0.00013, Cohen's d = 0.54) were significantly greater than the control group's change (by 3.7 and 2.6 points, respectively). This test builds on a significant difference among those three groups in a one-way, between-subjects ANOVA on *GWA-change-score*: F(2,325) = 17.16, p < 0.00001. The same pattern was obtained for the TiS gains: Dunnett's test (df = 325) showed that the PLP (p = 0.00958, Cohen's d = 0.38) *and* PSP groups' gains (p = 0.0018, Cohen's d = 0.45) were significantly greater than that of the control group (by 2.1 and 2.4 points, respectively). The one-way between-subjects ANOVA of the *TiS gains* warranting the test showed a statistically significant difference among groups: F(2,325) = 6.53, p = 0.00166. As with GWA and TiS, a one-way between-subjects ANOVA of the TiCS gains showed a statistically significant difference among groups: F(2,325) = 15.93, p < 0.00001. The follow-up Dunnett's test (df = 325) showed that the TiCS gain of the PLP group (4.2 points) differed significantly from that of the control group (p < 0.00001, Cohen's d = 0.69), and the TiCS gain of the PSP group (3.7 points) showed a significant difference from the control group (p = 0.00001, Cohen's d = 0.61). These results show that both the intervention-text's longer (H1a-H3a) and shorter (H1b-H3b) versions successfully increased readers' global warming acceptance and trust in climate (and generic) scientists; in other words, even the smaller, 253-word, "dose" of our intervention was successful.

Table 2

Change Scores by Condition (Posttest minus Pretest, rounded to nearest 0.1)

Group	N	GWA Gain		TiS Gain		TiCS Gain	
		M	*SD*	M	*SD*	M	*SD*
Control	113	-0.7	*4.1*	0.0	*4.4*	0.5	*5.1*
PLP	104	3.0	*5.6*	2.1	*5.8*	4.7	*6.3*
PSP	111	1.9	*4.5*	2.4	*5.9*	4.2	*6.5*

Note: The NPLP condition did not have a pretest.

Replicative gains for all NPLP measures (and no experimenter demand)

Table 3 shows the NPLP posttest scores' means and standard deviations (presented earlier in Table 1), along with the means and standard deviations of the pretest scores of the other three conditions combined, and (broken out of that combination) the PLP posttest scores. We performed two main comparisons with the NPLP condition's data: one assessing experimenter demand (H5), and another assessing coherence with the PLP data (H6).

Table 3

Relevant Between-Group Summary Statistics for NPLP Posttest, PLP Posttest, and Combined Pretest Scores

Group	n	GWA Pre		GWA Post		TiS Pre		TiS Post		TiCS Pre		TiCS Post	
		M	*SD*	M	*SD*	M	*SD*	M	*SD*	M	*SD*	M	*SD*
Combined	328	50.0	*16.0*	n/a	*n/a*	49.3	*9.5*	n/a	*n/a*	47.4	*13.0*	n/a	*n/a*
NPLP	91	-	-	56.5	*12.8*	-	-	53.0	*9.2*	-	-	53.7	*10.7*
PLP	104	n/a	*n/a*	50.5	*16.2*	n/a	*n/a*	51.0	*10.4*	n/a	*n/a*	50.7	*13.5*

Note. "Combined" = groups with pretests (PLP, PSP, & Control). Mean maximums = 72; n/a = not-applicable; - = no pretest.

We found no evidence of experimenter demand: NPLP and PLP posttest scores were compared with a one-sided equivalence test (i.e., a noninferiority test), with a decrease (PLP minus NPLP) of less than 1 point (of a possible 72-point sum) per measure considered negligible. The null hypothesis was that (*PLP-post – NPLP-post*) > 1 (i.e., experimenter demand exists), and the alternate hypothesis (H5) was that (*PLP-post – NPLP-post*) <= 1 (i.e., no experimenter demand). Our results showed no experimenter demand effect for any of the measures. For example, the 95% CI [-6.39, 0.46] for the TiCS PLP-NPLP posttest score difference does not contain 1, indicating *no* experimenter demand effect (p=0.0117, Cohen's d= 0.32). Similarly, *no* experimenter demand effect was found for either the TiS scores (p=0.0196, Cohen's d = 0.30, 95% CI [-4.73,0.85]), or the GWA scores (p=0.0005, Cohen's d=0.47, 95% CI [-10.07, -1.87]). If anything, the data indicate that taking the pretest and becoming sensitized to the variables under study reduces the text's effectiveness, demonstrating *lower* gains than would otherwise be obtained without pretest sensitization. This is the *opposite* of what one would expect had participants induced the hypotheses and tried to please the experimenters with biased ratings on the posttest.

Supporting hypothesis H6, the NPLP group's long text replicated significant gains (of moderate effect size) for all three measures—GWA, TiS, and TiCS (~6.5, ~3.7, and ~6.2 points, respectively): NPLP showed such significant gains for GWA (t(176.7)=4.07, p=0.00007, Cohen' d=0.42), TiS scores (t(417)=3.26, p=0.00119, Cohen's d=0.39), and TiCS (t(417)=4.19, p=0.00003, Cohen's d=0.50) relative to the combined groups' pretest scores. (NPLP posttest scores were compared to the pretest scores of the other three groups [combined] using an independent-samples t-test [two-tailed] for each gain variable. The GWA scores were compared assuming unequal variances, and the TiCS and TiS scores were compared assuming equal variances, as per Levene's test.)

No polarization, either regarding belief level or political affiliation

Supporting hypothesis H4, we found *no* evidence of our texts causing polarization (cf. Lord et al., 1979)—using three lenses: initial belief level, political affiliation, or conservatism. Neither those with low initial belief /attitude levels—nor those identifying as Republican or conservative—showed polarization or a backfire effect.

Regarding beliefs and attitudes, participants scoring 24 or lower (33% of 72) summed points on the GWA or TiCS *pre*tests numerically *increased* their mean post-intervention scores. Such "bottom-thirders" did *not* show the losses that polarization would predict. Indeed, PLP and PSP bottom-thirders yielded +8.0 and +3.4 respective

TiCS point-gains above pretest levels (and +1.2 and +3.3 respective GWA point-gains). (No PSP/PLP participant scored 24-or-under on the TiS pretest, so we report no TiS changes; likewise, NPLP had no pretest, so that group could show no polarization.) Turning to political affiliation, Republicans (a separate AGW denial correlate) did *not* exhibit the losses that would indicate polarization—indeed, they yielded *gains* on *all three* measures for both relevant groups: PLP (+3.1, +2.3, and +4.9, respectively, for GWA, TiS, and TiCS) and PSP (+3.1, +3.6, and 7.0, respectively, for GWA, TiS, and TiCS). Similar gains were found for Democrats and Independents, yet gains for Republicans (who had the lowest mean *pretest* scores) were generally the highest.

We can assess (the lack of) polarization more directly than with bottom-thirders and political party: The correlations between GWA/TiS/TiCS changes and (separately, economic and social) conservatism were all close to zero (with r's ranging from -0.06 to +0.18). The largest of these six correlations, between GWA-change and social-conservatism, was still weak (ρ=0.184, with a 99% CI of [0.01,0.35]). However, it—like most of the other (weaker) change-conservatism correlations—was *positive*, and thus (as above) in the opposite direction that polarization would predict. Likewise, for all nine levels of self-rated economic conservatism among PLP and PSP participants, mean changes (on TiCS, TiS, and GWA) were positive for 52 of the 54 (9x6) sub-cells—and the remaining two sub-cells showed losses of less than 0.5 points. (Results for *social* conservatism, which we have found are typically less linked to AGW denial, were similar.) Indeed, our *extreme* conservatives (with self-ratings of 9 of 9), exhibited gains for all three (GWA, TiS, and TiCS) measures for both PLP and PSP conditions.

Discussion

Political discourse often focuses on one's finances or affiliations, so it is not shocking that some people criticize climate scientists by suggesting that they largely follow greedy or tribal motivations. This libel (i.e., when knowingly false) is spread by special-interest groups (Oreskes & Conway, 2011)—and their agents/lobbyists—who oppose climate-friendly reductions in greenhouse gas emissions (and deny AGW's reality or huge scale). It is further intensified by some political influencers who portray climate scientists as enemies—heightening in/out-group separations that social-media algorithms tend to amplify. What our Trust-texts cultivate, though, is a humanizing empathy about being in a climate scientist's shoes (e.g., "Were I a climatologist, I'd want to aid society by providing veridical, actionable, information—even if I got pushback."). The interventions herein help people both cognitively and emotionally understand that virtually all climate scientists: (1) fervently wish global warming were false and (2) would gladly disconfirm GW if they could—due to the almost-unimaginable rewards they would reap. Our data show that readers are changed by this narrative, and in 253 words (let alone the longer, 483-word text) our experiment successfully increased (a) the more proximal construct of Trust in Climate Scientists *and* the more distal constructs of (b) Trust in Scientists overall and (c) Global Warming Acceptance.

In addition to our findings that both of this experiment's brief texts increased belief ratings for the TiCS, TiS, and GWA measures, the no-pretest group (NPLP) showed that the gains in normative beliefs were (a) not due to experimenter demand and (b) further replicable (i.e., the NPLP results replicate the PLP—and implicitly, the PSP—results). In sum, all six of our hypotheses (H1-H6) found support in the data. The findings both bolster extant research on evidence-based strategies to combat misinformation and support our (and Hmielowski et al.'s, 2014) strong link between trusting climate scientists and accepting their AGW findings. The results also show that explanatory persuasive-refutation texts can succeed without yielding polarization or backfire effects: most participants across each of several relevant spectra showed *gains* for all dependent variables (TiCS, TiS, and GWA). The gains are even robustly found across participant sub-spectra that are, *a priori*, most indicative of potential GW deniers—namely participants who had up to three indicators of strong content-skepticism (i.e., high conservatism, Republican [and Independent] affiliation, and low trust or GWA pretest scores).

Although we used common techniques to improve data reliability, they are not without external validity concerns. Attention and comprehension checks aid in reducing statistical noise, but they modify the inferential target to a subset of the population: people who complete the experiment and pass all screeners may differ from those who do not—especially in public-attitude studies (Aronow et al., 2019). Dropouts and inattentiveness in online studies may often be due to extraneous reasons, but a would-be-participant who exits upon viewing the pretest questions or an intervention text—or fails the quality checks—may denote (a) a difficulty in understanding the text and instructions, or (b) a reluctance to engage with the topics of GW and/or climate scientists.

Beyond addressing a common misconception among deniers, our texts also communicated science's incentive structure. SSIs make an excellent context for nature-of-science learning (e.g., Eastwood et al., 2012), and knowledge about the nature of science increases public acceptance of science regardless of identity factors (Weisberg et al., 2021). Our results indicate that explaining *science's motivations and methods* to the public can increase learners' trust in scientists, their expert findings—and hopefully their wisest recommendations.

Conclusions

This experiment supported six hypotheses (H1-H6) that advance climate change cognition. Its trust-text genre brings to 12 (detailed in Ranney & Velautham, 2021, and Velautham, 2022) the ways in which our lab's brief materials have been shown to boost AGW acceptance/concern. Other ways include statistics about climate change (even marbled with misleading statistics), related statistics (on energy efficiency, electrification, and reducing meat), graphs of Earth's warming (vs. the US stock market rise), statistics reducing nationalism, texts about high CO_2's cognitive harms, information about GW's physical and economic effects (e.g., sea-level rise), activities involving selecting climate change solutions, and texts and videos about global warming's mechanism or effects.

This experiment cannot escape the context of US subgroups who struggle to understand and access diagnostic information. From public health guidelines (e.g., slowing COVID-19's spread with masks) and US election-results denial to climate change mitigation and adaptation, people vary in how much they trust experts (Evans & Hargittai, 2020; Leiserowitz et al., 2011). Given the proliferation of misinformation in mass media and its effect in undermining trust in domain experts, it is crucial to make accurate, relevant, and non-polarizing information (such as those used in our texts) widely available—and repeated through multiple sources—to bolster trust and improve public science understanding. Not *all* scientists (whether they work on climate *or* fossil-fuels) are beyond reproach. Some are tempted to overstate or obscure in reporting, and some even fall from grace; legal and peer-review systems are imperfect. But history—and science-driven technologies—have shown that science largely, if not fully monotonically, eventually gets it right. Our findings demonstrate that reading even 60 seconds' worth of the shorter (PSP) text significantly changes minds about some of the most important elements of our era: scientific veracity—and its role in informing humanity about a potentially cataclysmic future.

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