Changing Global Warming Beliefs with Scientific Information: Knowledge, Attitudes, and RTMD (Reinforced Theistic Manifest Destiny Theory)

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Abstract

Unlike peer nations' residents, Americans are less accepting of, and concerned by, (especially anthropogenic) climate change. Reinforced Theistic Manifest Destiny theory (RTMD; e.g., Ranney, 2012) explains many such "U.S.-exceptionalist" phenomena by combining geopolitical history with six belief constructs: afterlife, deity, nationalism, creation, evolution, and global warming. We assess predictions that climate change acceptance is increased by mechanism-explaining interventions. A 270-participant survey established widespread mechanistic ignorance, and an experiment with 149 other Americans (Californians and Texans) showed that a 400-word description of climate change's mechanism dramatically reduced ignorance and increased climate change acceptance. The mechanism, briefly, is: (a) Earth's surface absorbs (mostly visible) sunlight and subsequently emits *infrared* light, which (b) greenhouse gases selectively absorb and retain (because these molecules can become asymmetrical), so (c) heat energy leaves more slowly, warming Earth. Our intervention yielded desirable conceptual changes and science-coherent attitude changes. RTMD-predicted between-construct relationships were obtained and/or again replicated.

Keywords: Climate Change; Global Warming; Conceptual Change; Society; Science Education; Belief Revision.

In contrast to our exploding human population, many species are dwindling—often due to people's actions (e.g., hunting, degrading environments, and introducing non-native species). Still, many past effects pale compared to the threat of global climate change. (Nb. We will henceforth largely use the colloquial term, "global warming," although of course not *all* locations may exhibit warming due to human-enhanced greenhouse conditions.) In geologic time—on the order of 10,000 years or more—warming periods have consistently resulted in high levels of extinction (Mayhew, Jenkins, & Benton, 2008). Now, though, comparable warming is occurring over hundreds of years or less—posing a unique threat to many species' futures (cf. Harte & Harte, 2008), and direct threats to humans (particularly the poor)—such as increased risks of floods, droughts, and low crop yields (Kerr, 2007). Nothing, then, seems to exceed the importance of researchers finding ways to help people accept that anthropogenic global warming is (1) occurring, and (2) crucial to quickly address (Harte & Harte, 2008).

This urgent state is due to dramatic, human-caused atmospheric greenhouse gas increases from pre-industrial levels (about 260 years ago); for instance, methane is up by 150% and carbon dioxide is up by 40%. These levels are *accelerating*, and may easily cause rapid mass extinctions (Malcolm et al., 2006), as with prior fast warmings. Fortunately, if humans act quickly, we may be able to conserve much of the current biosphere (Harte & Harte, 2008).

Sadly, U.S. attitudes clash with the 97% of actively publishing climate scientists who accept global warming's tenets (Anderegg, Prall, Harold, & Schneider, 2010). Leiserowitz, Maibach, and Roser-Renouf (2010) report that only 57% of the U.S. accepts global warming as occurring, and only 47% accepts it being "caused mostly by human activities." The U.S. accepts *both* less than do similarly developed "peer" nations. Indeed, among 33 peers *and* non-peers, only Indonesia, South Africa, and Nigeria rated global warming as less "serious" than the U.S. (Leiserowitz, 2007). Given global warming's potentially disastrous, irreversible effects, increasing Americans' global warming acceptance seems a worthy goal (Ranney, 2012). In the next subsection, we highlight a theory (RTMD) designed to explain U.S. exceptionalism regarding scientific, religious, and nationalistic affinities—especially the marked divergence in climate beliefs noted above. We then describe two empirical studies that test the RTMD-inspired notion that science instruction may powerfully rectify false beliefs about climate change.

Theory: Reinforced Theistic Manifest Destiny

As Ranney (2012; Ranney & Thanukos, 2011) and other researchers have discussed, Americans are clearly outliers compared to peer nations' residents. Beyond global warming acceptance, Ranney describes other dimensions of American exceptionalism (e.g., regarding guns, murders, prisoners, military costs, executive salaries, income variability, teen pregnancies, infant deaths, health inefficiency, evolution acceptance, biblical literalism, piety, and beliefs in God and an afterlife). He also proposed the Reinforced Theistic Manifest Destiny (RTMD) theory to explain how a nation's collective theistic (and related) beliefs are reinforced—militarily, economically, etc. (Ranney, 2012; Ranney & Thanukos, 2011). RTMD focuses on beliefs and attitudes regarding the six inter-related constructs shown in Figure 1. The theory predicts that (1) acceptances of *creation*, *nationalism*, a *deity/dieties*, and an *afterlife* positively correlate, (2) acceptances of *evolution* and *global warming* positively correlate, and (3) constructs in (1) negatively correlate with those in (2)—partly because creation and evolution incohere. Among other offered explanations, RTMD explains the U.S.'s low acceptance of both evolution (Mil-

ler, Scott, & Okamoto, 2006) and global warming, compared to peer nations. At its heart, RTMD posits that unparalleled U.S. military and economic success—especially in WWI and WWII—has bolstered U.S. nationalism and theism, inhibiting American acceptance of evolution and global warming (Ranney, 2012). (In brief, Americans feel most reinforced for thinking "God is on our side.")
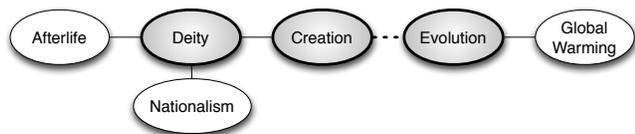

Figure 1. RTMD theory extends an often implicit "received view" (the three bold ovals; Ranney, 2012) of modest U.S. evolution acceptance with three extra constructs (non-bold ovals), such as global warming. Solid/dashed lines respectively represent coherent/conflicting conceptual links.

To date, RTMD has been assessed with seven data sets from the U.S. and one from Canada. RTMD predicts the directions of the 15 possible correlations among Figure 1's six constructs; only the five main theoretical links are shown. Empirically, the 15 correlations virtually always exhibit the directions RTMD predicts (Ranney, 2012). RTMD theory also predicts that a change in one's global warming acceptance may affect the other five variables—especially evolution acceptance. Analyses of such correlation-change predictions, though, exceed this piece's space and scope.

Mechanistic Knowledge and Climate Attitudes

RTMD notes the negative correlations between science-based and more faith-based constructs, and suggests that increased scientific knowledge may enhance positive attitudes towards evolution and climate change. Acceptance beliefs largely follow understanding, given variation in both. Thus, while evolutionary acceptance might be uniformly high or low in a certain classroom or campus, evolutionary biologists largely accept evolution more than do "Intro to Bio" students (Shtulman & Calabi, 2012). Therefore, low global warming acceptance may well be related to a lack of understanding. Consider humanity's adoption of a heliocentric model of our solar system over geocentrism. Although geocentrism had (or has) its appeal, an understanding of gravity and orbits renders geocentric arguments hard to accept—or even "silly." Similarly, we might expect that increasing individuals' knowledge of the mechanism of global warming may help them accept the "less desirable" model of the world in which global warming is occurring (Ranney & Thanukos, 2011; cf. just world theory, e.g., Feinberg & Willer, 2011). Our approach to environmental conceptual and belief changes thus differs from most other efforts, which don't focus as heavily on understanding the mechanism of the greenhouse effect (e.g., Al Gore's Climate Project). Ours appears to be the first work to examine the extent to which one's mechanistic global warming understanding affects relevant attitudes and support for climate policies.

Our research group is carrying out experiments and surveys that assess the hypotheses that (1) a proper understanding of global warming is rare, but (2) enhancing such understanding has desirable effects, such as increased global warming acceptance. There are many global warming education efforts, yet it is difficult to find an explanation of the basic physical/chemical mechanisms involved that is appropriately complete (see below) and yet not filled with too much extra detail (Ranney, Clark, Reinholz, & Cohen, 2012). We are not sure why this mechanistic pedagogical lack exists, but suggest that many would-be climate educators (1) do not adequately understand the mechanism themselves, and/or (2) fear that Americans are incapable of learning the basic scientific principles behind the greenhouse effect; others may (3) doubt that a scientific understanding would make much difference in our attitudes and policies towards global warming, and still others may (4) despair about the political, financial, or even agnotological (e.g., deceptive) elements of the quandary, suggesting that "the masses just can't learn this." But the aforementioned survey data suggest that peer nations' residents accept (and fear—e.g., anthropogenic) global warming more than Americans do, and humanity has accepted other difficult ideas that were heavily suppressed by political or economic powers—such as heliocentrism and the links between tobacco smoke and severe illnesses. Likewise, we predict that a mechanistic warming explanation *may* help many people appreciate the soundness of climate change's science—driving greater acceptance, concern, and imperative action.

Unless you read (and recall) this piece's abstract, it is not likely that you can explain (even quite basically) the physical mechanism by which global warming occurs—as was true of most of our research team prior to our studies. Indeed, part of the present piece's motivation stems from dozens of interviews the first author carried out with colleagues and acquaintances. Responses were often embarrassing and rarely accurate. So, imagine that you were chatting with a physicist/chemist, and she eyeballs you and asks, "How would *you* explain global warming's mechanism?" Please take 30 seconds to answer this query before reading on.

Now that you've pondered global warming's mechanism, please visit the abstract's points (a) through (c). Did your explanation include these fundamental mechanistic aspects? In contrast to our abstract's directly *mechanistic* explication (which is much abbreviated), many people articulate global warming's *temporal precursors*, such as over-industrialization, rather than the fundamental mechanism that greenhouse gases are transparent to the sun's incoming visible (i.e., "colors of the rainbow") light, yet largely opaque to the infrared light that the Earth radiates. Other people often articulate global warming's *effects*—such as increasing mean global temperatures, sea level increases, extinctions, or melting icecaps—but draw a blank mechanism-wise. Yet others focus on atmospheric features that don't, or negligibly, explain global warming (e.g., ozone layer depletion). Many people who are familiar with both global warming's potential precursors (e.g., more CO_2 emis-

sions) and effects cannot describe the *causal mechanism* between them. (Nb. Only one of the many dozens of interviewees knew that greenhouse gas molecules exhibit at least a transient electric dipole moment—e.g., via vibrations, bending, etc., to become asymmetrical—as CO_2 and CH_4 can, but O_2 cannot.)

Given the relations that RTMD theory coordinates, we infer that many Americans who *accept* global warming do so with sub-scientific rationales, and many who *reject* it do so by repressing the science due to religiously or nationalistically motivated reasoning. Thus, if Americans could grasp global warming's science, that might offer a better basis for shifting or strengthening their attitudes. Given that our dozens of informal interviews suggest the widespread lack of a mechanistic global warming understanding among U.S. residents, we predicted that this lack undermines U.S. global warming acceptance. Unfortunately, surveys about global warming knowledge (e.g., Leiserowitz, Maibach, & Roser-Renouf, 2010) rarely ask for mechanistic knowledge and often focus on recognition (thus likely overpredicting what is known by non-climatologists). Therefore, Study 1 below assessed our hypothesis that a broader, more representative sample than those in the informal interviews might also show a modest understanding of global warming's mechanism. Then, in Study 2, we assessed whether a brief explication of the mechanism might be successful in markedly enhancing both global warming knowledge and acceptance regarding anthropogenic climate change.

Study 1: Gauging Global Warming Knowledge

Prior studies have documented numerous difficulties in understanding global warming (e.g., Shepardson, Niyogi, Choi, & Charusombat, 2011; Bord, Fisher, & O'Connor, 1998). Herein, though, we focus on less-studied difficulties in *mechanistic* understanding, three of which we believed were most critical to understanding the greenhouse effect (as highlighted in the abstract): (a) differentiating types of light/radiation, (b) understanding how the greenhouse effect depends on infrared light's selective absorption by greenhouse gases, and (c) understanding how that consequently warms the troposphere, water, and ground. To test the hypothesis that an understanding of global warming is indeed related to acceptance, we needed to determine whether the above conceptual difficulties were prevalent in a general adult population. Thus, we designed and administered a survey of global warming attitudes *and* understandings.

Method: Participants, Design, Procedure, Materials

We collected 270 anonymous surveys from park visitors (n = 201) and community college students (n = 69) in San Diego. Random intercept sampling techniques were used for the park visitors; the community college students agreed to fill out the survey during a scheduled class break. A \$5 gift card compensated each participant. We refrain from offering contrived hypothesis tests below, simply reporting percentages—as is common with survey data. The full survey took 10-15 minutes to complete. We report here on a subset of items: (1) 20 policy preference Likert items (e.g., "How much effort do you want the federal government to put into X?"), (2) two global warming belief items, (3) six short-answer global warming knowledge questions, (4) 13 items on possible causes of global warming (e.g., participants were to label Y as a major/minor/non- cause of global warming), and (5) four items gauging respondents' willingness to make personal sacrifices for specific climate policies. Short answers were coded and scored with a rubric that showed high inter-rater reliability (mean Cohen's $\kappa = 0.74$).

Results and Discussion

The data support our hypothesis that Americans rarely understand global warming's mechanism. When asked to explain "the basic physical, chemical, or biological mechanism of global warming," only 32 participants (12%) referenced gases in the atmosphere (e.g., emissions, CO_2, or pollution) trapping heat—which is merely a partial understanding. Of these 32, only four (1%) attempted to differentiate types of energy (or light). Not a single participant (0%) mentioned either correct absorption(s) or the difference (input/output asymmetry) between visible and infrared light, which is the crux of understanding the greenhouse effect. Notably, only eight participants (3%) even named the greenhouse effect. Many responses included possible *causes*, yet few included possible mechanisms—and the item's median score was 0.

Problematic conceptions were also prevalent. For instance, in answering our question about global warming's mechanism, 42 participants (16%) claimed that the destruction of the atmosphere or ozone layer was letting in more heat, thus causing global warming. This finding echoes the results of previous work (e.g., Bord, Fisher, & O'Connor, 1998). Indeed, on a subsequent "possible cause" item, 201 participants (74%) incorrectly believed that ozone depletion was a major cause of global warming, but only 81 (30%) knew that livestock are a major cause of global warming.

Despite this poor showing regarding global warming knowledge, many people were willing to accept global warming and its anthropogenic origins. In particular, when the responses "mildly agree" and "strongly agree" are combined, 217 people (80%) agreed with the statement, "I am certain that global warming (i.e., climate change) is actually occurring," and 208 participants (77%) agreed that "human activities are a significant cause of global warming." Although this willingness to accept global warming is higher than the averages found on most national surveys, there appears not to have been a prohibitive ceiling effect.

Crucially, experimenter-scored knowledge of the mechanism significantly correlated with peoples' willingness to accept global warming as both real ($r = .22$, $p = .0002$) *and* anthropogenic ($r = .17$, $p = .005$). Also importantly, anthropogenic climate change acceptance significantly predicted (via ordinal models) *all four* survey items about willingness to sacrifice ($\chi^2(4) > 32$, $p < 0.001$)—and one's knowledge score significantly predicted two of these ($\chi^2(1) > 3.8$, $p < 0.05$). In addition, all 15 correlations among the six RTMD

constructs fell in the predicted directions—replicating previous findings—and 13 of the 15 were significantly different from zero at $p < .01$; likewise, evolution/creation acceptance strongly predicted global warming knowledge and acceptance (as occurring *and* anthropogenic)—notably, even more strongly than political party.

In sum, these U.S. respondents clearly knew little about the mechanism of the greenhouse effect—the anthropogenic increase of which is the basis for global warming. This is true even of individuals who accept the reality of global warming, which ought give us pause. The mere acceptance of global warming, even absent knowledge of its basic science, appears to yield warranted climate policy attitudes. We predict, though, that skeptically evaluated knowledge of a basic mechanistic account should enhance that precursory global warming acceptance. (Consider someone who might accept evolution without even having a rudimentary understanding of how organisms procreate!) Scientific literacy ought to mean that people seek out causal explanations, just as those who deny global warming—should they be believed—ought to explain the mechanism by which our planet would be unaffected by massive additions of greenhouse gas emissions. More directly, Study 1 shows that, in crucial cases, veridical knowledge has a clear relationship to one's willingness to sacrifice. It seemed incumbent upon us, then, to begin developing interventions meant to improve Americans' understandings of the basic physical-chemical global warming mechanism—as described in Study 2.

Study 2: Learning and Increased Acceptance

Drawing on past research on both physics cognition and the Numerically Driven Inferencing paradigm (NDI; e.g., Garcia de Osuna, Ranney, & Nelson, 2004), we hypothesized that a small amount of targeted information could yield dramatic conceptual changes—ultimately including changes in attitude and acceptance. In the NDI paradigm, people are asked to estimate the value of a quantity, and they are later told its true value. By having individuals "put their cards on the table" before receiving the true value, we inhibit hindsight bias and post-hoc rationalization, and the impact of the information is thus increased (Rinne, Ranney, & Lurie, 2006). Here we report on a similarly compact and empirically grounded intervention with a 400-word text that highlights the three key conceptual pieces noted in Study 1's introduction (labeled a-c). See Ranney et al. (2012) for the full text. Our most recent work combines NDI and RTMD, utilizing misleading "anti-climate change acceptance" numeric quantities—yielding notable shifts in attitudes and self-rated knowledge)—but this is outside the scope of this paper.

Method: Participants, Design, Procedure, Materials

For Study 2, 103 University of California, Berkeley, and 46 University of Texas, Brownsville, undergraduates were randomly assigned to one of two groups: "sandwich" or "no-pretest." Sandwich group participants: (1) both provided an explanation of the greenhouse effect (effectively "putting their cards on the table") and filled out knowledge and attitude surveys, (2) read a 400-word explanation of the mechanism of the greenhouse effect and gave a rating of experienced surprise, and (3) were re-tested on their knowledge and attitudes (with a posttest identical to the pretest). No-pretest (or "open-faced") group participants completed only (2) and (3) above. Thus, (1) and (3) can be thought of as "bread" and (2)—the explanation—is the "jam" of our design. The no-pretest group offers a between-subjects contrast via their posttest, obviating test/re-test concerns about experimenter demand regarding the sandwich group. Just before leaving the experiment, all participants also filled out a demographic questionnaire. Surveys were again anonymous, as in Study 1.

Below, we report data from the 85 Berkeley and 41 Brownsville students who completed the survey as intended and had been U.S. residents for ten years or more (because we expressly consider *U.S.* exceptionalism/nationalism). Of the Berkeley data, we analyzed 43 no-pretest (open-faced) surveys and the pretest part of 42 sandwich surveys—but due to anticipated time constraints, only 30 sandwich posttests could be completed/obtained. Of the Brownsville data, we analyzed 22 no-pretest and 19 sandwich surveys. To be conservative, all between-group t-tests were Welch-method adjusted for unequal variance and sample size. All hypotheses below were clearly stated as *a priori* ones and were replicated across our two samples except where noted.

The attitude survey used 12 items (on 9-point Likert scales) to assess the six RTMD constructs. True knowledge of global warming was assessed based on (1) three written responses by participants and (2) (on the posttest only:) two fill-in-the-blank items about the types of light (visible, infrared, etc.) involved in the greenhouse effect. *Self*-reports of knowledge were also reported on a 9-point Likert scale.

Results and Discussion

The Crucial Global Warming Mechanism Was Learned
Even our rather sophisticated samples initially exhibited incorrect or non-normative understandings of the greenhouse effect's mechanism (e.g., on the roles of ultraviolet light, the ozone layer's depletion, non-greenhouse-gas pollution, and the reflection of incoming light). Most notably, not a *single* pre-test explanation mentioned different light/radiation types or atmospheric retention time, despite an explicit prompt to explain any differences between the energy traveling toward and away from Earth. However, after reading the 400-word description, 61% of the Berkeley participants across both groups correctly answered that "infrared" light was emitted from Earth (in its fill-in-the-blank space), as did 55% of the Brownsville students who responded.

Beyond the blank-filling items, we statistically analyzed individuals' *qualitative* explanations—creating scoring rubrics for three central concepts: (a) differentiating between the types of light entering and exiting the atmosphere, (b) atmospheric greenhouse gases' interactions with radiation, and (c) the increased atmospheric retention time of energy. Inter-rater reliability was again high (weighted $\kappa = 0.71$ based on about one-third of the Berkeley data; $\kappa = 0.67$

across the full Brownsville dataset). Table 1 shows the percentages of all possible points: overall, we found dramatic knowledge increases (doublings, triplings, or more), which were significant for all subscales—both within-subjects for the sandwich condition, and between-subjects from the sandwich pretest to the no-pretest condition's posttest, ($p <$ .05 for all six improvement possibilities).

Table 1. The mean percentage scores for each of the three assessed global-warming constructs (with greenhouse gases = GHGs), for each test and sample (for California;Texas). All improved from pretest ('*': $p <$ .05; '**': $p <$ .005).

Group & Test (& means)	Light	GHGs	Energy
Sandwich *Pre*test (means$_{CA;TX}$ = 33%;11%)	33%; 7%	39%;16%	28%;11%
Sandwich Posttest (means$_{CA;TX}$ = 69%;37%)	78%;36% **;*	83%;39% **;**	47%;35% *;*
No-pretest Posttest (means$_{CA;TX}$ = 66%;49%)	66%;43% **;**	74%;54% **;**	57%;51% **;**

Global Warming Acceptance Via Mechanistic Learning
It may seem quite remarkable, but participants' global warming acceptance increased dramatically after our brief intervention, as predicted. To assess this, we used all of the 73 Berkeley posttest ratings in a paired t-test, and used imputation for pretest scores for the no-pretest group. (In particular, the full set of 42 pretest ratings was used to avoid sampling bias.) We found a significant change in global warming acceptance on the posttests, as compared to pretest measures ($t(72)$ = 2.28, p = .01). This result was replicated with the Brownsville surveys ($t(39)$ = 4.24, $p <$ .0001). In addition, although Study 2's statistical power was rather limited, the correlation matrices for the RTMD variables again largely supported RTMD theory—as was certainly found in Study 1 and all prior studies. The relationship between knowledge and attitudes was also reflected in Berkeley students' naïve pre-test data, in which participants' *self-perceived* ratings of their own global warming knowledge correlated significantly with their global warming attitudes (r = .39, p = .01). This was not the case with Brownsville students (r = .15, p = .55), which may be reflective of their overall lower self-perceived knowledge.

Please recall that we had also predicted a between-conditions difference in surprise ratings due to reduced hindsight biases among the sandwich participants. The difference for Berkeley students was at the significance borderline ($t(42.08)$ = 1.65, p = .05); the surprise ratings only reached "6" in the no-pretest condition (out of 9, with "5" being "somewhat surprising"), but were as high as "9" (i.e., "extremely surprising") in the sandwich condition. Among Brownsville students, surprise was uniformly higher, with a numerically similar difference between conditions, although this result was not significant ($t(38.1)$ = 0.92, p = .18).

Conclusions from Study 2
This experiment replicates and extends the findings noted earlier (from prior interviews and Study 1), such that even

rather well-educated people initially held mostly non-normative understandings of global warming's mechanism. Only 400 words later, though (roughly the duration of a TV commercial break), dramatic increases were observed in (1) mechanistic knowledge and (2) global warming acceptance. (Further, the increases were found in divergent U.S. states and colleges.) Differences in surprise ratings between the sandwich and "no-pretest" ("open-faced") groups further support the notion that eliciting an explanation or theory prior to offering information *increases* surprise and *reduces* post-hoc rationalization and hindsight bias. (On surprise, see Clark & Ranney, 2010; Munnich, Ranney, & Song, 2007.)

General Discussion

Of Study 1's 270 participants, none could fully explain that (a) visible light makes its way to Earth's surface where it is (mostly) absorbed and emitted later as infrared light, (b) this infrared light is largely (actually, 90%) absorbed by greenhouse gases before reaching outer space, and (c) this slows energy loss and warms Earth. (Ranney calls the unimpeded 10% the "Goldilocks tithe.") While others (e.g., Leiserowitz, 2007) have shown aspects of U.S. ignorance, we extend these results to mechanistic understandings of the greenhouse effect. If our sample even vaguely represents the U.S. public, then they rarely understand global warming's mechanism. Further, such knowledge *does* relate to policy preferences, willingness to sacrifice due to legislation, and beliefs about (anthropogenic) climate change's reality. We suggest that prior works' inattention to this mechanism may be because it is scientifically uncontroversial relative to the effects, mitigation strategies, and other causes re: climate change. However, it seems that mechanistic knowledge may play a key role in successful climate policy ventures.

Just as knowing "how reproduction works" supports evolutionary acceptance (cf. Shtulman & Calbi, 2012), our studies show that a mechanistic global warming understanding (e.g., a-c above) supports *its* acceptance. Study 2 showed that we increased students' acceptance by increasing global warming knowledge. Space prohibits a full treatment of this, but a new study further shows that, after providing people with misleading, cherry-picked facts, we caused them to discount climate change (dropping from 6.5 to 5.9 on a 9-point scale) with a dramatic, concurrent drop in their confidence in their knowledge (plummeting from 5.0 to 2.9, on a 9-point scale). Thus, as the nefarious are well aware, empirical data *do not always* increase acceptance, global coherence, and self-confidence in one's understanding.

In short, work spawned by the Reinforced Theistic Manifest Destiny theory (Ranney, 2012; Ranney & Thanukos, 2011) regarding concerns about U.S. exceptionalism led us to find a successful way to enhance wisdom about the greenhouse effect's mechanism. That is, we found that instruction focused on a mere 400 words of text dramatically increases undergraduates' global warming understandings *and* increases their mean acceptance of anthropogenic global warming. We suspect that our instruction is effective in that it addresses head-on the implicit mystery of how ener-

gy—as visible light—can easily get close to Earth's surface and troposphere, yet has difficulty leaving that surface/troposphere (as absorbed, intercepted infrared light). Future research will determine our intervention's longevity, among other attempts to better comprehend the landscape of the cognitions and emotions regarding global warming. As the studies above demonstrate, insights from cognitive science show much promise for tackling the challenges for climate-relevant education in the U.S. and abroad.

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