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Improving Americans' Modest Global Warming Knowledge in the Light of RTMD (Reinforced Theistic Manifest Destiny) Theory

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Abstract: Study 1 (N=270) reveals U.S. knowledge about global warming's mechanism to be poor, but Study 2's experiment (N=149) shows that a brief, 400-word text yields both large knowledge gains *and* more climate change *acceptance*. The results cohere with RTMD theory.

Global warming ("GW;" climate change) is generally occurring much faster than species adapted to in past eras (see Harte & Harte, 2008), threatening myriad species' (e.g., humans') futures. Unfortunately, U.S. residents are less concerned about GW than those of similarly developed "peer" nations (Leiserowitz, 2007)—one of many dimensions by which Americans are marked outliers (Ranney, in press). Ranney explains a variety of such divergences with Reinforced Theistic Manifest Destiny (RTMD) theory, addressing how various (largely peer) nations' collective, theistically-related beliefs have developed—due to military, economic, etc., feedback.

Beliefs generally follow understanding; for instance, biologists largely accept evolution more than do "Biology 1" students (cf. Shtulman & Calabi, 2008). In two studies, we assess the hypotheses that (1) proper GW understanding is rare, but (2) fostering GW understanding has desirable effects, such as increasing GW acceptance. One rarely finds a concise explanation of GW's basic physical/chemical mechanism without unnecessary details, so Study 2 assessed our prediction that such a mechanistic explanation can *markedly* help people appreciate the soundness of GW's science—increasing acceptance, concern, and imperative action.

Please take a minute to answer this: "How would *you* explain global warming's mechanism?" (This is a difficult question; even most professors answer inaccurately.) Now, read this 400-word answer, which we used as Study 2's intervention (written by Ranney, Reinholz, and Lloyd Goldwasser, with Ronald Cohen's counsel):

How does climate change ("global warming") work? The mechanism of the greenhouse effect

[Or: "Why do some gases concern scientists—like carbon dioxide (CO_2)—but not others, like oxygen?"]

Scientists tell us that human activities are changing Earth's atmosphere and increasing Earth's average temperature. What causes these climate changes? ¶ {¶= intervention paragraph break} First, let's understand Earth's "normal" temperature: When Earth absorbs sunlight, which is mostly visible light, it heats up. Like the sun, Earth emits energy—but because it is cooler than the sun, Earth emits lower-energy infrared wavelengths. Greenhouse gases in the atmosphere (methane, carbon dioxide, etc.) let visible light pass through, but absorb infrared light—causing the atmosphere to heat up. The warmer atmosphere emits more infrared light, which tends to be re-absorbed—perhaps many times—before the energy eventually returns to space. The extra time this energy hangs around has helped keep Earth warm enough to support life as we know it. (In contrast, the moon has no atmosphere, and it is colder than Earth, on average.) ¶ Since the industrial age began around the year 1750, atmospheric carbon dioxide has increased by 40% and methane has increased by 150%. Such increases cause *extra* infrared light absorption, further heating Earth above its typical temperature range (even as energy from the sun stays basically the same). In other words, energy that gets to Earth has an even *harder* time leaving it, causing Earth's average temperature to increase—producing global climate change. ¶ [In molecular detail, greenhouse gases absorb infrared light because their molecules can vibrate to produce asymmetric distributions of electric charge, which match the energy levels of various infrared wavelengths. In contrast, non-greenhouse gases (such as oxygen and nitrogen—that is, O_2 and N_2) don't absorb infrared light, because they have symmetric charge distributions even when vibrating.] ¶ Summary: (a) Earth absorbs most of the sunlight it receives; (b) Earth then emits the absorbed light's energy as infrared light; (c) greenhouse gases absorb a lot of the infrared light before it can leave our atmosphere; (d) being absorbed slows the rate at which energy escapes to space; and (e) the slower passage of energy heats up the atmosphere, water, and ground. By increasing the amount of greenhouse gases in the atmosphere, humans are increasing the atmosphere's absorption of infrared light, thereby warming Earth and disrupting global climate patterns. ¶ *Shorter summary*: Earth transforms sunlight's visible light energy into infrared light energy, which leaves Earth slowly because it is absorbed by greenhouse gases. When people produce greenhouse gases, energy leaves Earth even more slowly—raising Earth's temperature.

Study 1: A Paucity of American Mechanistic GW Knowledge is Evidenced

To assess GW attitudes and mechanistic understandings, we administered 270 surveys to San Diego park visitors (n = 201) and community college students (n = 69). Given space limits, we report here only on some of the survey's items about: (1) GW opinions, (2) short-answer GW knowledge, and (3) other RTMD constructs.

Our hypothesis that Americans rarely understand GW's mechanism was supported. In trying to explain the GW mechanism, only 32 (12%) of our 270 participants referenced any gases (CO_2, pollution, emissions, etc.) as raising heat retention (which represents a modest, partial understanding). Only four of these 32 (1%) tried to differentiate types of energy, and *not one* (0%) mentioned either correct absorption(s) or the input/output light asymmetry (e.g., visible/infrared)—which are jointly the crux of GW understanding. Just 8 people (3%) named the greenhouse effect. Misconceptions were abundant; for instance, 42 people (16%) claimed that GW occurs because more heat is entering the atmosphere due to its—or the ozone layer's—destruction. Importantly, participants' "true" mechanistic knowledge (scored with high reliability) was correlated with their willingness to accept GW as both real (r = .22, p = .0002) *and* anthropogenic (r = .17, p = .005). Finally, all 15 correlations among RTMD's six constructs were again found to be in the RTMD-predicted directions, replicating previous findings (see Ranney, in press); thirteen of the 15 were significantly different from zero at $p < .01$.

Study 2: People Quickly Learn the Mechanism and Then Accept GW More

Our intervention was the 400-word text above (see the prior page). University of California, Berkeley (n=103) and University of Texas, Brownsville (n=46) undergraduates were randomly assigned to one of two conditions (N=149): "Sandwich" students: (1) provided GW mechanism explanations and completed a knowledge-and-attitude survey, (2) read the 400-word GW explanation and rated their experienced surprise, and (3) performed (1) again. "No pre-test" students only did (2) and (3)—thus, no (1). Design-wise, (1) and/or (3) can be thought of as "bread slices" and (2)—the explanation—as "jam." (The no pre-test group provides a between-subjects contrast via their post-test, obviating anchoring or experimenter-demand concerns in the sandwich group.)

We largely report here data from the 85 Berkeley students who had been U.S. residents for ten or more years—to ensure sufficient American identity. (All students filled out a demographic sheet at experiment's end.) We analyzed 43 "no pre-test" surveys and the pre-test part of 42 sandwich surveys. Due to (expected) time constraints, only 30 sandwich post-tests were completed/obtained. As in Study 1, textual responses were rated to yield "true" GW knowledge scores. *Self*-reports of knowledge were reported on a 9-point Likert scale.

Study 2 replicated Study 1's findings of prevalent misconceptions. Across all pre-tests, not a *single* student mentioned different light/radiation types or atmospheric retention time, despite an explicit prompt to explain any differences between the energy moving toward and away from Earth. After reading the 400-word description, though, 61% of Berkeley students (and 55% of Brownsville students) across both conditions correctly answered that Earth emitted *infrared* light. We also found dramatic increases in true (scored) GW knowledge. Improvements within-subjects for the "sandwich" condition, as well as between-subjects (the "no pre-test" post-test vs. the "sandwich" pre-test), were significant—both overall (roughly doubling from 31% to 64%), and for all three subscales (i.e., knowledge measures about light, energy, and greenhouse gases; $p < .05$ for all six improvement possibilities). Remarkably, students' GW *acceptance* also increased dramatically after our brief intervention, as predicted. Using all 73 post-test ratings in a paired t-test, and employing imputation for pre-tests scores for the "no pre-test group," we found a significant gain in GW acceptance on the post-test, compared to the pre-test ($t(72) = 2.28$, $p = .01$). Brownsville surveys clearly replicated this result ($t(39) = 4.24$, $p < .0001$). The knowledge-attitude link was also reflected in naïve pre-test scores, as students' *self*-perceived ratings of their own GW knowledge significantly correlated with their GW attitudes ($r = .39$, $p = .01$).

Summary: Many More People Will Accept GW After They Learn Its Mechanism

None of Study 1's 270 people explained the *basic* greenhouse effect (which is possible in < 35 words, without using technical words such as "absorb" or "infrared"). If our samples even vaguely represent the U.S. public, then Americans rarely understand global warming's mechanism. Just as mechanistic knowledge of reproduction likely supports evolution acceptance (cf. Shtulman & Calabi, 2008), we have shown that mechanistic GW understandings support GW acceptance. In Study 2, we found that increasing GW knowledge correspondingly increases students' acceptance; a mere 400 words of instruction not only dramatically increased undergraduates' GW understandings—it also increased their mean acceptance that (anthropogenic) global warming is occurring.

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