Knowledge Helps: Mechanistic Information and Numeric Evidence as Cognitive Levers to Overcome Stasis and Build Public Consensus on Climate Change

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A clear, growing consensus indicates an urgent need for humans to reduce the burgeoning effects of global climate change ("global warming" or GW). Apt public instruction seems central to achieving critical behavioral changes, but some researchers suggest that U.S. climate attitudes are doomed to cognitive stasis (i.e., that little will be gained by educating the public). Herein are four studies that counter the stasis view. Our laboratory has previously reported findings that (1) virtually no Americans know the basic climate change mechanism, yet it (2) is quickly learned (in a few minutes, e.g., with a 400-word text), which (3) increases climate change acceptance. Below, Studies 1 and 4 replicate and extend these results to demonstrate (a) efficacy with an online presentation and broader populations and (b) retention up to a month after learning the mechanism. Studies 2-4 explore roles for germane numerical information using estimation with feedback. Study 2 shows that (d) misleading, cherry-picked, statistics can decrease climate change acceptance (and shake metacognition), while Studies 3 and 4 show that (e) surprising scientific information must be presented with care for it to foster beliefs in line with climate science's consensus. In sum, contrary to unnecessarily pessimistic (and correlational) "stasis" arguments, highly germane science information can clearly change the public's understandings and opinions.

Keywords: cognitive change, science education, explanation, climate change, global warming, acceptance, mechanism.

Climate Change as a Behavioral Problem

Our atmosphere's carbon dioxide (CO_2) concentration is higher now than in any of the past 15 million years (World Bank, 2012). Global warming (GW) akin to recent trends last occurred over 17 million years ago, when a 3-4°C gain occurred over *1,500,000 years*. Standard models show that continuing our current behavior will yield similar warming in *just 100 years*. In previous warming periods of this magnitude, widespread extinctions occurred. With imminent warming 10,000+ times faster than historical timescales, the biological systems we depend upon (e.g., for food) will clearly be severely impacted (Barnosky, 2009). Nearly all climate researchers have concluded that the problem is urgent and anthropogenic (i.e., essentially 100% human-caused). It is thus behavioral, and will be "solved" only by changes in human behavior. The IPCC (Intergovernmental Panel on Climate Change) and Skeptical Science have assembled and disseminated the scientific consensus on GW, but, sadly, the U.S. public is still divided on both GW's existence and its cause (cf. Hoffman, 2011).

A group of climate communication researchers, oddly, suggests that educational ventures would be of little or no help. Kahan et al. (2012) found (through correlational means) that, for the U.S. (a high per-capita carbon user), direct cognitive approaches (including numeracy *and* science education) seem to solidify biased views—reinforcing a kind of cognitive stasis for GW attitudes. This is reminiscent of Lord, Ross, and Lepper (1979), in which people *with a strong position* tended to polarize further after receiving (not particularly factual) information contrary to their views. Similarly, McCright and Dunlap (2011) highlight data indicating that climate-relevant effects of "education level" are moderated by conservatism or party. (Conservative or "Republican" GW denial was slightly positively related, if at all, with education.) This (also correlational) evidence, they claim, disproves a naïve "knowledge deficit" view—the view that more education can shift the public's beliefs toward the scientific consensus about climate change. However, their own work shows that liberals and conservatives tend to obtain different kinds of information. This split leaves open the possibility that *well-constructed* interventions may well induce conservatives to accept the scientific consensus (with little challenge to their core values). Indeed, Lewandowsky, Gignac, and Vaughan (2013) show that offering climate scientists' consensus boosts anthropogenic climate change acceptance.

Our laboratory has provided arguments and many experimental findings that run counter to these "polarization" and cognitive stasis views: For instance, even a small amount of true information can quickly act as a cognitive "lever" to enhance one's understanding and perspective on climate change (Ranney et al., 2012a)—and many other social issues (e.g., abortion and immigration)—and even using just a single number/statistic (Garcia de Osuna, Ranney, & Nelson, 2004; Munnich et al., 2003; Ranney et al., 2008). Below, we offer further experimental results that counter the stasis view for climate education. Notably, we analyze the full spectrum of participants, rather than filtering for those who are already relatively extreme.

Note that new knowledge often facilitates societal shifts *and* that science "education" has historically driven major social changes—from heliocentrism replacing church doctrine to the acceptance of a tobacco-cancer link in spite of industry obfuscation. (We offer more such germane evidence below.) These data-driven shifts demonstrate how sociologists and social psychologists who hold the stasis view *must* be incorrect or overly pessimistic. Whether or not they realize it, theorists are haggling over *speed*, and some

nations learn (e.g., to accept evolution or climate change; Ranney, 2012) faster than others. Of course, learning or acting too slowly can exacerbate existing problems.

We partially agree, though, with those who critique a "knowledge deficit" view of public attitudes (cf. Dickson, 2005). Arbitrary or propaganda-like information need not drive one toward a more empirically supported view. We see the problem, rather, as a *wisdom* deficit, for which cognitively sophisticated educators can provide the tools that help the public better evaluate the evidence and make choices that match their values. (See Lewandowsky et al., 2012, for a fine discussion of such tools, particularly the correction of misinformation.) We believe that the findings described here will demonstrate that a well considered educational approach is critical for public engagement.

The GW Mechanism: Extra Greenhouse Effect

Much of our laboratory's prior research has sought to foster worthwhile, notable conceptual changes with short activities that involve estimations, predictions, or explanations. These activities are followed by small amounts of feedback: Numerically Driven Inferencing studies (NDI; e.g., Ranney et al., 2008) have provided numeric feedback. RTMD (Reinforced Theistic Manifest Destiny) theory, which examines why people in the U.S. are less likely to accept evolution and climate change than are people in peer nations (e.g., Ranney, 2012), has yielded mechanistic interventions.

Ranney et al. (2012a) found that *almost no Americans* seem to understand the basic mechanism of global warming. Ranney et al. (2012b) includes a 400-word explanation (and experimental stimulus) of the physical-chemical mechanism of the greenhouse effect, here summarized: (1) Earth's surface absorbs (mostly visible) sunlight and then emits *infrared* light, which greenhouse gases absorb, causing heat energy to leave the atmosphere more slowly than it arrived; (2) as people add more greenhouse gases, the Earth experiences climate change (an *added* greenhouse effect). In one survey, not a single person out of 270 (mostly public park visitors) could correctly describe (1) and (2). Virtually none of those surveyed could explain a key conceptual piece: the asymmetry of how energy can reach Earth yet then get "trapped" after it arrives (like a "leaky one-way-valve"), due to the visible-to-infrared energy conversion.

Mechanism Knowledge is Related to GW Attitudes

Ranney et al. (2012a) found that the correlation between mechanistic climate change knowledge and attitude toward climate change was robust even when taking into account political party. Mechanistic knowledge correlates with acceptance that global warming is occurring ($r=0.22$, $p=0.0002$) and is anthropogenic ($r=0.17$, $p=0.005$). Anthropogenic climate change acceptance also predicted financial "willingness to sacrifice" ($\chi^2(4) > 32$, $p<0.001$ for each of four items), and one's knowledge score predicted two of these items ($\chi^2(1) > 3.8$, $p<0.05$ for both). Further, acceptance of biological *evolution* (another controversial science topic) was found to predict beliefs and attitudes

toward *climate change* (as RTMD hypothesizes, and, e.g., Ranney, 2012 found). These findings suggest that the effects of well-chosen aspects of education are both significant and somewhat independent of political affiliation. Indeed, though not reported previously, Ranney et al.'s (2012a) data also showed that evolution acceptance was a significant predictor of climate change acceptance *even in a model including the two major political parties* ($\chi^2(4)=12.3$, $p<0.02$; N.B., including other parties dramatically *reduces* quality of fit for any model, likely due to small bin sizes).

Efficacy in Learning Climate Change's Mechanism

Ranney, et al. (2012a & 2012b) also provided two divergent undergraduate samples (from UT-Brownsville, a "Hispanic-Serving Institution," and UC-Berkeley) with the aforementioned 400-word description. Strikingly, this three-minute intervention roughly tripled their mechanistic knowledge on the assessment metric. The intervention also caused both Texas and California undergraduates to increase their climate change acceptance. Contrasting with others' studies noted above, our intervention focused on a fundamental, *well-researched knowledge gap*, and our assessment focused on *acceptance/belief*. Such contrasts may explain the difference between observing instructional benefits (as we have) or polarization (as others occasionally have; cf. Lundmark, 2007). We provide further evidence below that such interventions are applicable across broader settings, time-frames, and populations, and that global warming understandings and attitudes are far from static.

Study 1: A Web-based and Longevity Extension

Given the replicated demonstrations of significant attitude changes described above, we proceeded to assess whether the mechanism-explanation effects we had obtained were durable or transient. This study extended prior work by delaying the post-test several days. We were also concerned that an "experimental demand" from the classroom setting might have driven our prior results, so we provided the intervention on-line; that is, we assessed whether our materials would elicit significant attitude change even though students participated via their own computers, without experimenter observation. Thus we concurrently explored both the longevity (via delay) and format (on-line) aspects of our phenomenon. We also extended our prompts to incorporate more demographic and introspective queries.

Methods. The instructional materials were those reported in Ranney et al. (2012a & 2012b; the latter includes the full 400-word text of our intervention). The empirical differences were that (a) the study was conducted online, via the Qualtrics Inc. (Provo, UT) system, (b) eight items were added to pre- and post-test attitude surveys to add reliability to the related RTMD metrics (specifically, national and religious affinities; these metrics will be reported elsewhere), and (c) five further items were introduced immediately following the instructional material to elicit introspection (about embarrassment, disagreement, etc.).

Undergraduates (N=80) were recruited via the Research Participation Program (RPP), of the University of California, Berkeley (UCB) psychology department, which allowed us to administer a pre-test to about half of the students (38) between eight and 26 days ($\overline{x}$=18.5 days) prior to the study, which may have allayed test-retest effects (although Ranney et al., 2012a, found little evidence for them). Thus, as with Ranney et al. (2012a), some students received the full survey testing "sandwich" while others had no pre-test. A delayed post-test was given to all participants between one and eight days later ($\overline{x}$=4 days); this range was used to assess the timecourse of retention in planning subsequent studies. We lack the power to test forgetting over time here (although numerically, we did not find any!).

Results and Discussion. In general and as anticipated, we replicated Ranney et al.'s (2012a) results and extended them by finding that gains were retained over the mean, four-day, delay. (Note: all of this piece's measures use 1-to-9 Likert scales.) Scored knowledge was again linked to self-rated knowledge (r=0.5, p<0.0001) and was similar to that of prior UCB students. Scored knowledge soared from 3.8 (pre-test) to 6.5 (post-test) and 6.3 (delayed post-test); gains were significant (p's<0.0001, simultaneous comparisons). Stated GW beliefs followed a similar pattern. Mean ratings rose from 6.20 (pre-test) to 6.54 (post-test) and were mostly retained at 6.44 (delayed post-test)—notable gains (again) for a 400-word text (t(79)=2.5, p=0.006 for immediate, and t(79)=1.7, p=0.05 for delayed). The largest post-test gains were found in agreeing with "Human activities are largely responsible for the climate change…" (a 0.25 gain) and certainty that global warming is occurring (a 0.19 gain). The self-rated knowledge mean similarly increased markedly from pre- to post-test (4.5 to 5.6). This gain's retention, gratifyingly, was also noted on the delayed post-test (5.2; simultaneous comparisons for both the gain and retained gain were again significant; p's<0.0001). The immediate increase in self-rated knowledge replicates results from Ranney et al. (2012a; the results were not reported then).

In sum, Study 1 extends the finding that well-considered information, *even received online*, increases anthropogenic GW acceptance and behaviorally relevant attitudes. Further, the conceptual changes that result from reading even 400 words have notable longevity. These effects have been replicated with the general public as well (unpublished data). Computer-based interventions often scale well, enhance reliability, and prove cost-effective; so, given our results, we recommend the online distribution of mechanistic explanations, especially about climate change.

Altering Beliefs with Factual Numbers

The aforementioned NDI paradigm has yielded marked attitudinal and conceptual shifts with quite minimalist interventions. NDI and one of its procedures, EPIC (both introduced by Ranney and students), represent a particularly compact, well-specified intervention. EPIC participants (1) provide an **Estimate** for each policy-relevant item's quantity, (2) state a preferred target (or monetary allocation) **Policy** (or **Preference**) for each quantity, (3) receive true feedback quantities to **Incorporate** (as new "**Information**"), and (4) indicate whether their policies have **Changed** due to the feedback. With just a single well-selected quantity, the EPIC procedure's feedback often shifts one's attitudes. EPIC-spawned conceptual changes are often remarkably durable for such a small intervention (e.g., Ranney et al., 2008), as evidenced by increased estimation accuracy 12 weeks after the procedure (Munnich, Ranney, & Bachman, 2005). Therefore, we sought to employ NDI interventions in addition to the mechanism intervention from Study 1 and prior studies. Specifically, we presented different participant groups with numerical information that is relevant to global climate change acceptance. We used numbers that were likely to boost acceptance (Studies 3 & 4), as well as numbers that we thought might erode individuals' acceptance of climate change (Study 2).

Study 2: Eroding Beliefs with "Evil" True Numbers

Some organizations publicize out-of-context facts to try to undercut the reality or gravity of human-caused GW. These are usually blatantly cherry picked, such as that Earth slightly *cooled* by 0.2°F (.04% re: absolute-zero terms) from 1940 to 1975 (Jastrow, Nierenberg, & Seitz, 1991). While surprising, this fact hardly contradicts the ever more obvious warming trend over the last 125+ years: one can easily pick endpoints that are oddly high or low in a noisy time series. (The slight decrease is also explained by a planetary motion trend.) Given this rather clear intent to mislead (Oreskes & Conway, 2010), we (partly tongue-in-cheek) label these numbers "evil." Thus, Study 2's hypotheses are that a few misleading facts can reduce one's (1) climate change acceptance, (2) ratings of knowledge of the issue, and (3) climate-change funding preferences. Of course, lest we erode participants' acceptance of anthropogenic climate change more than fleetingly, we debriefed them right afterward with more complete information—including the mechanism and a large dose of (non-evil) relevant facts.

Methods. The survey and instructional materials were analogous to those used in Ranney et al.'s (2012a) paper-and-pencil second study. The main difference was that the mechanism was replaced with one of two interventions. For one version, part (n=59) of a UCB college class (N=104) estimated each of eight items before receiving the feedback values, with an emphasis on maximizing the quantity of feedback numbers given to the student. To this end, this eight-item survey included only a post-test (i.e., no pre-test), and lacked a policy component (thus, it was an EI intervention, lacking "P" or "C"). A more comprehensive engagement containing only two items was administered to the rest of the class (n=45), and this version included a pre-test and extra questions about each item; we asked these students about their surprise level after each feedback value and requested both their climate-change funding *Policies*

and post-feedback policy *Changes* regarding/versus various UN (e.g., UNDP millennium) goals.

Results and Discussion. As predicted, preferences for funding GW-related UN goals dropped ($x^2(1)=22$, $p<0.01$) versus *all* eight non-climate UNDP funding alternatives. (Unfortunately for GW as a social priority, the highest mean pre-test preference for funding climate change initiatives reached only a 50-50 split of available funds.) Also as predicted, climate change acceptance significantly dropped, from a 6.5 pre-test mean to a 6.2 post-test mean for the two-item group (5.5% of the available room to drop on the 9-point scale, $t(42)=-4.3$, $p<0.001$), and significantly to 5.9 for the eight-item group (11% of the available room, $t(88.6)=-2.61$, $p<0.005$); note that these shifts were also in the direction of ambivalence (a "5" rating), and may reflect confusion rather than disagreement. Our third hypothesis was also supported: self-rated knowledge fell from a mean of 5.0 on the pre-test to 4.5 for the two-item group (12% of the available room, $t(44)=-2.5$, $p<0.01$), and plummeted to 2.9 on eight-item survey ($t(87.2)=-5.3$, $p<0.001$). This latter drop of 2.1 is 53% of the available room to drop on a 9-point scale, which is exceptionally large.

It is clear that even relatively educated members of the public (e.g., undergraduates at a top-tier university) are highly susceptible to misleading, cherry picked facts. Such facts are clearly known to organizations attempting to undermine the overwhelming scientific consensus about climate change. Thus, it seems incumbent upon cognitive science to counter the increasing sophistication with which such organizations distribute misleading information.

Study 3: "Saintly" Numbers Supporting GW

Given Study 2's observed efficacy for "evil" numbers and the NDI paradigm's prior successes, this study assessed the utility of numbers that support claims of global warming. Again partly tongue-in-cheek, we call these "saintly" numbers. Given prior NDI studies of similarly "shocking" magnitudes (e.g., Garcia de Osuna, et al., 2004), our hypothesis was that the accurate feedback would increase participants' climate change acceptance, but diminish self-confidence in their knowledge of the issue.

Methods. Like Study 1, Study 3 was both online and used a UCB-RPP pre-test survey (for a subset of 30 students); however, we increased the delay between pre-test and intervention to a mean of 18 days. We queried the individuals (N=60) about eight quantities. The eight items also included questions directed at participants' surprise and their reactions to each number. (Monetary preferences were left out of this version because we already observed attitude shifts in the simplified eight-item "evil" intervention.) An added feature of the on-screen intervention is that we could more saliently remind individuals of each of their estimates on the same page on which they incorporated numerical feedback, better ensuring that they contrasted the two. As with Study 1's online survey, a post-test about attitudes and

beliefs was administered both immediately after our intervention and after the 18-day retention interval.

Results and Discussion. Attitudes, acceptance, and beliefs about climate change were stable after this intervention with "saintly" numbers (pre-test: 6.71; post-test: 6.67). This stability was unexpected (but see below for explanations), especially because these items (as with the "evil" items) were, as anticipated, able to significantly erode self-rated knowledge (5.3 to 4.0, $t(29)=-3.6$, $p<0.01$). This erosion was comparable to that found with the "evil" numbers. These items were also relatively high regarding participant surprise, compared to Study 1's 400-word intervention. The mean surprise rating across Study 3's items was 4.8, while the mean surprise rating for the 400 words was 2.9. (All ratings above "1" indicate some level of surprise.)

One of the most surprising numbers (a 5.2 mean) was the near-100% of active researchers who support anthropogenic climate change's tenets, reflective of the strong relationship between the perceived scientific consensus and climate change acceptance, as Lewandowsky, Gignac, and Vaughan (2013) report. The two numbers most similar to the statistics in the 400 words were similarly surprising, with the rises in atmospheric methane (+151%) and CO_2 (+40%) yielding respective surprisingness means of 5.9 and 5.1.

Despite these powerful impacts, Study 3 yielded no effect on beliefs or attitudes. This lack of effect is counter to prior NDI studies, in which individuals' preferences and beliefs were often markedly shifted by even a single number. (An experimental silver lining here is the finding that participants will not report greater climate change acceptance by mere dint of experimenter demand!) One possible explanation regards an unintended method change: Participants in prior NDI and RTMD studies were usually told the particular scientific/literature source—both for each statistic that was sought and each true value provided as feedback. Study 3 omitted this, so is possible that participants were less compelled by the authority of this study's statistics, compared to those in Study 2. Another possibility is that these UCB students were near ceiling for acceptance, with a reluctance to admit the disturbing effects of GW. Further, it may be that, as in Study 2, participants were left feeling less knowledgeable—weakening any boost these surprising numbers could have had on climate change acceptance. Finally, perhaps students lacked an appropriate context for integrating this information. The next study illustrates one way to contextualize such feedback statistics.

Study 4: Consolidating Knowledge-Gain Effects

Study 4 explores combining (a) the replicated effect of explaining global warming's mechanism and (b) the promising effect of offering representative statistics that support understanding of GW's effects and dangers. Participants were 63 urban San Francisco Bay Area high-school students, who likely better represent the general public than do the prior studies' university undergraduates.

Methods. The students were in three junior-level chemistry classes. Much of the school (40%) is on free/reduced lunch (a low-income marker), 95.1% is "non-white," and just 35% lists English as their primary language. We presented them with (1) a more elaborated mechanistic explanation/mini-curriculum, and (2) six *key* GW statistics. A control group received (1) from above, with (3) six *unrelated* statistics. We predicted that (i) the mechanistic explanation would yet again yield gains in climate-change understanding and more pro-environmental attitudes, (ii) the key statistics would enhance such effects, and (iii) the effects would remain a month later. Felipe (2012) describes the intervention and results more completely. Everyone received 15 minutes' instruction on climate change's mechanism for each of three days. After estimating each of the six critical climate change quantities, the experimental group (n=33) received the true values as feedback. The control group (n=30) received six estimation-feedback values that proved equally surprising but which were unrelated to climate (drawn from Ranney et al., 2008). Each student filled out a pre-test, a post-test (three days later; N=63), and a delayed post-test (34 days later; N=59). Of each test's many measures, we focus here on scientific mechanistic knowledge, attitudes toward global warming, and Environmental Behavioral Intentions (EBI). We report below only the gist of some of Felipe's (2012) notable findings, yet provide some newer findings about the effects of relevant, surprising numbers on the retention of gains from the mechanistic knowledge curriculum.

Results and Discussion. Pre-test mechanism knowledge was so close to zero that the curriculum hugely increased both groups' GW-mechanism understandings—by 1,619%, on average (combined $t(62)=9.31$, $p<0.0001$). Gains in both groups' mean EBI scores were also quite notable ($t(62)=5.91$, $p<0.0001$); the effects emphatically replicate our prior three studies' findings that show the importance of mechanistic information in enhancing a person's GW understanding and "pro-environment" attitudes. Even more importantly, the gains were significant 34 days later for both groups (control $t(27)=3.01$, experimental $t(28)=5.2$, both p's<0.002), which seems an especially impressive effect for less than one day's class out of about 170 instructional days. (One might imagine the curriculum's effect if it were extended or reinforced multiple times—or given to the general public.) Interestingly, although the control group greatly gained by learning the mechanism, the experimental group's retention of their mechanistic knowledge was significantly greater than—about twice—that of the control group ($t(48.7)=-2.61$, $p=0.01$; planned comparison after a significant ANOVA interaction term), suggesting that the experimental group's critical statistical information helped reinforce and secure the mechanistic information. Thus, the numbers may have "primed the pump" for learners to more durably encode their new GW mechanism knowledge. The differences show separate utilities for both the mechanistic information and the statistically pertinent information—and the suitability of our brief intervention for high school students, and, likely, the wider public.

Students' acceptance of climate change and concern about its effects were both near ceiling on the pre-test (8.3 and 8.1, respectively, thus range-restricted on the 1-9 scales); even so, the experimental group exhibited a significant gain ($t(32)=1.76$, p<0.05). Interestingly, the curriculum inadvertently *slightly* increased students' acceptance that climate change is "just part of a *natural* cycle" (but to only a modest 3.7 on the 9-point scale) rather than anthropogenic (which slightly dropped, yet remained at about 7 on the 9-point scale). Upon analysis, this modest, counterproductive result was due to the curriculum focusing on how, prior to humans' influences, Earth's evolution already yielded greenhouse gases and a greenhouse effect. The curriculum failed to communicate carefully that humans have caused an *extra* greenhouse effect, which *represents* anthropogenic climate change. This finding highlights the importance of understanding that, while the greenhouse effect in which our species evolved had long kept Earth from being a virtual snowball, the extra greenhouse gases that humans have pumped into the atmosphere during the past 250+ years are disturbing a narrow thermal balance. Educators should emphasize that, as with drinking ten gallons of water, a beneficial substance can turn deadly in excess.

General Discussion

Our studies have provided an evidential medley that effectively disconfirms the idea that GW-relevant knowledge and attitudes are locked in cognitive stasis. Contrary to those who over-problematize a "knowledge deficit" (or "information deficit") view of global warming communication, we see a "wisdom deficit." Here (and in Ranney et al., 2012a) we have markedly un-problematized any deficit with our interventions' "cognitive levers." In contrast, it is unlikely that offering an ill-structured list of uncompelling facts to an unprepared mind (or thinly veiled rhetoric; cf. Lord, Ross, & Lepper, 1979) will notably alter beliefs or behaviors—especially for the difficult topic of climate change. Rather, one must be sensitive to specific (mis)understandings that may be relevant to a learner grappling with a domain. Ultimately, we will likely need to engage virtually all people, aiding them in connecting their long-term values to the long-term effects of their behaviors.

Disturbingly, Study 2 showed that climate change acceptance can be readily eroded by misleading, cherry-picked data. To guard against such "evil" misinformation, people need the context to recognize them as the clever propaganda that they are. Such prophylactic interventions may represent promising targets for further educational research initiatives (cf. Lewandowsky et al., 2012).

We are currently studying ways to disseminate the information that we have found to elicit worthwhile cognitive and belief changes. For instance, we are developing on-line instructional materials (e.g., videos) that can widely convey both global warming's mechanism and the statistics that reflect the scientific consensus of climate change—so the public can more fully join that consensus. Even if people forget an offered statistic or a mechanistic

aspect, we hope they will recall being rationally convinced of climate change's reality, danger, and need for action.

We have shown above that on-line survey interventions, brief curricula, and classroom lessons can have a marked and persistent effect on one's knowledge, understanding, beliefs, and attitudes about global warming. Despite arguments to the contrary, some simple cognitively-informed interventions may well be fundamental in building humanity's resolve to tackle global climate change.

Acknowledgments

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