frontiers in Communication

EMPIRICAL STUDY
published: 22 March 2019
doi: 10.3389/fcomm.2019.00007

Communicating Climate Change Oceanically: Sea Level Rise Information Increases Mitigation, Inundation, and Global Warming Acceptance

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Specialty section:
This article was submitted to Science and Environmental Communication, a section of the journal Frontiers in Communication

Received: 31 August 2018
Accepted: 04 February 2019
Published: 22 March 2019

Citation:
Velautham L, Ranney MA and Brow QS (2019) Communicating Climate Change Oceanically: Sea Level Rise Information Increases Mitigation, Inundation, and Global Warming Acceptance. Front. Commun. 4:7. doi: 10.3389/fcomm.2019.00007

Cognitive impediments and global warming's gradual pace, among other factors, have inhibited some people from detecting climate change's everyday effects. This results in global warming often being perceived as a non-urgent, non-personal, threat that inhibits larger-scale collective action combatting climate change and public will regarding such action. Extreme weather events that global warming causes or exacerbates (e.g., hurricanes, flooding, heat, and droughts), however, are memorable due to their high emotional, social, and economic costs. Sea level rise is an especially salient American issue, given recent heightened storm surges, and the large population-segment who live in or near coastal areas with dangerous flooding risks. In this experiment, we show that providing American participants with U.S.-specific information about the economic and/or geographic/cartological effects and risks of sea level rise results in (a) an increased acceptance of oceanic rise as a phenomenon that is concerning and caused by global warming, and (b) an increased acceptance, in general, of global warming's anthropogenic nature. Communicating sea level rise information also led to (c) a general decrease in nationalism and (d) changes in the perceived effectiveness of mitigation strategies for sea level rise–specifically (d1) a decrease in the perceived effectiveness of constructing sea walls /dikes and (d2) an increase in the perceived effectiveness of phasing out fossil fuel usage. Overall, we find that communicating striking information about this oceanic by-product of global warming is an effective way to motivate acceptance and engagement with the issue of climate change in a reasonably broad manner. The experimental findings replicate, extend, and dovetail with prior experiments by our laboratory, bringing up to six the number of brief interventions (i.e., of roughly 5 or fewer minutes) that have been proven to increase people's science-normative beliefs about global warming. Our laboratory's website, HowGlobalWarmingWorks.org, offers samples of these materials, which additionally include surprising statistics, textual and video explanations of global warming's mechanism, and a contrast of Earth's temperature rise since the 1880's vs. the U.S. stock market rise since then.

Keywords: cognition, sea-level-rise, global warming, nationalism, climate change, education, psychology

INTRODUCTION

Current sea level acceleration is unprecedented in human history (Woodworth et al., 2009; Rahmstorf, 2010). Sea levels, rising since the 1800's (Christensen et al., 2007; Church and White, 2011), are expected to rise at least until 2100 (Holgate and Woodworth, 2004; Church and White, 2006)—a phenomenon widely agreed to be due to global warming. Global sea levels are predicted to increase 0.2–0.6 m beyond 1990 levels by 2095 (Solomon et al., 2007) and alternative predictions vary from 0.5 to several meters before 2100 (Hansen et al., 2006; Schubert et al., 2006; Carlson et al., 2008). More recent projections (Fischer et al., 2018) indicate that even these alternative predictions may prove conservative.

Sea level rise is an especially salient U.S. concern, following striking hurricane-triggered flooding in New Orleans (Katrina), New York (Sandy), Houston (Harvey), North Carolina (Florence and Michael), and Puerto Rico (Maria and Irma), etc. (e.g., Kishore et al., 2018). Beyond storm surges, U.S. flooding frequency from non-storm high tides has doubled in just 30 years, causing human deaths and many billions of dollars in damage, with risks to infrastructure and coastal properties high and soaring (Nicholson-Cole and O'Riordan, 2009; Milman, 2018). Sea level rise's threat clearly impacts America's housing market, with homes more exposed to oceanic rise selling for approximately 7% less than equivalent homes at higher elevations yet equidistant from the beach (Bernstein et al., 2018). Besides property damage, frequent flooding and sea level rise cause many social, legal, and economic challenges, including issues from sanitation to gentrification (Kolbert, 2015). Growing concerns about extreme weather events have already caused reassessment of families' attachments to residential environments (Bates et al., 2008), altered citizens' perceived security (McDonald, 2008), elicited adaption and mitigation behaviors among low-lying coastal-area residents (Brody et al., 2008), and reduced energy consumption (Spence et al., 2011).

Despite strong global warming evidence, including rising oceans, many Americans are skeptical about the fact of Earth's average surface temperature increase; about 32% deny that the increase is mostly anthropogenic (Leiserowitz et al., 2018). Partisan divides exist regarding global warming's anthropogenicity and its actual and projected side effects (Krosnick et al., 2000; Leiserowitz, 2006; Dunlap and McCright, 2008; Hulme, 2009; Klick and Smith, 2010; McCright and Dunlap, 2011; Villar and Krosnick, 2011; Zhao et al., 2011; Park and Vedlitz, 2013). Some explain this acceptance asymmetry as reflecting biased assimilation (building on Lord et al., 1979), in which people holding a strong belief may (a) occasionally be more likely to reject information running counter to it or (b) subject such information to higher critical standards than they would information that supported their pre-existing beliefs (McCright and Dunlap, 2011; also see motivated reasoning, confirmation bias, or motivated skepticism: Kunda, 1990; Nickerson, 1998; Redlawsk, 2002; Taber and Lodge, 2006).

Kahan et al.'s (e.g., Kahan et al., 2012) cultural cognition perspective posited that one adopts a worldview reflecting one's identifying group. Related to Festinger's cognitive dissonance theory (e.g., 1957, regarding other topics), Kahan et al. suggest that communicating climate change information, such as scientific evidence/facts, yields selective attention to this information–particularly aspects that reinforce prior beliefs–while virtually dismissing contravening aspects. Such a biased assimilation would suggest that communicating climate change information could drive people with opposing prior worldviews apart. Our research group, however, has consistently shown that providing people with coherent scientific information about global warming, such as its scientific mechanism and salient statistics, leads to global warming acceptance *increases* across both the full left/right liberal-to-conservative spectra for both economic and social conservatism (Ranney and Clark, 2016; Ranney et al., 2016, in press; also see van der Linden et al., 2017).

Along with increasing global warming acceptance, it seems desirable for America to use its collective identity to help mitigate global warming's effects, such as rising oceans–a view informed by Gould's 1993 model associating nationalism with the formation of social ties and networks among citizens. However, our laboratory has consistently shown negative correlative and causal relationships between nationalism and global warming acceptance over the course of many surveys and experiments, which we have explained using the induced Reinforced Theistic Manifest Destiny theory (RTMD, Ranney and Thanukos, 2011; Ranney, 2012; Ranney et al., 2012; etc.)—a generative theory that predicts and explores relationships among six constructs, including global warming acceptance, nationalism, and the acceptances of: evolution, creationism, a higher power(s), and an afterlife. The negative relationship between nationalism and global warming acceptance may be exacerbated by political rhetoric that often tries to pit U.S. nationalism ("America First") against environmental concerns–such as the fossil-fuel-friendly "Drill, Baby, Drill" slogan at one party's political convention (McCright and Dunlap, 2003)—and the widespread framing of climate change as threatening (e.g., "job-killing") to economic stability and growth (Hardin, 1968; Hennes et al., 2016; see also Lewandowsky et al., 2013, on free-market adherence's association with global warming denial). The relationship between strong national identification and inhibited support for environmental change was posed, by Feygina et al. (2010), as a manifestation of System Justification Theory, in which threats to the legitimacy and stability of social (and national) institutions/systems lead to motivated recall of environmental facts (Hennes et al., 2016). Better understanding the bi-directional relationship between nationalism and the perception/acceptance of global warming (and its effects) seems increasingly important because many environmental resources (e.g., the atmosphere) are international, and nationalistic concerns must be transcended to produce the international agreements necessary to dramatically reduce greenhouse gas emissions.

This paper presents a new experiment showing that clearly communicating the economic and/or inundation effects/risks associated with sea level rise–some global warming by-products–increases the acceptance that oceanic rise is a current, worsening phenomenon that is both concerning and caused by global warming. Communicating such information led, in some cases, to a direct increase in acceptance that climate change is

anthropogenic, even though climate change is barely–and sometimes never–mentioned in the interventions' modules. After reading such sea rise information, participants exhibited general acceptance increases regarding (a) sea level rise *and* (b) global warming. We also observed (c) a decrease in nationalism, (d) a decrease in the perceived effectiveness of constructing mitigating sea barriers, and (e) an increase in the perceived effectiveness of phasing out fossil fuel usage. Overall, we (1) once again replicated that information-based communications of environmental risk/effects can clearly modify global warming attitudes, and (2) illustrated that such communications alter beliefs about other forms of climate change engagement, such as altering participants' preferences for mitigating actions.

Some Climate Communication Background

Cognitive barriers prevent most people from identifying climate change's full threat. Global warming's gradual pace and its corresponding environmental changes inhibit some from detecting its effects amid weather variability (Marx et al., 2007; Weber, 2010; Weber and Stern, 2011). Most environmental degradation is incremental and modestly tangible in casual observers' typical epochs. We cannot visually perceive air's greenhouse gas accumulation, and we generally perceive ecological changes only following severe environmental damage. A view of climate change as a non-urgent, non-personal, threat has–heretofore–been thought to hinder proactive behavioral responses to the issue (Lorenzoni and Langford, 2001). Leiserowitz et al. (2018) note that 30% of Americans do not believe that global warming will affect the U.S. and 48% believe it will not harm them individually. A dozen years ago, Krosnick et al. (2006) accordingly noted that climate change ranked as less important in people's lives than competing issues such as terrorism, health care, and the economy. Climate change's non-urgent, non-personal, perceptions have been proffered to explain the value-action gap, whereby people's actions do not match the green attitude levels they express in surveys (Pedersen and Neergaard, 2006; Röös and Tjärnemo, 2011).

Another communication challenge is that climate changes are hardly just localized, being manifest over wide, diverse, geographical scales (Hamilton and Keim, 2009; Ruddell et al., 2012). The potential lack of climate change's salience in one's local daily environment (Helgeson et al., 2012), coupled with its global scope (Breakwell, 2010), yields little concrete or personally affective imagery to motivate engagement with global warming (Leiserowitz, 2006, 2007)—producing disconnects between perceptions of climate change's seriousness and one's feelings about obligatory actions (Hulme, 2009).

This experiment's manipulations communicate information about aspects of global warming's effects that seem highly relevant to Americans. In keeping with (a) dual processing theories emphasizing the most vivid elements of direct and vicarious experiences as superior methods for risk and climate communication (Sloman, 1996; Chaiken and Trope, 1999; Slovic et al., 2004), and (b) our own work that has emphasized the pivotal role of surprise in learning (Ranney et al., 2016; Munnich and Ranney, 2019) and rationality-monitoring (e.g., Ranney, 1996), we designed interventions that intended to elicit affective responses–hypothesizing that these would lead to rapid categorizations and useful evaluations of such information (Slovic et al., 2004). The chosen communication topic–sea level rise–seemed likely to (1) have been personally or indirectly experienced by U.S. participants and (2) carry affective associations for participants.

Methodological Contextualization of Sea Level Rise

Oceanic rise was this experiment's selected topic due to its impacts on many people and institutions across the socio-economic continuum, including military bases (e.g., Norfolk, Virginia's), small businesses, and home owners across vast U.S. coastline swathes. Because inundation is relevant and/or personally threatening to many Americans, it seems among the likeliest issues useful for influencing behavior/actions (Weber, 2006). Other advantages of sea level rise communication over less salient climate change effects, are clear linkages between oceanic rise and global warming, with scientists proving that warming temperatures have increased hurricanes' strengths and that oceanic expansion increases chronic nuisance flooding frequencies (Milman, 2018)—science demonstrable in simple classroom experiments. The media occasionally, persuasively, state the relationships between climate change and its effects, such as flooding (Olausson, 2009)—and personal experiences with extreme weather events (e.g., flooding) have highlighted climate change for non-victims (Konisky et al., 2016). Sisco et al. (2017), for example, found that associations between global warming and extreme weather, including coastal flooding, frequently became simultaneous Twitter posts.

Although sea level rise is relatively underexplored, topically, within climate change communication, Wong-Parodi et al. (2018) recently studied communicating both flood risk projections and flood-mitigating actions to respondents affected by Hurricane Sandy. Communicating about protective actions was most successful at encouraging action, but it reduced the perceived probability of future flooding and did not change perceptions of climate change as driving future flooding–due, the authors argued, to unfamiliarity with quantitative estimates of risk and changes in resilience upon reading about protective actions. In complement to their study, we herein assess communicating salient and compelling sea level rise risk information to a broader U.S. audience who hadn't necessarily experienced flooding. We developed three instructional modules that communicated cartological and/or statistical information about sea level rises. The first encapsulated some current and future *economic* ramifications of oceanic rise on coastal *housing* markets. The second showed land inundated in s*outhern Florida* following zero-, one- and four-degree (Celsius) global temperature increases. The third was extreme, showing how the *southeast U.S.* coastline would change if Earth's frozen water *completely* melted.

TABLE 1 | Summary of the modules presented in each condition.

Condition number	Modules included	Abbreviations of the modules included
1	Economic impacts ($)	$
2	Economic impacts ($) + Shorter-term geographic impacts: Southern Florida (FL)	$ + FL
3	Economic impacts ($) + Shorter-term geographic impacts: Southern Florida (FL) + Longer-term geographic impacts: South eastern US (SE)	$ + FL + SE
4	Economic impacts ($) + Longer-term geographic impacts: South eastern US (SE)	$ + SE
5	Shorter-term geographic impacts: Southern Florida (FL)	FL
6	Longer-term geographic impacts: South eastern US (SE)	SE
7	Shorter-term geographic impacts: Southern Florida (FL) Longer-term geographic impacts: South eastern US (SE)	FL + SE
8	Control Group: Tides [described above]	[Control: Tides]

high flood-risk, areas. Part 1's statistics were: (1a) Attom Data Solutions' by-county data show that 2011–2016 flood-prone area home sales increased roughly 25% slower than those in usually flood-free counties–and that people living on the coast are reconsidering their purchases, (1b) climatologists predict that Southeast Florida's tidal floods will increase from roughly the current 10 to about 240 in 2045, (1c) prior-year U.S. home sales were higher by 2.6%, but in Miami-Dade County's high-risk flood zones, they *decreased* roughly 7.6%, and (1d) for high-risk U.S. flood areas, median home values were 4.4% *lower* than a decade ago, yet those in low-risk places were 29.7% higher. Participants then received the economic module's part 2, including a data table (developed by the online real estate company Zillow.com) that drew on a projected six-foot sea level rise by the year 2100 to calculate/display property losses in terms of number of projected lost properties, the percentage of each state's total housing stock lost (e.g., 12.6% for Florida), and total value of projected lost properties for the five states projected to lose the most in property value (Rao, 2017). The table's five states (and respective billions in projected lost property value) were: Florida ($413B), New Jersey ($93B), New York ($71B), Massachusetts ($51B), and California ($49B). Text above the table informed participants that a six-foot rise was projected in a 3/31/16 Nature peer-reviewed journal article that, according to NOAA and Zillow.com, would lead to total U.S. property losses of $882 billion dollars–with roughly 1 in 50 U.S. houses ("1.9 million homes") getting swamped.

Some participants received the Southern Florida module, which was based on projections made by an article in the *Proceedings of the National Academy of the Sciences* and climatecentral.com that calculated the sea-rise corresponding to specific increases in global mean temperature. According to such (conservative) projections, sea levels following equilibrium would rise seven feet with a 1°C global average temperature increases, and 29 feet following a 4°C increase. While climatecentral.com made projections for every terrestrial Earth location, participants receiving this module were asked to review maps only of how southern Florida would/will be affected by the two respective sea level increase scenarios (corresponding to the two global mean temperatures increases, see **Figure 1**). These maps were simplified versions of climatecentral.com's projections (i.e., not indicating inundation *heights*) and were black and white, using cross-hatching to differentiate inundated from non-inundated areas.

Participants receiving the southeastern U.S. module viewed a simplification of a projection that *National Geographic* produced displaying how coastlines would appear if *all* of Earth's ice melted (see **Figure 2**). This representation was not linked to any particular greenhouse gas emissions scenario, although Earth has been occasionally ice-free (prehistorically, as explained to participants). **Figure 2**'s map and text were intended to illustrate America's physical vulnerability in a surprising, striking manner.

Procedure

Beyond receiving an intervention, each participant also completed a pre-test and a post-test consisting of a 36-item survey that included items about global warming acceptance, sea level rise acceptance, and two possible solutions to sea level rise: phasing out fossil fuels and building sea level walls/dikes. Most of these 36 items (other than the 10 specific to sea-level rise) were used in prior studies (e.g., Ranney and Clark, 2016; Ranney et al., in press, etc.). The two policy-solution items represented (a) the most well-known engineering sea level rise risk mitigation policy (i.e., hard infrastructure defense; Tol et al., 2008; Abel et al., 2011), and (b) a highly general, well known, global warming mitigation strategy to reduce greenhouse gas emissions. As in prior studies, some of the previously-used items probed participants' views on religion, evolution/creation, and nationalism–as additional constructs in Ranney's (2012) RTMD theory–for instance, to assess the modules' and interventions' effects on participants' acceptance of nationalism, as well as of global warming and sea level rise. Cronbach's alpha for this study's ten sea level rise items, eight global warming items, and four (reduced in number from prior studies) nationalism items were, respectively, 0.91, 0.81, and 0.73.

Participants were recruited from *all* U.S. states/territories to assess intervention-modulated beliefs related to sea level rise as a phenomenon of interest to Americans in general. Participants completed the experiment in successive batches during 6/16/17−6/25/17. We recruited participants in batches in order to roughly ensure that participants were being sorted evenly into each condition. Participants were paid $0.60–$1.00 on completing the survey, as compensation increased following participant feedback (and regarding completion-duration data) from initial (condition-balanced) participant batches. On average, participants spent 22 total minutes on the experiment.

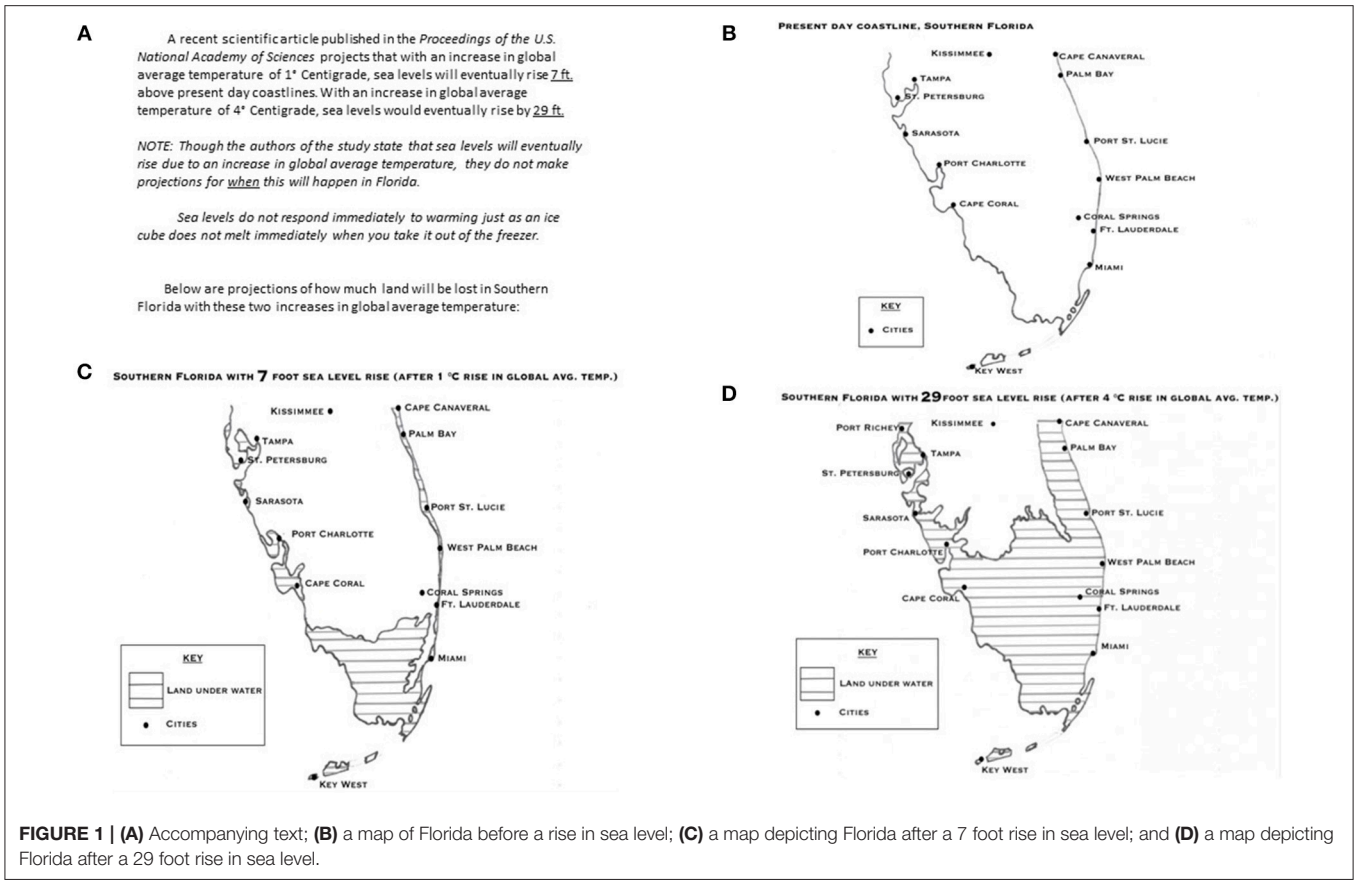

FIGURE 1 | (A) Accompanying text; **(B)** a map of Florida before a rise in sea level; **(C)** a map depicting Florida after a 7 foot rise in sea level; and **(D)** a map depicting Florida after a 29 foot rise in sea level.

Beyond typical attentional "catch" questions in the pre- and post-tests–designed to assess participant attention and response coherence (including an item asking participants to self-report what percentage of attention they paid to the intervention)—information checks for each module ensured that participants engaged properly with the material. Participants experiencing the economic module received a comprehension query about which U.S. state would lose the greatest number of properties and participants experiencing the inundation modules received items about which cities would be under seawater from (as module-appropriate) 7-foot, 29-foot, or 214-foot inundations. Timers were also employed. Each participant was scored based on catch-item success, responses to the interventions' comprehension questions, and duration to complete the pre- and post-tests. Excluded participants scored <75% on this index, compared to the maximum possible for their condition. Participants were also excluded whenever (a) an IP address (by longitude and latitude) was outside the U.S., (b) multiple people used the same IP address, and/or (c) if one's response exhibited an extremely long or short survey completion time (in accordance with the mean and standard deviation of the times participants spent on each condition). If participants' answers to free response questions were problematic–for instance, markedly incomplete/incoherent or plagiarized (e.g., from Wikipedia), their responses were also excluded. After filtering through these detailed exclusion criteria, 384 of 498 initial participants remained. Seven of the one hundred fourteen eliminated respondents were disqualified based on IP address, 12 because they were above or below duration thresholds for the total time taken on the condition, and 95 based on their scores for the indexed cumulative exclusion criteria.

Because participants were assigned to groups in a randomized control trial experimental design, the conditions' effects were assessed using both *between*-participant *t*-tests (to compare pre-to-post-test changes among the major dependent variables for the experimental participants to pre-post-changes for the control participants), and *within*-participant *t*-tests. These allow assessment of pre-to-post-test changes in sea level rise acceptance, global warming acceptance, and nationalism—as well as changes in preferred mitigation strategy (support for barriers and/or fossil fuel phaseouts). ANOVAs assessed interaction effects among the three modules, and correlations and regression analysis explored relationships among the main variables and certain demographic variables.

RESULTS

Increases in Sea Level Rise Acceptance

Communicating information about sea level rise generally led, as hypothesized, to a robust gain in sea level rise acceptance: the aggregation of all seven experimental conditions yielded an average increase of sea level rise acceptance from $M = 6.49$

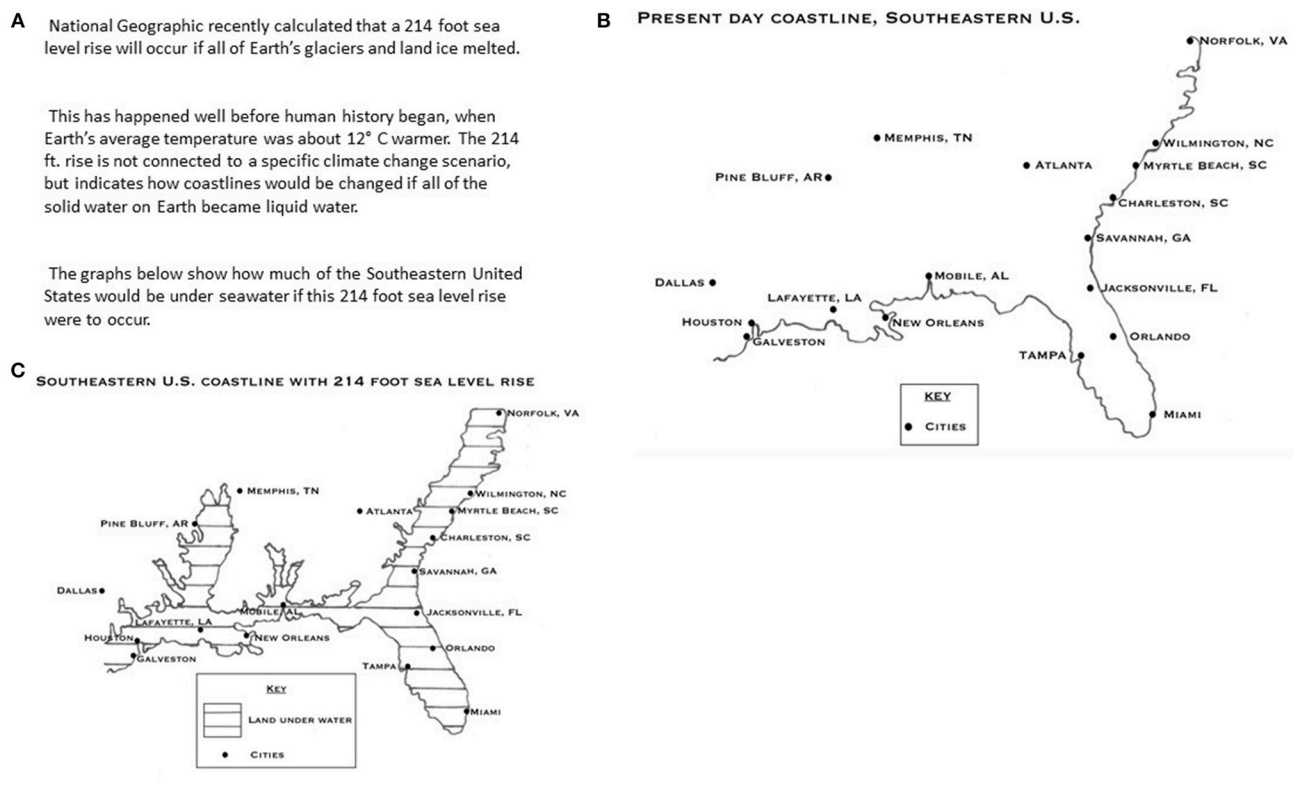

FIGURE 2 | (A) Accompanying text; **(B)** map depicting the southeastern U.S. coastline; **(C)** map depicting how the southeastern U.S. coastline would appear if all of Earth's ice melted.

(SD = 1.50) to M = 6.68 (SD = 1.53) on a 9-point scale [$t_{(332)} = 7.22$, $p < 0.001$, $d = 0.401$]. Through sub-aggregations, the effects of the *amounts* of information included in the various conditions on changing participants' sea level rise acceptance were also assessed. Excluding the statistically significant condition 3 from the analysis (given that it was the only three-module condition), we found potent increases in sea level rise acceptance with roughly double the amount of information included in relevant conditions (i.e., for the three two-module interventions, numbers 2, 4, and 7; $t_{(157)} = 5.307$, $p < 0.001$, $d = 0.442$; **Table 2**).

Presenting participants with sea-level risk information also yielded numeric increases in acceptance of sea level rise (as a phenomenon that is concerning and caused by global warming) across each of the seven individual experimental conditions—with each of the seven also yielding a higher t-value, numerically, than the (non-significant) control condition (**Table 2**; binomial $p < 0.01$ for both findings). *Statistically significant* increases in participants' sea level rise acceptance were observed in five of the seven experimental conditions, with four of these seven yielding p-values of lower than 0.005 (**Table 2**). Four of the five conditions that led to significantly increased acceptance involved the economic module, either by itself (condition 1) or in combination. Subsequent analysis supported the notion that the economic module may have been superior to the cartographic-based ones at increasing sea level rise acceptance because the economic module's contribution to that increase was significant [$F_{(1,376)} = 4.41$; $p = 0.036$, $d = 0.216$] using a ($2 \times 2 \times 2$ ANOVA). These results suggest that information about economic consequences or damages can be a powerful communication arena for changing minds regarding sea level rise. The combination of information about southern Florida's and the southeastern U.S.'s projected oceanic rises were also shown to be potent (as per condition 7's and condition 3's robust gains).

Increases in Climate Change Acceptance

Additionally, despite making little explicit use of the phrase "climate change" or "global warming" in the modules and none at all in the southern Florida module, aggregating over all seven experimental conditions showed that participants' acceptance of global warming increased significantly after being exposed to sea level rise information ($p < 0.01$, $d = 0.143$; **Table 3**). As was done for sea level rise, we assessed the effects of *amounts* of oceanic rise information on participants' global warming acceptance (**Table 3**). Given condition 6's ambiguous utility in isolation (see the next paragraph, etc.), it is not surprising that aggregating the one-module conditions did not yield a significant difference. However, significant increases in global warming acceptance were observed with roughly double the amount of information included in conditions [i.e., two-module conditions; $t_{(157)} = -3.506, p < 0.001, d = 0.304$; **Table 3**]. More instruction,

TABLE 2 | Change in sea level rise acceptance by condition and number of modules.

Condition(s)	*n*	Pre-SLR acceptance/ out of 9.0		Post-SLR acceptance/ out of 9.0		Change from pre- to post	*t*-value	*df*	*p*-value	*d*
		M	*SD*	*M*	*SD*					
1 ($)	52	6.48	1.50	6.74	1.53	+0.26	+4.19	51	0.00011***	0.613
2 ($ + FL)	56	6.24	1.50	6.40	1.56	+0.16	+2.29	55	0.026*	0.308
3 ($ + FL + SE)	49	6.61	1.45	6.86	1.40	+0.25	+3.09	48	0.0033**	0.431
4 ($ + SE)	57	6.34	1.75	6.55	1.82	+0.21	+3.25	56	0.0019**	0.424
5 (FL)	38	6.87	1.32	6.93	1.29	+0.05	+0.67	37	0.50	0.121
6 (SE)	36	6.16	1.37	6.28	1.51	+0.12	+1.64	35	0.109	0.105
7 (FL + SE)	45	6.76	1.37	7.00	1.36	+0.24	+4.26	44	0.0001***	0.619
8 (control:tide)	51	6.18	1.69	6.21	1.84	+0.03	+0.41	50	0.68	0.063
1-module (conditions 1, 5, and 6)	126	6.51	1.43	6.66	1.47	+0.15	+3.831	125	0.000201***	0.332
2-modules (condition 2, 4, and 7)	158	6.43	1.57	6.63	1.61	+0.20	+5.307	157	3.74E-7***	0.450
All 7 experimental conditions	333	6.49	1.50	6.68	1.53	+0.19	+7.221	332	3.13E-10***	0.401

*$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

naturally, seems requisite for cognitive change regarding a less direct construct (and global warming is indirectly changed by ocean-level information).

Disaggregating further, significant changes in participants' global warming acceptance were also observed in two of the seven experimental conditions (conditions 2 and 7: p =0.0391, $d = 0.294$; and $p = 0.010$, $d = 0.415$ respectively; **Table 3**). Numerical increases in global warming acceptance were observed in six of the seven experimental conditions. Condition 6, which offered the southeastern U.S. inundation projection module in isolation, yielded the only decrease (which was non-significant and not even marginal) among the conditions regarding global warming acceptance—and yielded a numeric outlier described in the next sub-section, too. We suspect that, *in isolation*, the 214-foot sea level rise may seem fantastical, shocking, or even surreal to some participants—perhaps, occasionally enhancing skepticism in some. (The control condition's 0.00 change from pre- to post-test, showed, as predicted, no evidence of experimenter demand bias, which suggests no such bias for the experimental conditions, either.)

Nationalism Reductions

Extending findings by Ranney et al. (in press), decreases in nationalism were generally observed after exposure to the interventions' scientifically representative climate-change-relevant information. Pooling all seven experimental conditions, it was found that presenting people with information about sea-level rise risks (conceptually associated with global warming) led to significant decreases in nationalism [$t_{(333)} = -3.80$, $p < 0.001$, $d = -0.201$; **Table 4**]—again, while increasing global warming's and oceanic rise's acceptances. Assessing the effect of the amount of information included in the various conditions on changing participants' nationalism, we found that the informational increases in acceptance of sea level rise and global warming with roughly double the amount of information (two-module conditions: **Tables 2**, **3**, respectively) were mirrored by a *decrease* in nationalism [$t_{(157)} = -3.48$, $p < 0.01$, $d = -0.290$ for the two-module conditions; **Table 4**]. Indeed, in spite of condition 6's outlier character, aggregating its data with the other two one-module conditions (which were significant and marginal) also yielded a significant nationalism decrease [$t_{(126)} = -1.99$, $p < 0.05$, $d = 0.162$].

Four of the seven experimental conditions yielded statistically significant or marginally significant decreases in participants' nationalism from pre-to-post-test, and nationalism numerically dropped in six of the seven experimental conditions (**Table 4**). As for global warming acceptance, the southeastern U.S. module in isolation was the only condition with a numerical result suggesting a contra-predicted directional change. The 214-foot rise again seemed to stretch participants' credulity when not being paired with an additional module(s). Overall, however, these results support previous findings about the inverse and even bi-causal relationship between nationalism and global warming acceptance (Ranney, 2012; Ranney et al., 2012, in press; Ranney and Clark, 2016). (The control condition again showed no significant change.)

The Major Dependent Variables' Results More Broadly

These results (**Tables 2–4**) largely support the reasonable idea that more information, when germane/crucial, contributes to greater belief changes. This follows a trend also observed in Ranney and Clark (2016), in which participants' increased acceptance of global warming reflected the amount of received information about the mechanism of global warming. The trend was even more formally assessed and observed in Ranney et al.'s (in press) Experiment 4, regarding the lengths of mechanism-explaining videos (from 1 to 5 min) as well as texts (from 35 to 596 words). However, there is a hint that the present experiment's two-module effects gain little with a third module's (quasi-redundant) addition, and may cause participants to lose attention, given that condition 3's effects were as directionally predicted, but only statistically significant for the sea level rise dependent variable (**Table 2**; $p = 0.003$, $d = 0.431$).

TABLE 3 | Change in global warming acceptance by condition and number of modules.

Condition(s)	*N*	Pre-test GW acceptance/out of 9.0		Post-test GW acceptance/out of 9.0		Change from pre- to post	*t*-value	*df*	*p*-value	*d*
		M	*SD*	*M*	*SD*					
1 ($)	52	6.90	1.89	6.98	1.90	+0.08	+1.451	51	0.153	0.212
2 ($ + FL)	56	6.49	2.08	6.64	2.07	+0.15	+2.120	55	0.0386*	0.294
3 ($ + FL + SE)	49	7.17	1.95	7.24	1.98	+0.07	+1.327	48	0.191	0.179
4 ($ + SE)	57	6.57	2.34	6.67	2.31	+0.10	+1.585	56	0.143	0.214
5 (FL)	38	7.38	1.68	7.39	1.62	+0.01	+0.167	37	0.868	0.021
6 (SE)	36	6.78	1.87	6.68	1.90	−0.10	−1.144	35	0.261	−0.189
7 (FL + SE)	45	7.14	1.93	7.30	1.89	+0.16	+2.583	44	0.0102*	0.415
8 (control:tide)	51	6.75	2.12	6.75	2.19	+0.00	+0.110	50	0.913	0.00
1-module (conditions 1, 5, and 6)	126	7.01	1.82	7.02	1.83	+0.01	+0.140	125	0.888	0.022
2-modules (condition 2, 4, and 7)	158	6.72	2.14	6.85	2.12	+0.13	+3.506	157	0.000592***	0.304
All 7 experimental conditions	333	6.90	2.00	6.97	1.99	+0.07	+2.955	332	0.00812**	0.143

*$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$.

TABLE 4 | Change in nationalism by condition and number of modules.

Condition(s)	*n*	Pre-test nat out of 9.0		Post-test nat/out of 9.0		Change from pre- to post	*t*-value	*df*	*p*-value	*d*
		M	*SD*	*M*	*SD*					
1 ($)	52	5.74	1.39	5.53	1.40	−0.21	−1.940	51	0.0508†	−0.276
2 ($ + FL)	56	5.54	1.78	5.42	1.79	−0.12	−1.643	55	0.106	−0.238
3 ($ + FL + SE)	49	5.27	1.61	5.21	1.66	−0.06	−0.593	48	0.556	−0.093
4 ($ + SE)	57	5.71	1.64	5.45	1.65	−0.26	−2.581	56	0.0125*	−0.338
5 (FL)	38	5.80	1.49	5.61	1.47	−0.19	−2.271	37	0.0291*	−0.368
6 (SE)	36	5.70	1.76	5.79	1.72	+0.09	+0.940	35	0.354	0.162
7 (FL + SE)	45	5.74	1.68	5.63	1.64	−0.11	−1.768	44	0.0841†	−0.267
8 (control:tide)	51	5.47	1.58	5.58	1.81	+0.11	+1.178	50	0.244	0.174
1-module (1, 5, and 6)	126	5.75	1.52	5.63	1.51	−0.12	−1.99	125	0.0483*	−0.186
2-modules (condition 2, 4, and 7)	158	5.66	1.69	5.49	1.69	−0.17	−3.48	157	0.000643***	−0.290
All 7 experimental conditions	333	5.63	1.62	5.50	1.62	−0.13	−3.80	332	0.000123***	−0.201

†$p < 0.1$, *$p < 0.05$, and ***$p < 0.001$.

Descriptive statistics and intercorrelations for the three major "change" dependent variables (sea level rise acceptance change, global warming acceptance change and nationalism change) across all seven conditions are summarized in **Table 5**, along with participants' economic and social conservatisms, which were self-reported on separate 9-point scales at the experiment's end. A significant positive correlation was found between *change* in global warming acceptance and *change* in sea level rise acceptance ($r = 0.29$, $p < 0.001$), consistent with an association between perceptions of sea level rise and global warming. A multiple regression analysis (**Table 6**) evidenced that, consistent with expectations, sea level rise acceptance changes were positively associated with global warming acceptance changes, *even after* adjusting for participants' economic and social conservatism ratings. Global warming acceptance and inundation acceptance were moderated by neither economic nor social ideology.

Belief Changes Regarding Sea Level Rise Mitigation Strategies

Decreases regarding the effectiveness of sea walls or dikes as a solution to sea level rise were observed, aggregating across all seven experimental conditions [$t_{(332)} = -2.19$; $p = 0.029$, $d = -0.127$]. Two-module interventions, when aggregated, also displayed significant decreases regarding sea walls or dikes as an effective ocean-rise solution (**Table 7**; $p < 0.01$, $d = -0.213$). Numerical decreases in such effectiveness beliefs were observed in five of the seven of the experimental conditions. A significant decrease manifested in condition 2, which was comprised of the economic and southern-Florida map modules [$t_{(55)} = -2.3117$, $p = 0.024$, $d = -0.302$; **Table 7**]—and which produced statistically significant increases in both global warming and sea level rise acceptance (**Tables 2**, **3**), and a near-marginal nationalism decrease ($p = 0.106$, $d = -0.338$;

TABLE 5 | Intercorrelations of Main Study Variables across all conditions (including control), along with measures of conservatism.

	Variable mean	*SD*	1	2	3	4	5
1. GW acceptance change	+0.07	0.46	–				
2. SLR acceptance change	+0.19	0.48	0.29***	–			
3. Nationalism change	−0.13	0.63	−0.082	−0.075	–		
4. Social conservatism	3.91	2.32	0.025	0.011	0.091†	–	
5. Economic conservatism	4.46	2.38	−0.025	−0.075	0.10†	0.77***	–

†$p < 0.1$ and ***$p < 0.001$.

TABLE 6 | Multiple regression of change in sea level rise on changes in acceptance of global warming and related constructs (experimental conditions; i.e., 1–7).

Predictor	Step 1		Step 2	
	b (SE)	β	b (SE)	β
Intercept	0.17 (0.026)		0.19 (0.056)	
GW acceptance change	0.31 (0.055)	0.29***	0.30 (0.055)	0.28***
Nationalism change			−0.037 (0.041)	−0.049
Social conservatism			0.019 (0.017)	0.091
Economic conservatism			−0.022 (0.017)	−0.11
Social conservatism*GW acceptance change			0.038 (0.036)	0.037
Economic conservatism*GW acceptance change			0.0053 (0.037)	0.0069

***$p < 0.001$.

Table 4). As expected, the control condition about tides showed no significant change.

In contrast to the decreased support for the barrier solution (**Table 7**), an *increase* in support for phasing out fossil fuels obtained across the seven aggregated experimental conditions [$t_{(332)} = 2.29$; $p = 0.02$, $d = 0.120$]. Furthermore, the aggregated *two-module* conditions yielded a significant increase in support of phasing out fossil fuels [$t_{(157)} = 2.543$, $p = 0.01$, $d = 0.197$; **Table 8**]. Numerical increases in post-test beliefs about the effectiveness of combatting sea level rise through fossil fuels phase-outs were observed for five of the seven conditions, with the increases in two conditions being marginally significant. Please note that the average pre-test and post-test ratings ($M = 6.26$, $SD = 2.28$ and $M = 6.42$, $SD = 2.23$, respectively) for fossil fuel phase-out effectiveness are much higher than the respective effectiveness ratings for sea barriers ($M = 4.41$, $SD = 2.03$ and $M = 4.27$, $SD = 2.16$). These figures indicate higher support—and perhaps familiarity regarding—a fossil fuel phaseout, compared to the sea wall/dike solution.

Results Summary

Providing participants with scientifically representative information about sea level rise and its risks, including current and projected economic aspects of oceanic rise, generally yielded acceptance increases in sea level rise *and* global warming (**Tables 2**, **3**). Likewise, receiving combinations of modules—that is, a greater "dose" of information about oceanic inundation—caused sea-level-rise acceptance *and* global-warming acceptance to increase (**Tables 2**, **3**), even though an explicit link between global warming and sea level rise was rarely, if ever, raised for participants. These acceptance increases occurred while the sea-level-rise information also caused a *decrease* in nationalism (**Table 4**)—extending findings by Ranney et al. (in press; also see Ranney et al., 2016) that demonstrated causal, inhibitory, relationships between global warming and nationalism in both directions.

Information about the consequences of sea-level-rise, when aggregated, led to decreases in the perceived utility of sea walls or dikes, especially for the two-module interventions, and even for condition 2 on its own (with its economic module and southern Florida module; **Table 7**). In contrast, the perceived effectiveness of phasing out fossil fuels generally *increased* from pre-testing to post-testing (**Table 8**).

GENERAL DISCUSSION

Increased Global Warming and Sea Level Rise Acceptance

This experiment's interventions were largely successful, by collectively demonstrating yet another way that representative empirical evidence and scientific information about climate change and/or its associated (here, sea level) effects can lead to greater acceptance of those effects/risks—as well as greater acceptance that global warming is occurring, concerning, and anthropogenic. Sea level rise information now joins five other ways our laboratory has shown that brief instruction (usually under 5 min) can increase global warming acceptance. The other five ways include poignant statistics, temperature (compared to stock market) time series graphs, supra-nationalist statistics, and both texts and videos explaining global warming's mechanism. The present experiment also provides yet another empirical disconfirmation regarding (Kahan et al., 2012) stasis view (see Ranney and Clark, 2016; van der Linden et al., 2017; Ranney et al., in press) while showing the powerful importance of communicating empirical, scientific, and/or quantitative information for improving the justifiable adoption of more science-normative climate beliefs and policy preferences. Particularly noteworthy is that the present modules and interventions each regarded just a single *effect* of global warming—sea level rise—and not global warming more directly.

TABLE 7 | Changes in the perceived effectiveness of building sea walls or dikes by condition and number of modules.

Condition(s)	*n*	Pre-test barrier acceptance/out of 9.0		Post-test barrier acceptance/out of 9.0		Change from pre- to post	*t*-value	*df*	*p*-value	*d*
		M	*SD*	*M*	*SD*					
1 ($)	52	4.69	1.73	4.73	2.00	+0.04	+0.2602	51	0.796	0.042
2 ($ + FL)	56	4.46	2.02	3.98	2.27	−0.48	−2.312	55	0.0246*	−0.302
3 ($ + FL + SE)	49	4.20	2.13	4.33	2.47	+0.13	+0.785	48	0.437	0.136
4 ($ + SE)	57	4.75	2.29	4.61	2.32	−0.14	−0.797	56	0.429	−0.105
5 (FL)	38	4.08	2.11	3.87	2.29	−0.21	−1.091	37	0.282	−0.188
6 (SE)	36	4.31	2.12	4.17	1.93	−0.14	−0.531	35	0.599	−0.085
7 (FL + SE)	45	4.13	1.91	3.87	2.03	−0.26	−1.522	44	0.135	−0.227
8 (control:tide)	51	4.43	1.89	4.47	2.17	+0.04	+0.198	50	0.844	0.031
1-module (1, 5, and 6)	126	4.40	1.97	4.31	2.09	−0.09	−0.779	125	0.438	−0.074
2-modules (condition 2, 4, and 7)	158	4.47	2.10	4.18	2.13	−0.29	−2.719	157	0.00730**	−0.213
All 7 experimental conditions	333	4.41	2.05	4.25	2.16	−0.16	−2.194	332	0.0289*	−0.127

*$p < 0.05$ and **$p < 0.01$.

TABLE 8 | Changes in the perceived effectiveness of phasing out fossil fuel use, by condition and number of modules.

Condition(s)	n	Pre-test phaseout acceptance/out of 9.0		Post-test phaseout acceptance/out of 9.0		Change from pre- to post	*t*-value	*df*	*p*-value	*d*
		M	*SD*	*M*	*SD*					
1 ($)	52	6.38	2.11	6.69	2.11	+0.31	+1.907	51	0.0622†	0.268
2 ($ + FL)	56	5.88	2.27	6.05	2.28	+0.17	+1.256	55	0.214	0.160
3 ($ + FL + SE)	49	6.80	2.13	6.78	2.18	−0.02	−0.136	48	0.892	−0.019
4 ($ + SE)	57	6.11	2.71	6.33	2.36	+0.22	+1.251	56	0.216	0.153
5 (FL)	38	6.89	1.96	6.55	2.19	−0.34	−1.379	37	0.176	−0.236
6 (SE)	36	5.97	2.35	6.28	2.02	+0.31	+1.281	35	0.209	0.209
7 (FL + SE)	45	6.40	2.19	6.80	1.96	+0.40	+1.889	44	0.0655†	0.269
8 (control:tide)	51	5.88	2.24	6.00	2.53	+0.12	+0.830	50	0.411	0.134
1-module (conditions 1, 5, and 6)	126	6.42	2.15	6.53	2.10	+0.11	+0.903	125	0.368	0.079
2-module (condition 2, 4, and 7)	158	6.11	2.41	6.37	2.23	+0.26	+2.543	157	0.0120*	0.197
All 7 experimental conditions	333	6.33	2.28	6.49	2.17	+0.16	+2.292	332	0.0225*	0.120

†$p < 0.1$ and *$p < 0.05$.

The effects we observed from communicating information about current and projected economic risks seem particularly promising regarding ways to increase sea level rise acceptance (see **Table 2** and associated analysis). This subfinding coheres with McCright and Dunlap's (2011) theory of anti-reflexivity. They posed that conservatives respond more positively to information focused on the "production sciences"—economic impacts of climate change—and react less positively to "impact science" (here, the non-economic of our modules solely about the inundations' cartological/topological impacts). Their theory, however, doesn't assert that liberals will reject production science. Therefore, we propose that communications about climate change's projected economic impacts can be honed to become even more effective ways to increase climate change acceptance across the entire socio-political spectrum. System Justification Theory may also explain the impacts from communicating economic information, in particular, regarding sea level rise acceptance. In this theory, communicating sea level rise's potential effects on socio-economic systems may lead participants to acknowledge our current system's shortcomings and practices, and to thus perceive environmentalism as a way of upholding (rather than threatening) the American way of life—producing pro-environmental intentions (Feygina et al., 2010).

Increased Support for a Fossil Fuel Phaseout, but Reduced Support for Barriers

Our seven experimental conditions offer copious data. A relatively normative exemplar is condition 2, combining the economic and southern Florida modules, that led to increases in global warming and sea level rise acceptances, along with a near-marginal drop in nationalism. It also yielded a decrease in

perceived utility for sea barriers (**Table 7**) and, directionally, an increase in desiring a fossil fuel phaseout. Condition 7 produced a similar result-pattern.

The decreased acceptance of sea barrier effectiveness was a general effect when aggregating the seven experimental conditions (**Table 7**). In contrast, receiving sea level rise information *increased* participants' desires to phase out fossil fuels (**Table 8**), possibly due to greater knowledge or familiarity with phaseout solutions. Phaseout mitigation strategies have been widely publicized, and many examples exist of social norm messaging campaigns seeking to reduce individual fossil fuel usage, regarding: energy consumption (Allcott, 2011), recycling (Schultz, 1999), and hotel towel use (Goldstein et al., 2008; Schultz et al., 2008). Judging by the rather high ratings of fossil fuel reduction solutions even at the pre-test (**Table 8**), participants seemed, *a priori*, familiar with—and obviously somewhat persuaded by—fossil fuel phaseout mitigation strategies. Unfamiliarity about sea-inundation solutions other than fossil fuel reductions possibly caused participants to favor more familiar solutions (a behavioral momentum manifestation; Nevin et al., 1983) and to adopt more intransigently ensconced behavior (perhaps a sunk-cost example; Cunha and Caldieraro, 2009): if time, money, or behavior has already been invested in fossil fuel reductions, such actions might seem preferable to less familiar solutions. Constructing barriers may also be associated with lower personal efficacy, compared with reducing fossil fuels, given absent clear infrastructures/pathways to support building sea walls/dikes.

An attractive, alternative, (co-)explanation for preferring fossil fuel phaseouts over barrier building may be economic. Diekmann and Preisendörfer (2003) proposed explaining why people with even high environmental concern engaged primarily in the lowest impact pro-environmental behaviors—using a relative cost model. People with pro-environmental beliefs were modeled as engaging in pro-environmental behaviors; for instance, being more likely to start recycling (an inexpensive change) than to reduce driving or flying (a costly change). Likewise, O'Connor et al.'s (2002) Pennsylvania survey found respondents willing to engage in money-saving pro-environmental behaviors like buying energy efficient devices, but less willing to try harder actions, such as installing solar panels (see also Byrka et al., 2017). Policies implying more direct costs, such as barrier building, generally have lower public support, according to Bostrom et al.'s (2012) finding that "inexpensive" environmental policies are largely favored over costlier ones. In the short term at least, sea walls are a more costly protection strategy (Nicholson-Cole and O'Riordan, 2009), especially given the enormous coastline loss associated with even a 7- or 29-foot sea level rise (see **Figures 1**, **2**)—compared to fossil fuel emission reductions, which are associated with *savings*. The potential scale of lost land, depicted in our inundation maps of southern Florida and the southeastern U.S., plausibly led participants to consider sea walls/dikes as especially expensive, impracticable, solutions compared to fossil fuel reduction. For instance, southern Florida has about 4,000 coastline miles and the southeastern U.S. has about 32,000 coastline miles; dikes for these are virtually unimaginable compared to Holland's roughly 350 miles. Consistent with this hypothesis, when participants saw only the cartographic modules (FL, SE, or FL + SE: conditions 5-7), each condition produced numeric drops in barrier effectiveness ratings.

Reduced Nationalism

This experiment's observed *inverse* relationship between nationalism and global warming acceptance replicates Ranney et al.'s (in press) Experiments 3 and 4, which demonstrated bidirectional causality between these two constructs (also see Ranney et al., 2016). It also reflects many of our laboratory's earlier correlational findings of an inverse relationship between nationalism and global warming acceptance—before being shown causally that increasing global warming acceptance suppresses nationalism and that reducing nationalism (with a supranationalist-statistics-quiz-plus-feedback technique) increases global warming acceptance (e.g., Ranney and Clark, 2016; Ranney et al., 2016, in press). This inverse relationship was formally hypothesized in Ranney's RTMD theory (e.g., Ranney and Thanukos, 2011; Ranney, 2012; Ranney et al., 2012), which also noted positive associations between global warming acceptance and biological-evolution acceptance (and negative associations between each of those two and creationism, nationalism, afterlife acceptance, and deity/deities acceptance)[1]. The observed decrease in nationalism upon learning about sea level rise's effects is also explained by RTMD theory, since oceanic rise is a climate change phenomenon that global warming spawns (Ranney, 2012; Ranney et al., 2016, in press). In advancing a set of causal relationships among such constructs, we draw on Category 3, and specifically sub-category 3.9, of the Slater and Gleason framework (2012) by (a) our demonstration of the underlying relationship between nationalism and sea level rise, and (b) by showing how manipulating one construct produces changes in others.

Future Work

We seek to further characterize people's attitudes and understandings regarding climate change and its solutions, and so we are piloting interventions addressing (a) the inexpensiveness of sustainable solutions, (b) why one should trust climate scientists, and (c) false claims that climate change is a hoax. Likewise, we seek the most effective combinations and/or "dosages" of our various interventions for varying kinds of participants. We note that, compared to most of the intervention-types our laboratory has (successfully) assessed so far regarding enhancing global warming acceptance, our sea level rise manipulations have been among the least direct (i.e., other than by reducing global warming acceptance by using supra-nationalistic statistics, Ranney et al., 2016, in press); this may be why the magnitude of observed changes following our nationalism and sea-level-rise interventions seem a bit more modest than the more direct interventions of germane statistics, time-series graphs, and mechanistic explanations. In general, our findings also help illuminate a panoply of pro-social and/or more emotional aspects that feed into support for climate change

[1] RTMD's central gist is that Americans generally see their country as having been most rewarded by God (or providence, etc.; Ranney, 2012; Ranney et al., 2012).

mitigation strategies. Going forward, we seek to uncover the influences of various emotions, particularly hope, in shaping efficacy perceptions about individual or collective actions to mitigate climate change.

As noted earlier, this experiment's sea level rise intervention represents our laboratory's sixth kind of brief, information-based intervention that has been shown to increase global warming understanding *and* global warming acceptance among Americans. That such intervention-types can take mere minutes to change minds (e.g., a 400-word text of the mechanism of global warming; Ranney and Clark, 2016; Ranney et al., in press) has also further encouraged us to explore their possible utilizations *beyond* our empirically-vetted efforts through the aforementioned HowGlobalWarmingWorks.org (including its various translations to non-English languages)—for instance, to directly inform the public using telephone-based communication.

Limitations

Our study's experiment includes the strengths of having developed informational aids about sea level rise that were informative and compelling enough to improve engagement with this important issue—along with our use of mixed between-participant (conditions) and within-participant (pre-post) analyses (as opposed to studying solely correlational trends). One limitation is that MTurk participants are hardly fully demographically representative of America's population. However, MTurk provides more U.S.-representative data than typical *student* samples. MTurk has increased access for harder-to-reach populations (Smith et al., 2015) and, despite its slightly liberal population bias, it seems a valid recruitment tool for psychological research relating to political ideology and in general, compared to national benchmark data (Berinsky et al., 2012; Clifford et al., 2015). A notable issue regarding MTurk as a sampling pool, however, is the reduced "naiveté" of participants (Chandler et al., 2014). This, coupled with the relatively small sample and effect sizes, indicate that this study should be extended/replicated with a larger sample size, refined interventions, and/or even more nationally representative participants.

Following a planned analysis, we did not find differential responding to the interventions by those who are (or will be) more directly impacted by sea level rise (e.g., participants living in Florida or the southeast-coast states depicted in the graphical interventions). However, the economic intervention included data from a range of states, and coupled with the relatively low number of participants recruited from Florida and the southeast, it's not surprising that differences were not found between those who are "directly" impacted by sea level rise compared to those who are not. A more thorough exploration of this question will require more precise, systematic, participant selection processes.

Another limitation stems from the experiment using a single-session pre- and post-testing design. While this reduced some ecological utility, having a post-test immediately after the informational treatments allowed assessing the effects of these treatments alone—and enabled us to collect enough data to carry out within-participant, as well as between-participant, analyses (given the likely response drop-off, were a multi-wave study design adopted). The fact that the pre-/post-changes from the control condition were non-significant also indicates that experimenter demand and sensitization were not significant factors in the changes observed. A multi-wave study design, however, might have offered affordances—for instance, further reducing experimenter sensitization, or demand effects caused by answering the same items in a relatively short amount of time, and providing data on the longer-term effectiveness of our interventions. Given that our past experiments have demonstrated such long-term changes in global warming acceptance up to 34 days after exposure to interventions (Ranney and Clark, 2016; also see Ranney et al., in press), we are optimistic about the importance and efficacy of providing information in the context of meaningfully improving how people engage with rising oceans in particular and climate change in general.

Concluding Thoughts

This experiment demonstrates that communicating information about the physical and economic consequences of global warming's effects due to rising seas generally led to, despite sea level rise barely being explicitly related to global warming in the interventions, (a) increases in the acceptance of, and concerns about, oceanic rise and (b) increased global warming acceptance, especially in aggregate and higher "information doses." Elucidating the current and projected financial damage due to oceanic rise (as in our economic module) may be especially effective in increasing the public's willingness to act on sea level rise, relative to the more cartographic (Florida and southeast-U.S.) instructional modules we employed.

While our interventions' materials were derived directly from news media and the internet (i.e., effectively available to the public), the information was entirely empirical and fact-based, in contrast to the ways in which climate change information is *usually* presented to the public by the media—with media's common adherence to journalistic norms such as personalization, "balance," and dramatization. Adherence to such norms led Boykoff and Boykoff (2007) to label the U.S.'s mass media climate change coverage as "informationally deficient," which partially explains why recent increases in media coverage have not yielded marked increases in the acceptance of anthropogenic climate change, compared to the success of our laboratory's short interventions (e.g., Ranney and Clark, 2016; Ranney et al., in press).

As predicted, our sea level information also caused a decrease in nationalism, presenting yet more empirical evidence for RTMD theory (Ranney, 2012, etc.; Ranney and Clark, 2016), which proposed (at least) correlational relationships among six constructs—relationships that are appearing increasingly causal, such as the bidirectional inverse causality between nationalism and global warming acceptance (Ranney et al., in press). Further, we found an increased preference for the mitigating solution of phasing out fossil fuel use, whereas a solution involving sea walls/dikes decreased in desirability.

The results are heartening in several ways. For instance, we once again showed that communicating empirical information about climate change's effects can increase people's acceptance of (e.g., the anthropogenicity of) global warming, disconfirming Kahan's stasis view even more saliently (Ranney and Clark, 2016; Ranney et al., 2016, in press; van der Linden et al., 2017, etc.). (Nb. Kahan et al., 2015, disconfirm stasis themselves, showing increased climate change concern following geoengineering information). As shown historically regarding tobacco's health effects and heliocentrism, knowledge usually leads to science-normative attitude changes, rather than leaving people divided (i.e., few people still believe Earth to be flat). Our results also indicate neither fatalism nor solution-aversion after participants learn the adverse actual-and-projected effects of sea level rise (cf. Lorenzoni et al., 2007). Further encouraging is that our oceanic rise information yielded increased desires to phase out fossil fuels. Additional study into what might inhibit people from engaging with even more obviously *collective* climate change solutions (e.g., demanding government action) is desired.

The six numerical, mechanistic, and graphical types of interventions our group has developed—now including a set of sea level rise statistics and maps—have been shown to successfully increase *individuals*' understandings and acceptances regarding global warming. However, our website HowGlobalWarmingWorks.org (Ranney and Lamprey, 2013), which contains the majority of these interventions, has even had considerable "viral" success at more wholesale levels—with over one million page views attributable to it to date. With the continuing translation of many of its videos, pages, and texts into multiple languages, such as Mandarin, German, and Spanish, we hope to extend the website's reach to the largest audience possible. We thus hope to provide people around the globe with crucial climate knowledge tools, in the hope that individuals and groups might become more/highly active regarding global warming with the receipt of scientific information—another step in fostering worldwide activism to inhibit climate change's destructive course.

ETHICS STATEMENT

This study was carried out in accordance with the recommendations of the University of California, Berkeley's Committee for the Protection of Human Subjects (and its guidelines) with written informed consent from all subjects. All subjects gave written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the University of California, Berkeley's Committee for the Protection of Human Subjects.

AUTHOR CONTRIBUTIONS

QB and MR conceived, designed, and implemented the experiment. LV performed the statistical analyses and wrote the first draft of the present manuscript. All authors contributed to manuscript revision, read, and approved the submitted version, and all authors agree to be accountable for the content of the work.

FUNDING

Financial support for this work was provided by The University of California, Berkeley's, (a) Barbara White Bequest and (b) Committee on Research.

ACKNOWLEDGMENTS

We especially thank Lloyd Goldwasser, Oliver Taube, Perman Gochyyev, Paras Kumar, Edward Maibach, the two reviewers, and members of the Reasoning Group at the University of California, Berkeley (UCB) for contributions that led to this article.

REFERENCES

Abel, N., Gorddard, R., Harman, B., Leitch, A., Langridge, J., Ryan, A., et al. (2011). Sea level rise, coastal development and planned retreat: analytical framework, governance principles and an Australian case study. *Environ. Sci. Policy* 14, 279–288. doi: 10.1016/j.envsci.2010.12.002

Allcott, H. (2011). Social norms and energy conservation. *J. Public Econ.* 95, 1082–1095. doi: 10.1016/j.jpubeco.2011.03.003

Bates, B., Kundzewicz, Z., Wu, S., and Palutikof, J. (2008). *Climate Change and Water*. Technical Paper of the Intergovernmental Panel on Climate Change. Geneva; IPCC Secretariat.

Berinsky, A. J., Huber, G. A., and Lenz, G. S. (2012). Evaluating online labor markets for experimental research: Amazon.com's Mechanical Turk. *Polit. Anal.* 20, 351–368. doi: 10.1093/pan/mpr057

Bernstein, A., Gustafson, M., and Lewis, R. (2018). Disaster on the horizon: the price effect of sea level rise. *J. Finan. Econ.* Forthcoming. Available online at: https://ssrn.com/abstract=3073842, http://dx.doi.org/10.2139/ssrn.3073842 (accessed May 4, 2018).

Berrang-Ford, L., Ford, J. D., and Paterson, J. (2011). Are we adapting to climate change? *Glob. Environ. Change* 21, 25–33. doi: 10.1016/j.gloenvcha.2010.09.012

Bostrom, A., O'Connor, R. E., Böhm, G., Hanss, D., Bodi, O., Ekström, F., et al. (2012). Causal thinking and support for climate change policies: International survey findings. *Glob Environ Change* 22, 210–222. doi: 10.1016/j.gloenvcha.2011.09.012

Boykoff, M. T., and Boykoff, J. M. (2007). Climate change and journalistic norms: a case-study of US mass-media coverage. *Geoforum* 38, 1190–1204. doi: 10.1016/j.geoforum.2007.01.008

Breakwell, G. M. (2010). Models of risk construction: some applications to climate change. *Wiley Interdisc. Rev. Clim. Change* 1, 857–870. doi: 10.1002/wcc.74

Brody, S. D., Zahran, S., Vedlitz, A., and Grover, H. (2008). Examining the relationship between physical vulnerability and public perceptions of global climate change in the United States. *Environ. Behav.* 40, 72–95. doi: 10.1177/0013916506298800

Byrka, K., Kaiser, F. G., and Olko, J. (2017). Understanding the acceptance of nature-preservation-related restrictions as the result of the compensatory effects of environmental attitude and behavioral costs. *Environ. Behav.* 49, 487–508. doi: 10.1177/0013916516653638

Carlson, A. E., LeGrande, A. N., Oppo, D. W., Came, R. E., Schmidt, G. A., Anslow, F. S., et al. (2008). Rapid early Holocene deglaciation of the Laurentide ice sheet. *Nat. Geosci.* 1:620–6. doi: 10.1038/ngeo285

Chaiken, S., and Trope, Y. (Eds.). (1999). *Dual-Process Theories in Social Psychology*. New York, NY: Guilford Press.

Chandler, J., Mueller, P., and Paolacci, G. (2014). Nonnaïveté among Amazon Mechanical Turk workers: consequences and solutions for behavioral

researchers. *Behav. Res. Methods* 46, 112–130. doi: 10.3758/s13428-013-0365-7

Chang, C. (2015). *Bex and the Magic of Averaging Regarding Global Warming.* Berkeley, CA: Master's project, Graduate School of Education; University of California.

Christensen, J. H., Hewitson, B., Busuioc, A., Chen, A., Gao, X., Held, R., et al. (2007). "Chapter 11: Regional climate projections, climate change, 2007: the physical science basis," in *Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge: University Press), 847–940.

Church, J. A., and White, N. J. (2006). A 20th century acceleration in global sea-level rise. *Geophys. Res. Lett.* 33:L01602. doi: 10.1029/2005GL024826

Church, J. A., and White, N. J. (2011). Sea-level rise from the late 19th to the early 21st century. *Surveys Geophys.* 32, 585–602. doi: 10.1007/s10712-011-9119-1

Clifford, S., Jewell, R. M., and Waggoner, P. D. (2015). Are samples drawn from Mechanical Turk valid for research on political ideology? *Res. Polit.* doi: 10.1177/2053168015622072

Cunha, M. Jr, and Caldieraro, F. (2009). Sunk-cost effects on purely behavioral investments. *Cogn. Sci.* 33, 105–113. doi: 10.1111/j.1551-6709.2008.01005.x

Delucchi, M. A., and Jacobson, M. Z. (2011). Providing all global energy with wind, water, and solar power, part II: reliability, system and transmission costs, and policies. *Energy Policy* 39, 1170–1190. doi: 10.1016/j.enpol.2010.11.045

Diekmann, A., and Preisendörfer, P. (2003). Green and greenback: the behavioral effects of environmental attitudes in low-cost and high-cost situations. *Rational. Soc.* 15, 441–472. doi: 10.1177/1043463103154002

Dietz, T., Dan, A., and Shwom, R. (2007). Support for climate change policy: social psychological and social structural influences. *Rural Sociol.* 72, 185–214. doi: 10.1526/003601107781170026

Dunlap, R. E., and McCright, A. M. (2008). A widening gap: republican and Democratic views on climate change. *Environ. Sci. Policy Sustain. Dev.* 50, 26–35. doi: 10.3200/ENVT.50.5.26-35

Festinger, L. (1957). *A Theory of Cognitive Dissonance.* Stanford, CA: Stanford University Press.

Feygina, I., Jost, J. T., and Goldsmith, R. E. (2010). System justification, the denial of global warming, and the possibility of "system-sanctioned change." *Personal. Soc. Psychol. Bull.* 36, 326–338. doi: 10.1177/0146167209351435

Fischer, H., Meissner, K. J., Mix, A. C., Abram, N. J., Austermann, J., Brovkin, V., et al. (2018). Palaeoclimate constraints on a world with post-industrial warming of 2 degrees and beyond. *Nat. Geosci.* 11, 474–485. doi: 10.1038/s41561-018-0146-0

Garcia de Osuna, J., Ranney, M., and Nelson, J. (2004). "Qualitative and quantitative effects of surprise: (Mis)estimates, rationales, and feedback-induced preference changes while considering abortion," in *Proceedings of the Twenty-Sixth Annual Conference of the Cognitive Science Society,* eds K. Forbus, D. Gentner, and T. Regier (Mahwah, NJ: Erlbaum), 422–427.

Gilbert, J. K. (2010). The role of visual representations in the learning and teaching of science: an introduction. *Asia Pacific Forum Scie. Learn. Teach.* 11, 1–19. Retrieved from: www.eduhk.hk

Goldstein, N. J., Cialdini, R. B., and Griskevicius, V. (2008). A room with a viewpoint: using social norms to motivate environmental conservation in hotels. *J. Consum. Res.* 35, 472–482. doi: 10.1086/586910

Gould, R. V. (1993). Collective action and network structure. *Am. Sociol. Rev.* 58, 182–196. doi: 10.2307/2095965

Hamilton, L. C., and Keim, B. D. (2009). Regional variation in perceptions about climate change. *Int. J. Climatol.* 29, 2348–2352. doi: 10.1002/joc.1930

Hansen, J., Sato, M., Ruedy, R., Lo, K., Lea, D. W., and Medina-Elizade, M. (2006). Global temperature change. *Proc. Natl. Acad. Sci. U.S.A.* 103, 14288–14293. doi: 10.1073/pnas.0606291103

Hardin, G. (1968). The tragedy of the commons. *Science* 162, 1243–1248. doi: 10.1126/science.162.3859.1243

Hatfield-Dodds, S., and Morrison, M. (2010). *Confusing Opportunity Costs, Losses and Forgone Gains: Assessing the Effect of Communication Bias on Support for Climate Change Policy in the United States and Australia (No. 0910).* Centre for Climate Economics & Policy, Crawford School of Public Policy, The Australian National University.

Helgeson, J., van der Linden, S., and Chabay, I. (2012). "The role of knowledge, learning and mental models in public perceptions of climate change related risks," in *Learning for Sustainability in Times of Accelerating Change,* eds A. Wals and P. Corcoran (Wageningen, NL: Wageningen Academic Publishers), 329–346. doi: 10.3920/978-90-8686-757-8_21

Hennes, E. P., Ruisch, B. C., Feygina, I., Monteiro, C. A., and Jost, J. T. (2016). Motivated recall in the service of the economic system: the case of anthropogenic climate change. *J. Exp. Psychol.* 145, 755–771. doi: 10.1037/xge0000148

Holgate, S. J., and Woodworth, P. L. (2004). Evidence for enhanced coastal sea level rise during the 1990s. *Geophys. Res. Lett.* 31:L07305. doi: 10.1029/2004GL019626

Hughes, S. (2015). A meta-analysis of urban climate change adaptation planning in the US. *Urban Clim.* 14, 17–29. doi: 10.1016/j.uclim.2015.06.003

Hulme, M. (2009). *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity.* Cambridge: Cambridge University Press. doi: 10.1017/CBO9780511841200

Hurlstone, M. J., Lewandowsky, S., Newell, B. R., and Sewell, B. (2014). The effect of framing and normative messages in building support for climate policies. *PLoS ONE* 9:e114335. doi: 10.1371/journal.pone.0114335

Jacobson, M. Z., Delucchi, M. A., Bauer, Z. A., Goodman, S. C., Chapman, W. E., Cameron, M. A., et al. (2017). 100% clean and renewable wind, water, and sunlight all-sector energy roadmaps for 139 countries of the world. *Joule* 1, 108–121. doi: 10.1016/j.joule.2017.07.005

Kahan, D. M., Jenkins-Smith, H., Tarantola, T., Silva, C. L., and Braman, D. (2015). Geoengineering and climate change polarization: testing a two-channel model of science communication. *Ann. Am. Acad. Pol. Soc. Sci.* 658, 192–222. doi: 10.1177/0002716214559002

Kahan, D. M., Peters, E., Wittlin, M., Slovic, P., Ouellette, L. L., Braman, D., et al. (2012). The polarizing impact of science literacy and numeracy on perceived climate change risks. *Nat. Clim. Chang.* 2, 732. doi: 10.1038/nclimate1547

Kahneman, D., Knetsch, J. L., and Thaler, R. H. (1986). Fairness and the assumptions of economics. *J. Bus.* 59, 285–300. doi: 10.1086/296367

Kishore, N., Marqués, D., Mahmud, A., Kiang, M. V., Rodriguez, I., Fuller, A., et al. (2018). Mortality in Puerto Rico after Hurricane Maria. *N. Engl. J. Med.* 379, 162–170. doi: 10.1056/NEJMsa1803972

Klick, H., and Smith, E. R. (2010). Public understanding of and support for wind power in the United States. *Renew. Energy* 35, 1585–1591. doi: 10.1016/j.renene.2009.11.028

Kolbert, E. (2015). *The Siege of Miami.* The New Yorker. Available online at: https://www.newyorker.com/magazine/2015/12/21/the-siege-of-miami

Konisky, D. M., Hughes, L., and Kaylor, C. H. (2016). Extreme weather events and climate change concern. *Clim. Change* 134, 533–547. doi: 10.1007/s10584-015-1555-3

Krosnick, J. A., Holbrook, A. L., Lowe, L., and Visser, P. S. (2006). The origins and consequences of democratic citizens' policy agendas: a study of popular concern about global warming. *Clim. Change* 77, 7–43. doi: 10.1007/s10584-006-9068-8

Krosnick, J. A., Holbrook, A. L., and Visser, P. S. (2000). The impact of the fall 1997 debate about global warming on American public opinion. *Public Understand. Sci.* 9, 239–260. doi: 10.1088/0963-6625/9/3/303

Kunda, Z. (1990). The case for motivated reasoning. *Psychol. Bull.* 108, 480–490. doi: 10.1037/0033-2909.108.3.480

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: the role of affect, imagery, and values. *Clim. Change* 77, 45–72. doi: 10.1007/s10584-006-9059-9

Leiserowitz, A. (2007). "Communicating the risks of global warming: American risk perceptions, affective images, and interpretive communities," in *Creating a Climate for Change: Communicating Climate Change and Facilitating Social Change,* eds S. Moser and L. Dilling (Cambridge: Cambridge University Press), 44–63. doi: 10.1017/CBO9780511535871.005

Leiserowitz, A., Marlon, J., Howe, P., Mildenberger, M., Zhang, B., and Wang, X. (2018). *Estimated % of Adults Who Think Global Warming is Happening.* Available online at: http://climatecommunication.yale.edu/visualizations-data/ycom-us-2018

Lewandowsky, S., Oberauer, K., and Gignac, G. E. (2013). NASA faked the moon landing—therefore, (climate) science is a hoax: an anatomy of the motivated rejection of science. *Psychol. Sci.* 24, 622–633. doi: 10.1177/0956797612457686

Lockwood, M. (2011). Does the framing of climate policies make a difference to public support? Evidence from UK marginal constituencies. *Clim. Policy* 11, 1097–1112. doi: 10.1080/14693062.2011.579301

Lord, C. G., Ross, L., and Lepper, M. R. (1979). Biased assimilation and attitude polarization: the effects of prior theories on subsequently considered evidence. *J. Pers. Soc. Psychol.* 37:2098. doi: 10.1037/0022-3514.37.11.2098

Lorenzoni, I., and Langford, I. H. (2001). *Climate Change Now and in the Future: A Mixed Methodological Study of Public Perceptions in Norwich (UK).* Norwich: Centre for Social and Economic Research on the Global Environment Working Paper ECM 01–05.

Lorenzoni, I., Nicholson-Cole, S., and Whitmarsh, L. (2007). Barriers perceived to engaging with climate change among the UK public and their policy implications. *Glob. Environ. Change* 17, 445–459. doi: 10.1016/j.gloenvcha.2007.01.004

Marx, S. M., Weber, E. U., Orlove, B. S., Leiserowitz, A., Krantz, D. H., Roncoli, C., et al. (2007). Communication and mental processes: experiential and analytic processing of uncertain climate information. *Glob. Environ. Change* 17, 47–58. doi: 10.1016/j.gloenvcha.2006.10.004

McCright, A. M., and Dunlap, R. E. (2003). Defeating Kyoto: the conservative movement's impact on US climate change policy. *Soc. Probl.* 50, 348–373. doi: 10.1525/sp.2003.50.3.348

McCright, A. M., and Dunlap, R. E. (2011). The politicization of climate change and polarization in the American public's views of global warming, 2001–2010. *Sociol. Q.* 52, 155–194. doi: 10.1111/j.1533-8525.2011.01198.x

McDonald, R. I. (2008). Global urbanization: can ecologists identify a sustainable way forward? *Front. Ecol. Environ.* 6, 99–104. doi: 10.1890/070038

Milman, O. (2018). *Flooding from High Tides Has Doubled in the US in Just 30 Years*. The Guardian. Available online at: https://www.theguardian.com/us-news/2018/jun/06/flooding-from-high-tides-has-doubled-in-the-us-in-just-30-years

Munnich, E., and Ranney, M. A. (2019). Learning from surprise: Harnessing a metacognitive surprise signal to build and adapt belief networks. *Top. Cogn. Sci.* 11, 164–177. doi: 10.1111/tops.12397

Munnich, E., Ranney, M. A., and Song, M. (2007). "Surprise, surprise: the role of surprising numerical feedback in belief change," in *Proceedings of the Twenty-Ninth Annual Conference of the Cognitive Science Society,* eds D. S. McNamara and J. G. Trafton (Mahwah, NJ: Erlbaum), 503–508.

Nevin, J. A., Mandell, C., and Atak, J. R. (1983). The analysis of behavioral momentum. *J. Exp. Anal. Behav.* 39, 49–59. doi: 10.1901/jeab.1983.39-49

Nicholson-Cole, S., and O'Riordan, T. (2009). *Adaptive Governance for a Changing Coastline: Science, Policy and Publics in Search of a Sustainable Future*. Cambridge: Cambridge University Press.

Nickerson, R. S. (1998). Confirmation bias: a ubiquitous phenomenon in many guises. *Rev. Gen. Psychol.* 2, 175–220. doi: 10.1037/1089-2680.2.2.175

O'Connor, R. E., Bord, R. J., Yarnal, B., and Wiefek, N. (2002). Who wants to reduce greenhouse gas emissions? *Soc. Sci. Q.* 83, 1–17. doi: 10.1111/1540-6237.00067

Olausson, U. (2009). Global warming—global responsibility? Media frames of collective action and scientific certainty. *Public Understand. Sci.* 18, 421–436. doi: 10.1177/0963662507081242

Park, H. S., and Vedlitz, A. (2013). Climate hazards and risk status: explaining climate risk assessment, behavior, and policy support. *Sociol. Spectr.* 33, 219–239. doi: 10.1080/02732173.2013.732900

Pedersen, E. R., and Neergaard, P. (2006). Caveat emptor–let the buyer beware! environmental labelling and the limitations of 'green'consumerism. *Bus. Strategy Environ.* 15, 15–29. doi: 10.1002/bse.434

Rahmstorf, S. (2010). A new view on sea level rise. *Nat. Rep. Clim. Change* 4, 44–45. doi: 10.1038/climate.2010.29

Ranney, M. (1996). Individual-centered vs. model-centered approaches to consistency: a dimension for considering human rationality. *Vivek A Q. Art. Intell.* 9, 35–43.

Ranney, M., Clark, D., Reinholz, D., and Cohen, S. (2012). "Changing global warming beliefs with scientific information: knowledge, attitudes, and RTMD (Reinforced Theistic Manifest Destiny theory)," in *Proceedings of the 34th Annual Meeting of the Cognitive Science Society,* eds N. Miyake, D. Peebles, and R. P. Cooper (Austin, TX: Cognitive Science Society), 2228–2233.

Ranney, M. A. (2012). "Why don't Americans accept evolution as much as people in peer nations do? A theory (Reinforced Theistic Manifest Destiny) and some pertinent evidence," in *Evolution Challenges: Integrating Research and Practice in Teaching and Learning About Evolution,* eds K. S. Rosengren, S. K. Brem, E. M. Evans, and G. M. Sinatra (Oxford: Oxford University Press), 233–269.

Ranney, M. A., and Clark, D. (2016). Climate change conceptual change: Scientific information can transform attitudes. *Top. Cogn. Sci.* 8, 49–75. doi: 10.1111/tops.12187

Ranney, M. A., and Lamprey, L. N. (Eds.). (2013). *How Global Warming Works.* Available online at http://www.HowGlobalWarmingWorks.org (Accessed July 27, 2018).

Ranney, M. A., Munnich, E. L., and Lamprey, L. N. (2016). "Increased wisdom from the ashes of ignorance and surprise: numerically-driven inferencing, global warming, and other exemplar realms," in *The Psychology of Learning and Motivation,* Vol. 65, ed B. H. Ross (New York, NY: Elsevier), 129–182.

Ranney, M. A., Shonman, M., Fricke, K., Kumar, P., and Lamprey, L. N. (in press). "Information that boosts normative global warming acceptance without polarization: toward J. S. Mill's political ethology of national character," in *Anthology of the Experimental Philosophy of Science,* eds R. Samuels and D. Wilkenfeld (New York, NY: Bloomsbury).

Ranney, M. A., and Thanukos, A. (2011). "Accepting evolution or creation in people, critters, plants, and classrooms: the maelstrom of American cognition about biological change," in *Epistemology and Science Education: Understanding the Evolution vs. Intelligent Design Controversy,* eds R. S. Taylor and M. Ferrari (New York, NY: Routledge), 143–172.

Rao, K. (2017). *Climate Change and Housing: Will a Rising Tide Sink All Homes?* Available online at: https://www.zillow.com/research/climate-change-underwater-homes-12890/

Redlawsk, D. P. (2002). Hot cognition or cool consideration? Testing the effects of motivated reasoning on political decision making. *J. Polit.* 64, 1021–1044. doi: 10.1111/1468-2508.00161

Röös, E., and Tjärnemo, H. (2011). Challenges of carbon labelling of food products: a consumer research perspective. *Br. Food J.* 113, 982–996. doi: 10.1108/00070701111153742

Ruddell, D., Harlan, S. L., Grossman-Clarke, S., and Chowell, G. (2012). Scales of perception: public awareness of regional and neighborhood climates. *Clim. Change* 111, 581–607. doi: 10.1007/s10584-011-0165-y

Schubert, R., Schellnhuber, H. J., Buchmann, N., Epiney, A., Griebhammer, R., Kulessa, M., et al. (2006). *The Future Oceans: Warming Up, Rising High, Turning Sour*. Berlin: German Advisory Council on Global Change.

Schultz, P. W. (1999). Changing behavior with normative feedback interventions: a field experiment on curbside recycling. *Basic Appl. Soc. Psych.* 21, 25–36. doi: 10.1207/s15324834basp2101_3

Schultz, P. W., Khazian, A. M., and Zaleski, A. C. (2008). Using normative social influence to promote conservation among hotel guests. *Soc. Influence* 3, 4–23. doi: 10.1080/15534510701755614

Shwom, R., Bidwell, D., Dan, A., and Dietz, T. (2010). Understanding US public support for domestic climate change policies. *Glob. Environ. Change* 20, 472–482. doi: 10.1016/j.gloenvcha.2010.02.003

Sisco, M. R., Bosetti, V., and Weber, E. U. (2017). When do extreme weather events generate attention to climate change? *Clim. Change* 143, 227–241. doi: 10.1007/s10584-017-1984-2

Slater, M. D., and Gleason, L. S. (2012). Contributing to theory and knowledge in quantitative communication science. *Commun. Methods Meas.* 6, 215–236. doi: 10.1080/19312458.2012.732626

Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychol. Bull.* 119:3. doi: 10.1037/0033-2909.119.1.3

Slovic, P., Finucane, M. L., Peters, E., and MacGregor, D. G. (2004). Risk as analysis and risk as feelings: some thoughts about affect, reason, risk, and rationality. *Risk Anal.* 24, 311–322. doi: 10.1111/j.0272-4332.2004.00433.x

Smith, N. A., Sabat, I. E., Martinez, L. R., Weaver, K., and Xu, S. (2015). A convenient solution: using MTurk to sample from hard-to-reach populations. *Ind. Organ. Psychol.* 8, 220–228. doi: 10.1017/iop.2015.29

Solomon, S., Qin, D., Manning, M., Chen, Z., Marquis, M., Averyt, K. B., et al. (2007). *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Spence, A., Poortinga, W., Butler, C., and Pidgeon, N. F. (2011). Perceptions of climate change and willingness to save energy related to flood experience. *Nat. Clim. Chang.* 1, 46–49. doi: 10.1038/nclimate1059

Taber, C. S., and Lodge, M. (2006). Motivated skepticism in the evaluation of political beliefs. *Am. J. Pol. Sci.* 50, 755–769. doi: 10.1111/j.1540-5907.2006.00214.x

Tol, R. S., Klein, R. J., and Nicholls, R. J. (2008). Towards successful adaptation to sea-level rise along Europe's coasts. *J. Coast. Res.* 24, 432–442. doi: 10.2112/07A-0016.1

Tversky, A., and Kahneman, D. (1991). Loss aversion in riskless choice: a reference-dependent model. *Q. J. Econ.* 106, 1039–1061. doi: 10.2307/2937956

van der Linden, S., Maibach, E., Cook, J., Leiserowitz, A., Ranney, M., Lewandowsky, S., et al. (2017). Culture versus cognition is a false dilemma. *Nat. Clim. Change* 7:457. doi: 10.1038/nclimate3323

van der Linden, S. L., Leiserowitz, A. A., Feinberg, G. D., and Maibach, E. W. (2014). How to communicate the scientific consensus on climate change: plain facts, pie charts or metaphors? *Clim. Change* 126, 255–262. doi: 10.1007/s10584-014-1190-4

Villar, A., and Krosnick, J. A. (2011). Global warming vs. climate change, taxes vs. prices: Does word choice matter? *Clim. Change* 105, 1–12. doi: 10.1007/s10584-010-9882-x

Weber, E. U. (2006). Experience-based and description-based perceptions of long-term risk: why global warming does not scare us (yet). *Clim. Change* 77, 103–120. doi: 10.1007/s10584-006-9060-3

Weber, E. U. (2010). What shapes perceptions of climate change? *Wiley Interdisc. Rev. Clim. Change* 1, 332–342. doi: 10.1002/wcc.41

Weber, E. U., and Stern, P. C. (2011). Public understanding of climate change in the United States. *Am. Psychol.* 66, 315–328. doi: 10.1037/a0023253

Wile, R. (2017). *The Estimated Costs of Hurricanes Irma and Harvey are Already Higher than Katrina*. Money. Available online at: http://money.com/money/4935684/hurricane-irma-harvey-economic-cost/

Wong-Parodi, G., Fischhoff, B., and Strauss, B. (2018). Effect of risk and protective decision aids on flood preparation in vulnerable communities. *Weather Clim. Soc.* 10, 401–417. doi: 10.1175/WCAS-D-17-0069.1

Woodworth, P. L., White, N. J., Jevrejeva, S., Holgate, S. J., Church, J. A., and Gehrels, W. R. (2009). Evidence for the accelerations of sea level on multi-decade and century timescales. *Int. J. Climatol.* 29, 777–789. doi: 10.1002/joc.1771

Zhao, X., Leiserowitz, A. A., Maibach, E. W., and Roser-Renouf, C. (2011). Attention to science/environment news positively predicts and attention to political news negatively predicts global warming risk perceptions and policy support. *J. Commun.* 61, 713–731. doi: 10.1111/j.1460-2466.2011.01563.x

Conflict of Interest Statement: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.