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The Impact of Message Valence on Climate Change Attitudes: A Longitudinal Experiment

Emily Diamond

Kaitlin Urbanski

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Emily Diamond, PhD *(corresponding author)*
University of Rhode Island ~ diamond@uri.edu
Twitter: @EmilyPDiamond
ORCiD: https://orcid.org/0000-0001-5643-4842

Kaitlin Urbanski
University of Rhode Island ~ kurbanski@uri.edu
Twitter: @KatieMUrbanski

Abstract

Media framing plays an important role in shaping attitudes and behaviors toward climate change, but the literature remains split on whether positive or negative frames are more effective. Additionally, few studies have investigated the effects that message exposure may have on audiences long-term. This study used a longitudinal experiment to investigate how repeated exposure to negatively- or positively-valenced news articles about climate change impacts attitudes, behaviors, and policy preferences. Participants read either a positive or negative article each week over the course of four weeks, with a follow-up four weeks after treatment concluded. Exposure to both types of messaging increased climate concern and perceived importance in the short term, but this effect only persisted over time in the negatively-valenced article group. Exposure to positively-valenced articles was associated with short-term increases in self- and societal efficacy around climate change, but this did not persist over time. There were minimal effects on behaviors and policy preferences.

Keywords: framing, climate change, message valence, efficacy, media

Introduction

Climate change continues to be a salient and pressing issue as the world moves toward a warmer climate and governments attempt to mobilize more aggressive mitigation strategies. Periodic reports from scientific bodies such as the Intergovernmental Panel on Climate Change (IPCC) remind us of the urgency of addressing climate change to avoid catastrophic impacts. How the media covers the findings of these reports can be a driving force in shaping public opinion about the issue (McCombs, 2005). For example, climate change coverage spiked after the release of the Intergovernmental Panel on Climate Change (IPCC) Special Report on 1.5° C (SR15) in October 2018 (*IPCC, 2018: Summary for Policymakers.*, 2018). News coverage of the report was largely negative in tone, latching onto what were perceived as "deadlines" by which it was necessary to stop or lower current warming trends to avoid tipping points (Boykoff & Pearman, 2019). More recently, Google Trends data shows a spike in web searches for "climate change" and related terms the week after the release of the first section of the IPCC's Sixth Assessment Report (AR6) in 2021 (*IPCC, 2021: Summary for Policymakers.*, 2021), which emphasized the dire consequences of unmitigated climate change. While an increase in news coverage of climate change may theoretically increase public awareness of and concern about climate change (Downs, 1972; Mutz & Soss, 1997), the positive or negative tone of media coverage can also affect audience attitudes and beliefs in unforeseen ways.

Studies of persuasive messaging often find that messages with an overall negative tone are useful for changing attitudes and behaviors. One common strategy involves framing the message in such a way as to evoke fear in the audience. This strategy has been successfully employed in public and personal health campaigns to encourage behavior change (Das et al., 2003; de Hoog et al., 2005; Janis & Feshbach, 1953; Witte & Allen, 2000). Meanwhile, studies of news coverage of environmental issues have also found that messages with positive or hopeful tones motivate people to care about environmental issues (Feinberg & Willer, 2011; Gifford & Comeau, 2011; Hart & Feldman, 2016; Jacobson et al., 2019; O'Neill & Nicholson-Cole, 2009; Smith & Leiserowitz, 2014).

These conflicting findings have implications for the coverage of climate change in the media. Scientific reports about climate change are unlikely to increase in optimism in the near future, which may lead to increasingly negative coverage in U.S. news outlets. The effect that repeated exposure to negative coverage of climate change will have on audiences immediately and long-term is unclear. To begin to understand this effect, this study was designed to assess whether repeated positively- or negatively-valenced news articles have different impacts on audience attitudes toward climate change over time. Valenced messages are those that, through the use of words and other elements that convey a certain affect, carry either an overall positive or negative connotation (C. de Vreese & Boomgaarden, 2003). McIntyre & Gibson (2016) define a positively valenced message as "one that focuses on the benefits of an event or issue," and a negatively valenced message as "one that focuses on the harmful outcomes of an event or issue," (p. 305). The results of this study can inform media framing decisions when interpreting and communicating the latest climate change information.

The Effects of Negative and Positive Media Valence

Framing is a common communication technique that involves highlighting certain aspects of an issue to influence how it is perceived (Entman, 1993; Nisbet, 2009; Spence & Pidgeon, 2010). A frame, or "central organizing idea," (Gamson & Modigliani, 1989, p. 3) helps to emphasize a specific aspect of a story and guides the audience to understand an issue in a particular way (C. H. de Vreese, 2005). Of particular relevance here, framing in news media can be used to give

the article an overall positive or negative tone, or “inherent valence” (Vreese & Boomgaarden, 2003, p. 362). By focusing on themes or perspectives seen as beneficial or detrimental, articles may have a general affect of positivity, negativity, or neutrality. This overall valence can then impact how a reader perceives the issue, influencing their emotions, attitudes, and potentially even behaviors and policy preferences. For example, in a study on the effects of catastrophic news on audiences, Balzarotti and Ciceri (2014) demonstrated how catastrophic events can be framed in terms of either their negative impacts or their positive, hopeful outcomes. When framed more positively, stories on these disasters resulted in lower fear among audiences than the negatively framed versions. Similarly, Baden et al (2019) found that using solution-oriented frames, as well as messages that result in positive emotions, led to more positive affect and intentions to take behavior among readers than articles with catastrophic frames that led to negative emotions.

The valence of news stories is particularly important when discussing political issues because political news coverage with a discernible valence has been demonstrated to have an effect on audience policy support (C. de Vreese & Boomgaarden, 2003). This is in contrast to news with no clear valence, which is less likely to impact support (C. de Vreese, 2003). Positive or negative message valence can similarly increase or decrease motivation to engage in pro-environmental behavior, respectively (Baden et al., 2019). Due to these differential effects, some scholars call for a shift to “constructive journalism,” which advocates for frames that are inspiring and solutions-focused in order to encourage optimism among audiences (Baden et al., 2019).

Positive and Negative Valence in Climate Change Media

Because of the nature of climate change as an issue with overwhelmingly negative outcomes, media coverage of climate change information often results in messages with an overall negative valence. Several studies have applied negative and positive message framing to ascertain how message tone affects attitudes and behaviors toward climate change, as well as policy preferences and mitigation actions. Though these studies differ in how they categorize their frames (for example, gain versus loss, hope-inducing versus fear-inducing, consequences-focused versus solutions-focused), most studies use frames with a discernible contrasting valence.

Across these studies, the results are mixed in terms of which valence is more motivating. Some find that negatively-valenced messaging results in behavior and attitude change more so than positively-valenced messaging. For example, Howell (2014) found that a one-time exposure to distressing climate change information heightened concern about climate change and led to increased mitigation behaviors. Negative frames have also been found to be more persuasive than positive frames when individuals have low concern about climate change (Newman et al., 2012). Though positive information may increase feelings of hope, it may not spur audiences to act in the way that negative information can (Hornsey & Fielding, 2016). Hopeful messages are therefore not necessarily damaging to existing intentions to act (Ettinger et al., 2021; Hornsey & Fielding, 2016), but it has been suggested that they should be balanced with a reminder of the bleak nature of climate change to become more motivating (Hornsey & Fielding, 2016).

Yet, there is also evidence that negative messaging may not be useful for motivating attitudinal and policy responses to climate change. In some cases, messages with a negative valence have backfired entirely and caused audiences to feel disempowered and to subsequently disengage from the issue (O’Neill & Nicholson-Cole, 2009). Similarly, messages that focus on the dire and inequitable impacts of climate change risk distancing those who hold strong beliefs

that the world is an ultimately just place. This mismatch between values and messaging can increase skepticism and disbelief in climate change (Feinberg & Willer, 2011).

To counter this effect, some suggest using messages that focus on optimism and hope within the climate change mitigation movement. While worry may strengthen policy support, so too do emotions such as interest (Smith & Leiserowitz, 2014), which may be evoked through positively-valenced stories. Hope is another emotion that has been correlated with increased policy support (Smith & Leiserowitz, 2014). Hope or optimism have previously been evoked by framing messages in terms of the public health benefits of combatting climate change (Myers et al., 2012), its potential solutions (Feinberg & Willer, 2011), or by discussing actions that have already been taken to mitigate its effects. In those with strong just world beliefs, the solutions frame in particular leads to increased belief in climate change and acceptance of its occurrence (Feinberg & Willer, 2011).

One important consideration in climate change messages is the impact of valence on two types of efficacy. Self-efficacy is an individual's perception that they can effectively carry out an action recommendation on their own, while societal or collective efficacy is the sense that society at large can come together to successfully mitigate a problem (Hart & Feldman, 2014). The Extended Parallel Process Model (EPPM) offers one way to conceptualize the importance of efficacy. It postulates that an individual's perception of the degree of threat (as communicated through a negatively-valenced message, for example) informs their emotional reaction, while their perceived sense of their own effectiveness in controlling the situation informs the subsequent actions they take (Witte, 1992). This interaction is particularly salient in climate change communications, which often pair the threat of the situation with potential individual or societal responses to alleviate the threat. An experimental application of the EPPM found that exposure to a message with both threatening information about climate change and action recommendations with perceived high efficacy resulted in the strongest attitude and behavior changes as compared to a message with a less salient threat and seemingly ineffective action recommendations (Li, 2014). Although positively- or negatively-valenced messages may impact policy support, the EPPM implies that they should also have an effect on efficacy and intended behavior change.

Duration of Framing Effects

Most research to date has studied the immediate effects of one-time exposures to positive or negative messaging, leaving a gap in understanding the effects of sustained exposures as well as the effects that exposures have over time. It has been suggested that responses to pessimism may appear more quickly than responses to optimism, but have weaker staying power (Hornsey & Fielding, 2016), or that treatments used in other studies on a short-term basis might yield different results if sustained over time (Hart & Feldman, 2016). Others have posited that emotional appeals about climate change may lack staying power with audiences because it is a phenomenon with seemingly distant impacts, and because a constant barrage of bad news desensitizes audiences in the long run (O'Neill & Nicholson-Cole, 2009). Given that the American public is not exposed to climate change news on a one-time basis, examining the effects of sustained exposure is critical to understanding how this impacts attitudes, policy support, and behaviors in the short- and long-term.

As yet, few studies have examined the impact of message valence on a longitudinal scale. Milfont (2012) tracked individuals' knowledge, efficacy, and concern about climate change over a period of a year in order to understand how the relationship among these variables influences support for mitigation policies. However, this study did not include exposure to a treatment.

Howell (2014) examined valence effects by studying the impacts of a one-time negative climate change information exposure immediately, and then with follow-ups at ten weeks and one-year post-exposure. However, this study examined impacts following a single exposure incident, which less realistically mimics ongoing media exposure. De Hoog & Verboon's (2020) study measured audience affect as a result of a ten day news exposure, and found that exposure to more negative and personally relevant news resulted in higher reported negative affect in individuals. Exposure was to all types of news and depended on the participants coming into contact with news stories over the course of their daily lives rather than via deliberate exposure by the researchers. Though the results demonstrate the impact of a constant barrage of negatively-valenced media, they were also dependent on the participants hearing or seeing news stories individually and their subjective ratings of valence.

Materials & Methods

The primary research question that this study was designed to answer was: How does exposure to positively- or negatively-valenced news articles on climate change impact climate change concern, behaviors, and policy preferences? And how long do the effects of repeated message exposure last? We expected that, compared to negatively-valenced messages, positively-valenced messages would decrease climate change concern and importance (because the issue would seem less urgent), but increase feelings of self- and societal efficacy, likelihood of undertaking pro-climate behaviors, and policy preferences in line with emissions reductions.

We tested these hypotheses through a pre-registered,[1] longitudinal framing experiment with both within- and between-subject variation. The experiment was approved by the University of Rhode Island Institutional Review Board (IRB2021-097) and all participants provided written informed consent to participate in each survey. In this section we report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study.

Participants (n=600) were randomly assigned to either a positive valence or negative valence treatment group[2] and responded to a series of surveys over the course of nine weeks in the spring of 2021. The first survey (Week 1) collected baseline measures of the various outcome and control variables. The next four surveys (Weeks 2-5) asked participants to read a news article about climate change and respond to attention- and manipulation-check questions. Participants in the positive group received articles with a positive tone, while participants in the negative group received articles with a negative tone. The Week 5 survey also repeated the outcome measures initially asked in Week 1. Four weeks later (Week 9), participants received a final survey repeating the outcome measures from Weeks 1 and 5. To maximize the likelihood that the articles were read closely by participants, we required that they stay on the page with the article for a set amount of time (at least 45 seconds) and followed the news article with a question asking participants to identify the topic. If they responded incorrectly, they were routed back to the article to re-read it. Various attention check questions were included in each survey to encourage high-quality responses, and these were controlled for in the analysis. Figure 1 shows the experimental cadence.

Figure 1: Cadence of surveys over duration of experiment

[1] Egap Registration ID: 20210118AB

[2] To maintain adequate statistical power with a small sample size, we were unable to include a control group for this experiment.

Week 1	Week 2	Week 3	Week 4	Week 5	Week 9
Baseline measure of outcome and control variables	*Climate article + valence validation measures*	*Climate article + valence validation measures*	*Climate article + valence validation measures*	*Climate article + valence validation measures + outcome variables*	*Outcome variables*

The treatment articles were selected from major news sources through an iterative process and a pilot test to validate the valence of the articles. We selected the initial sample of articles by searching databases from prominent news sources with climate change coverage, including *Scientific American, National Geographic, Time, The Guardian, Smithsonian Magazine, The New York Times, Huffington Post, Fox News, The Washington Post, Slate, Grist, National Review, Vox, The BBC, The Economist, World Economic Forum, Medium,* and *Treehugger*. Initially, our search entailed reviewing the most recent relevant articles per our criteria, browsing back one or two years depending on the density of articles published by each news source. Additionally, to target the greatest number of very positive and very negative articles, we did a specific search of a few databases with the most publications on climate change (for example, *The New York Times, The Washington Post*) at two particular points in time. The first was a search between December 2015 and December 2016 with the intention of targeting positive articles following the adoption of the Paris Agreement in December 2015. The second was a search between September 2018 and December 2018 to target negative articles following the release of the IPCC's SR15 in October 2018.

We used the search term "climate change" and/or browsed recent articles in the environment/science section on the topic of climate change that had either a distinctly negative or positive framing, as judged by the research team. We also prioritized articles that avoided a partisan bias, including articles mentioning a specific climate change policy that may activate partisan identities, or those that linked climate change to other highly polarizing issues such as immigration, racial justice, or coronavirus. After this initial search, 67 articles were identified. The research team reviewed these articles and evaluated their valence, identifying 10 that had the strongest negative framing and 10 that had the strongest positive framing. The articles were edited to be of a similar length and to avoid any blatantly political content that may activate partisan identities.

After identifying the 20 finalist articles, we then conducted a session of pilot coding. Nine student pilot coders each read and coded the 20 finalist articles to evaluate their overall valence on a series of metrics measuring article tone, including fearful vs. hopeful, pessimistic vs. optimistic, consequences vs. solutions-focused, and negative vs. positive tone. Details about the pilot coding outcomes can be found in the online appendix. The average responses on each metric were summed for each article to create an overall valence score of 1-10 (from negative to positive). Intercoder reliability testing found an average 84.4% agreement between the coders across all articles. The four articles with the most negative score and the four articles with the most positive score were selected as the final articles to be included in the experiment. The sources of the final articles were *National Geographic, Time, Huffington Post, The New York Times, Fox News,* and *The Washington Post*. However, the sources of the articles were not revealed to the participants to avoid any media outlet bias. Additionally, all formatting, images, and advertisements were removed to reduce any media bias effects. The final articles (as presented to participants) can be found in the online appendix.

Sample

Participants were recruited from the online survey platform Prolific, which offers researchers access to a large population of individual survey respondents. Studies have found the participant base of the Prolific platform to be more diverse, more naive, less dishonest, and generally of a higher quality for academic research than other online survey platforms such as Amazon's Mturk (Palan & Schitter, 2018; Peer et al., 2017). The recruitment message emphasized the longitudinal nature of the study and the requirement for participants to respond to all six surveys over nine weeks (while there was no punishment for dropping out early, a bonus payment was awarded to participants who completed all six surveys).

Participants were adults (18+) residing in the United States. The sample of 600 respondents to the Week 1 survey were randomly assigned to either the positive (n=295) or negative (n=305) treatment group. The average drop-off rate between Week 1 and Week 5 was 16% (n=505 in Week 5), and the average drop-off rate between Week 1 and Week 9 was 39% (n=368 in Week 9). The negative treatment group experienced a 14% drop-off rate by week 5 and a 41% drop-off rate by Week 9. The positive treatment group experienced an 18% drop-off rate by Week 5 and a 37% drop-off rate by Week 9.

Key Variables

Dependent Variables

This study was interested in the effect of message valence on climate change attitudes, pro-climate behaviors and policy preferences. Attitudinally, we measured climate change concern ("How concerned are you about climate change" - **Concern**) (adapted from Gifford & Comeau, 2011), perception of the importance of climate change ("I feel that climate change is an important issue to address" - **Importance**) (adapted from Hart & Feldman, 2016), personal self-efficacy around climate change ("I feel like I can do something to mitigate the effects of climate change" - **Efficacy**) (adapted from Hart & Feldman, 2016), societal efficacy to address climate change ("If we act collectively as a society, we will be able to minimize the consequences of climate change" - **Society**), and perceptions of the consequences of climate change ("The consequences of climate change will be...positive/negative"- **Consequences**) (adapted from Whitmarsh, 2008), all measured on 7-point Likert scales.

Pro-environmental behavior was measured through likelihood to change personal behavior in the next month to combat climate change (**Behavior**), likelihood to sign a petition to urge political action on climate change (**Petition**), and likelihood to contact your elected representative to ask them to support legislation to combat climate change (**Representative**), all measured on 7-point scales from extremely unlikely to extremely likely (Diamond, 2020).

Policy preferences were measured through willingness to support policies that limit emissions from power plants (**Emissions**), increase government investment in renewable energy research (**Renewable**), and implement a carbon tax (**Tax**). Support was measured on a 7-point scale from strongly oppose to strongly support (Diamond, 2020).

Control Variables

In addition to climate change attitudes, behaviors, and policy preferences, several other variables were measured as control variables for regression analysis. We controlled for demographic variables associated with climate change attitudes, including age, gender, education, and income. We also controlled for participants' political ideology, partisan

affiliations, and frequency of general news exposure and climate change news exposure. These factors are particularly important to control for as this experiment took place in the U.S. context, where these variables are highly correlated with climate change attitudes (Hornsey et al., 2018). Finally, we controlled for belief in global warming (is it happening and is it caused by humans), as well as a modified scale of the New Environmental Paradigm (NEP), a general measure of an individual's environmentalism (adapted from Whitmarsh, 2008).

Analysis Strategy

Analysis occurred in two steps. First, we calculated the mean responses in each group at the three time points - Week 1 (baseline), Week 5, and Week 9. We used a difference-in-difference analytical approach to measure whether there was a significant difference between treatment groups in changes in responses between the time periods. A new variable was created measuring the change in outcome variables from Week 1 to Week 5, and a second variable was created measuring the change in outcome variables from Week 1 to Week 9. We then calculated the difference in means of these two variables between treatment groups, using t-tests.

To account for external variation based on participant demographics, we followed this with ordinary least-squares regressions to measure the effect of receiving the positive (vs. negative) treatment on the outcome variables, controlling for the variables described in the previous section. We also controlled for whether the participants had failed an attention check at any point during the experiment (n=67).

Results

Differences in Means

The first step in the analysis was to compare the means between time periods (Weeks 1-5 and Weeks 1-9) in each treatment group to determine whether the positive and negative treatments had a baseline effect on outcomes. Table 1 (columns 1, 2, 4, 5) shows the difference in each outcome variable over the two time periods (Weeks 1-5 and Weeks 1-9), for each treatment group. The outcome variables were measured on a scale from 1-5, and the results in Table 1 indicate the numerical differences in the mean values for each outcome variable. We also calculated the difference in means across treatment groups and over time to understand how the positive and negative treatments impacted each of the outcome variables. Columns 3 and 6 in Table 1 show the difference in mean change in response between treatment groups. For example, the mean increase in climate change concern from Week 1 to Week 5 was 0.264 in the positive group and 0.212 in the negative group. While both of these were statistically significant increases, the difference between the means of the two groups (0.052) was not significant.

Table 1: Difference in means between negative and positive treatment groups

Dependent Variable	**Mean Change in Response from Week 1- Week 5** $(\mu_{Week\ 5}-\mu_{Week\ 1})$	**Mean Change in Response from Week 1- Week 9** $(\mu_{Week\ 9}-\mu_{Week\ 1})$

	(1) Negative Group	(2) Positive Group	(3) Difference in means	(4) Negative Group	(5) Positive Group	(6) Difference in means
Concern	0.264***	0.212***	0.052	0.160**	0.041	0.119†
Importance	0.207***	0.081*	0.126*	0.116*	-0.135*	0.251**
Efficacy	-0.490***	0.295***	-0.785***	-0.126	0.042	-0.168†
Society	-0.392***	0.179**	-0.572***	0	0.104†	-0.103
Consequences	0.265***	-0.049	0.314***	-0.160†	-0.458***	0.298*
Behavior	0.051	0.127*	-0.075	0.097	0.005	0.092
Petition	0.012	-0.099	0.111	0.011	-0.225*	0.237*
Representative	0.127†	0.090	0.049	0.006	-0.171*	0.177
Emissions	-0.008	0.070	-0.078	0.069	-0.079	0.147†
Renewable	0.095*	0.004	0.091†	0.114*	0.010	0.104
Tax	-0.047	-0.033	-0.015	0.126†	0.088	0.038

†p<.1 *p<.05 **p<.01 ***p<.001

In general, the attitudinal variables showed more pronounced treatment effects than the behavioral or policy variables. Participants in both the positive and negative groups reported increased concern about climate change at Week 5 (compared to Week 1) (p<.001), although the change in concern was not significantly different between the treatment groups. This increased concern persisted in the negative group through Week 9, but not in the positive group. This difference between treatment groups at Week 9 was marginally significant (p<.1).

Similarly, participants in both groups reported increased perceptions of the importance of climate change at Week 5, although this increase was higher in the negative group (p<.05). This increased importance was maintained through Week 9 in the negative group, but climate change became less important to those in the positive group by Week 9 (p<.01).

After the treatment period (Week 1-5), participants in the negative group reported significantly less self-efficacy around climate change, while those in the positive group reported significantly greater self-efficacy. This difference was statistically significant (p<.001), but neither effect was maintained significantly through Week 9. A similar effect was observed for societal efficacy, with perceptions of societal efficacy declining significantly among those in the negative group and increasing among those in the positive group (p<.001). This increase was maintained (with marginal significance) through Week 9 in the positive, but not negative, treatment group.

Finally, participants in the negative group perceived the consequences of climate change to be significantly more negative after the treatment period, while those in the positive group reported no change in perceived consequences. This difference was statistically significant (p<.001). By

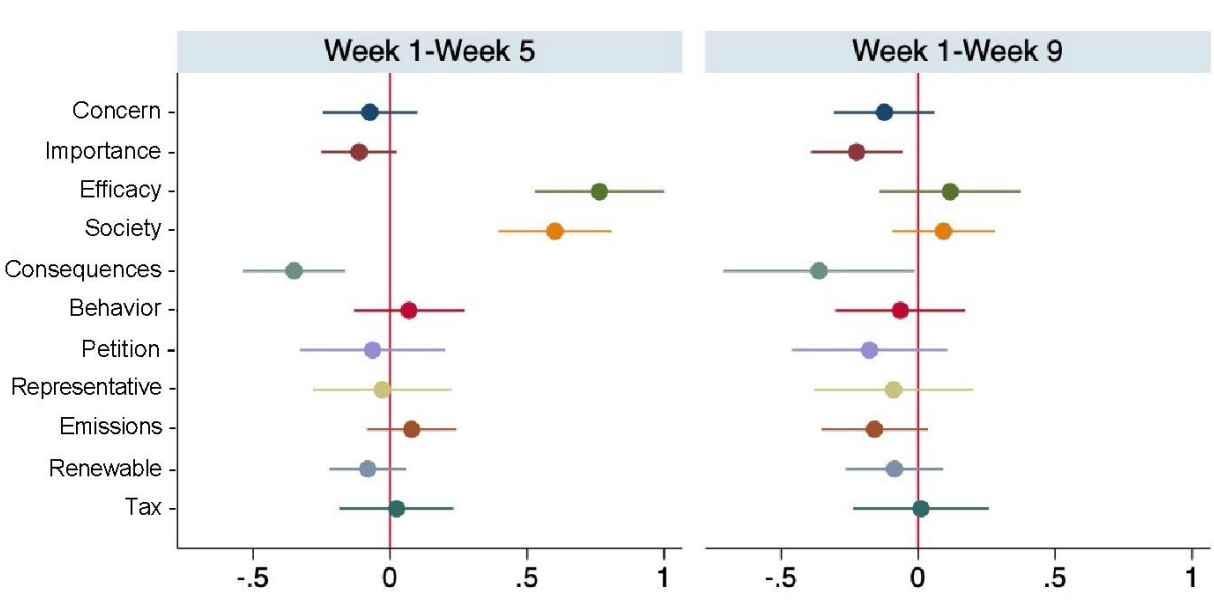
Week 9, participants in the positive group reported perceiving the consequences of climate change to be significantly more positive than negative, while those in the negative group perceived the consequences as *slightly* more positive than negative. There remained a significant difference in changes in perceptions of the consequences of climate change between the two groups at Week 9 ($p<.05$).

Neither of the treatments had a consistent effect on the behavioral or policy variables. While the participants in the positive treatment group did report an increased likelihood to undertake pro-climate behaviors from Week 1 to Week 5 ($p<.05$), the difference between treatment groups for this outcome was not significant, and the effect did not persist through Week 9. While the treatment period (Weeks 1-5) led to no significant change in willingness to sign a petition supporting climate policy, those in the positive group reported being *less* willing to sign a petition in Week 9, an effect that was significantly different than those in the negative group ($p<.05$). Participants in the negative group were marginally more likely to contact their representative about climate policy after the treatment ($p<.1$), but this was not significantly different from those in the positive group. Like the petition, participants in the positive group were significantly less likely to contact their representative about climate change in Week 9 than they were in Week 1. Regarding policy support, participants in the negative group were more likely to support investment in renewable energy after the treatment period (Weeks 1-5), and this effect persisted through Week 9. This difference was marginally significant from those in the positive group from Week 1- Week 5, but not in Week 9.

Regression Analyses

Climate change is a highly polarizing issue, and there are several ideological and demographic factors that can influence how people respond to messages about climate change. To that end, we also ran regression analyses that allowed us to control for various factors that may have influenced treatment effects. OLS regressions measured the effect of being in the positive (vs. negative) treatment group on change in responses from Week 1 to Week 5, and then again from Week 1 to Week 9. These analyses controlled for participant gender, education level, age, exposure to general news, exposure to climate change news, party identification, ideology, belief in global warming, income, modified NEP, and whether they failed any attention checks during the entire study. Figure 2 shows the treatment effect on changes in outcome variables between time periods (i.e., was the change in outcome from Week 1 – Week 5, or Week 1 – Week 9, greater in the positive group compared to the negative group). Variables for which the 95% confidence intervals do not overlap with the center line are statistically significant effects at the p<.05 levels. Full OLS regression results for each analysis can be found in Table A1 and Table A2 in the online appendix, which includes the effects of control variables in the models.

Figure 2: Regression coefficients and 95% confidence intervals for the effect of positive (vs. negative) treatments over time



During the treatment period (Weeks 1-5), three variables showed a statistically significant difference in treatment effect between the positive and negative groups. Compared to those in the negative treatment group, being in the positive treatment group was associated with an 11% greater increase in perceived self-efficacy (p<.001), a 9% greater increase in perceived societal efficacy (p<.001), and a 5% more positive perception of the consequences of climate change (p<.001). There were no other significant differences in changes in outcomes between Week 1 and Week 5 based on treatment received.

Most of the significant differences in treatment groups at Week 5 were eliminated by Week 9. At Week 9, receiving the positive treatment was associated with a 3% decrease (from Week 1 levels) in perception of the importance of climate change compared to receiving the negative treatment (p<.05). The effect on the perceived consequences of climate change also persisted beyond the treatment period; receiving the positive treatment was associated with a 5% more positive perception of the consequences of climate change (p<.05).

Discussion

The goal of this study was to understand how positively- and negatively-valenced media messaging about climate change affects attitudes, behaviors, and policy preferences in the American public. A secondary goal was to understand how lasting the effects of climate change message exposure are. Based on the existing literature on positive and negative framing on climate change and other issues more broadly, we expected that negatively-valenced messages (compared to positively-valenced messages) would increase climate change concern and perceived importance, but decrease feelings of self- and societal-efficacy, likelihood of undertaking pro-climate behaviors, and policy preferences in line with emissions reductions. Overall, the findings point to the effectiveness of negatively-valenced messages at increasing climate concern and importance, an effect which shows some evidence of duration past the treatment period. Positively-valenced messages seem more effective at increasing efficacy around climate change, although these effects are less lasting.

The primary differential effect of the two treatments was on attitudes towards climate change; there were very few significant differences in behaviors or policy preferences between the two groups over time. The negative treatment increased climate concern and perceptions of importance more than the positive treatment. These findings support the Drive Model, which emphasizes the effectiveness of a perceived threat within a message at evoking an emotional response (Janis, 1967). In contrast to the tendency of some environmental communications to focus on hope and other positive messages, negative messages and fear appeals may be more effective at prompting concern about climate change and perceptions of the importance of the issue.

An important caveat is the impact of message valence on efficacy, which can moderate how positive and negative messages impact concern, and what behavior changes, if any, individuals will undertake to mitigate a threat in accordance with the EPPM (Witte, 1992). Receiving the positively-valenced messages tended to increase both self- and societal efficacy more than the negatively-valenced messages. This reflects similar findings by O'Neill & Nicholson-Cole (2009) and Hart & Feldman (2016). Both studies demonstrated that messages with positive tones increased feelings of efficacy, while negative messages disempowered audiences. Additionally, examining our treatment effects on importance and self-efficacy in tandem reveals that negative messaging increased the feeling that climate change is important to address while simultaneously lowering self-efficacy, a relationship also observed by O'Neill & Nicholson-Cole (2009). This presents a potential conflict for communicators, who can increase concern about climate change with negative message framing, but risk leaving audiences with feelings of hopelessness and lowered intentions to act. This relationship is especially important to consider given that feelings of efficacy may increase feelings of hope, which may in turn increase individual political participation (Hart & Feldman, 2016). Given these findings, an important area for future study would be to understand how efficacy prompts in messages may interact with the message tone.

The results of this experiment also suggest there are some differential long-term effects of exposure to positive and negative messages about climate change. Specifically, one month after treatment ended, recipients of the negative messages perceived climate change as more important than those who received positive messages. They were also more likely to view the consequences of climate change as more negative than positive, and to have lasting support for renewable energy investment policies. This opposes the longevity finding of Hornsey & Fielding (2016), which found that responses to negative messages had *less* staying power. The contradictory findings of these studies open the door for more work to be done to understand whether positive or negatively toned messages stay with audiences for a longer period of time. Importantly, impacts on self and societal efficacy around climate change did not persist over time for either group in this study. Given that feelings of efficacy have been positively linked to both increased political action (Feldman & Hart, 2016) and behavior change (Witte, 1992), this finding suggests that when efficacy is not sustained, climate activism may not be sustained either, a concern similarly echoed by Milfont (2012). Indeed, message tone showed limited effects on the behavior and policy preferences of our study population, and even when marginal differences were noted, they were not usually sustained over time, or the persistence was not significant.

This study is not without limitations. One significant challenge of this kind of longitudinal study is that we cannot completely control for, or measure, what other information the participants are exposed to throughout the duration of the experiment. It is possible that participants consumed other media about climate change that may have conflated the effect of our study's treatments. We attempted to control for this by using a combined within and between-subject approach, and

controlling for climate media consumption habits, but this potential variance should be taken into consideration. Additionally, because we used real-world media articles, we could not control for other types of content frames within the articles themselves, which could have had an effect on outcomes. This is a potential pathway for future study – to understand the effect of the interaction between valence and content frames within media articles.

While the results of this study provide preliminary evidence that positive and negative media messages do impact audience attitudes towards climate change in different ways, there are numerous opportunities for further study. This experiment was designed to compare the two treatment groups against each other. However, the reality of news consumption is that individuals are rarely exposed to only positive or negative messages on climate change. Therefore, including a third condition that provides a mix of positive and negative messages may be helpful in future studies. Additionally, this study only investigated the effects of print media, whereas many people get their news and information from multimedia or social media. Future research should investigate the role of message valence in videos, audio/podcasts, and social media to gain a more holistic understanding of how message tone influences attitudes.

The implications of these findings suggest that negative framing is not necessarily detrimental when communicating about climate change - in fact, it may increase concern, importance, and some policy preferences. However, if these increases are coupled with declines in self- and societal efficacy, what long-term impact might that have on public attitudes and willingness to take action to mitigate climate change? This disconnect suggests a potential role for constructive journalism. Future climate change articles might effectively leverage both valence types by first increasing concern about climate change through a negative valence, and then offering a positively-valenced conclusion that is focused on highlighting solutions to the problem, a core component of constructive journalism (K. McIntyre & Gyldensted, 2018). The role that efficacy plays in moderating the effects of message valence is an important area for future research, particularly because this study found that message valence can have such a substantial impact on feelings of self- and societal efficacy.

Conclusion

For communication practitioners and journalists, understanding how message tone may impact audience attitudes, behaviors and policy preferences is an important consideration. The urgent and dire nature of climate change often leads to media coverage that is negatively-valenced or “doomsday” in nature. Concerns that such messages could lead audiences to become discouraged and “tune out” of climate change media are prevalent. This study offers a first look at the longitudinal effects of climate change message tone, finding that negative messages may be more effective than positive messages at increasing climate change concern and perceptions of importance, and that these effects may be long-lasting. However, the message tone does not seem to differentially affect behaviors and policy preferences, and positive messages may help people feel more capable of making a difference on the issue of climate change. Future research into the effects of message tone is needed to provide concrete guidance to communicators about how to deliver messages that both activate concern and empower audiences to act on climate change.

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Appendix A: Pilot Testing Procedures

After the researchers selected the 20 most strongly-valenced articles from the original 67 identified from various news sources, we conducted pilot coding with student research assistants. We recruited ten student assistants to code each of the 20 articles via an online survey. Coders were presented with each article one at a time, and then received either one or two attention check questions to confirm their understanding of the article. Coders were then asked to rate the article's tone based on how much they perceived the article to be fearful versus hopeful, pessimistic versus optimistic, consequences-focused versus solutions-focused, and negative versus positive, each on a scale of 1 to 10. They were also asked to rank their feelings of anxiety and calmness after reading the article, as well as the extent to which the article gave them the sense that society can adapt to climate change, both on a 0 to 10 scale. Students received a $20 e-gift card as a thank you for their time. We received nine full responses to our coding survey from the original ten students recruited.

Valence scores were obtained by calculating the average response for each metric of each article, and then calculating an overall average score across all metrics for each article. This gave each article one value on a scale from 0 to 10. Articles were then ranked according to their final score, which organized them from most negative to most positive based on the responses received from the coders. After discussing the results, we decided to use the four most negative articles as determined by coding, and the four most positive, with one exception. The third most positive article as determined by coding was switched out for the fifth most positive article. The original selection, which discussed the declining cost of solar panels, was determined to be positive in tone but the relationship between solar panels and climate change was not clear. The article that we selected instead also received a highly positive score and focused on the efforts of businesses to actively mitigate climate change impacts by changing their practices on a large scale. We felt that this article had a more direct relevance to climate change and was easier to understand. The article also included concrete statistics and examples, and discussed climate change mitigation as financially positive, which is a common positive frame but was missing from the other selected articles.

Appendix B: Pilot Coding Results

Final Valence Scores of Selected Articles (1-10 scale)

Title of Article (Note: some titles were edited from the original to match edited content and retain strong valence)	**Fearful vs. Hopeful**	**Pessimistic vs. Optimistic**	**Consequences-focused vs. Solutions-focused**	**Negative vs. Positive**	**Anxious vs. Calm**	**Unlikely vs. Likely**	**Final Valence Score** (<5 indicates negative valence, >5 indicates positive valence)
"How Climate Change is Clobbering Kids' Health"	2.5	2.375	1.857	2.375	2.125	3.25	2.41
"Climate change driving entire planet to dangerous 'tipping point'"	1.778	2.5	2.429	2.778	2.75	3.5	2.62
"Melting Antarctic ice will raise sea levels and endanger New York: study"	2.375	2.75	2.857	2.875	2.143	4.143	2.86
"Climate Change Is Likely to Devastate the Global Food Supply"	2.625	2.625	2.714	2.75	2.625	3.875	2.87
"Clean up climate change? It's just good for business."	7.444	7.222	7.667	6.889	5.444	6.333	6.83
"Climate change report card: These countries are reaching targets"	7.25	7.5	7.5	7.125	5.375	6.375	6.854
"Terrified about global warming? Finally, here's some good news."*	7.556	7.444	7.778	7.667	5.778	6.333	7.09
"The Soil Revolution that Could Save Farming and the Climate"	8	7.75	8.25	7.25	5.75	6.5	7.25
"Something New May Be Rising Off California Coast: Wind Farms"	7.286	7.429	7.429	7.714	7.286	7	7.357

*article not included in final selection

Appendix C: Final Experimental Articles

Positive Article 1

Climate change report card: These countries are reaching targets

By Kieran Mulvaney
September 19, 2019

It has been a little under four years since 196 countries negotiated the Paris Agreement, under which they committed to taking steps to limit the increase in global average temperature this century to well below 2 degrees Celsius (3.6 degrees Fahrenheit) over preindustrial levels, and ultimately to limit that increase to 1.5 degrees C (2.7 degrees F). Under the agreement, each signatory submits its own national plan, setting targets for emissions reductions and specifying pathways by which it aims to meet those targets.

Are countries making progress? What kind? We got together with the Climate Action Tracker to see who's making the best efforts. As countries prepare to revisit their targets at the United Nations Climate Change Summit on September 23, here is a summary of some of the leaders so far.

Morocco: According to CAT, Morocco is one of only two countries with a plan to reduce its CO2 emissions to a level consistent with limiting warming to 1.5 degrees C. Morocco's National Energy Strategy calls for generating 42 percent of its electricity production from renewables by 2020, and 52 percent by 2030. Already it is at 35 percent, not least because of investment in such projects as the Noor Ouarzazate complex, the largest concentrated solar farm in the world, which covers an area the size of 3,500 football fields, and generates enough electricity to power two cities the size of Marrakesh.

The Gambia: The Gambia is the other country with a 1.5 degrees C emissions reduction strategy. As with Morocco, one of its principal pathways to reduction is the use of renewables, in the form of a program that will increase the country's electricity capacity by one-fifth partly through construction of one of the largest photovoltaic plants in West Africa. The country has also launched a large project to restore 10,000 hectares of forests, mangroves, and savannas. It is also replacing flooded rice paddies with dry upland rice fields and promoting adoption of efficient cook stoves to reduce the overuse of forest resources.

India: India has emerged as a global leader in renewable energy, and in fact it is investing more in them than it is in fossil fuels. Having established a goal of generating 40 percent of its power through renewables by 2030, its progress has been so rapid that it could easily reach that target a decade early, so there is every opportunity for India to increase that target. CAT calculates that India's plan is compatible with a 2 degree C increase, but that its National Energy Plan could be 1.5 degrees C compatible if the country abandoned plans to build new coal-fired power plants.

Costa Rica: Costa Rica aims for its electricity production to be 100 percent renewable by 2021. It's already extremely close: in 2018 it generated 98 percent of its electricity from renewable sources—primarily hydropower—for the fourth consecutive year. Two-thirds of its greenhouse gas emissions

are from transportation, and the country has made it a national priority to use renewable energy across its roads and rails. The National Plan for Electric Transportation calls for at least five percent of the bus fleet to be replaced by electric buses every two years, and for at least 10 percent of new taxi concessions to be given to electric vehicles. Additionally, in February 2019 Costa Rica extended a moratorium on oil extraction and exploitation from 2021 until the end of 2050.

European Union: The EU was a comparatively early adopter of climate targets. In 2009, it set a goal of reducing greenhouse gas emissions by 20 percent by 2020; its Paris target increased that to a 40 percent reduction by 2030. Its present policies, if fully enacted, would enable it to exceed that target. In May, the EU formally adopted into law a series of measures that included a binding target for 32 percent of electricity production to come from renewables by 2030. To achieve that figure across the EU, different countries within the bloc have adopted different national targets: For example, for Malta, the goal is 10 percent renewables, while for Sweden it is 49 percent.

CAT calculates that meeting this and other targets contained in the European Commission's "Clean Energy for all Europeans" package would result in a reduction in emissions of 48 percent by 2030; a separate study has concluded that further improving energy efficiency targets and closing coal power plants across the EU by 2030 would increase that figure further, to 58 percent.

Positive Article 2

The Soil Revolution That Could Save Farming And The Climate

By Alexander C. Kaufman
September 25, 2020

BROOKHAVEN, N.Y. — Tropical Storm Isaias downed power lines and trees across the greater New York City area in early August, snapping limbs from the ancient oaks that ring Patty Gentry's small Long Island farm.

Dead branches were still dangling a month later. But rows of mustard greens were unfurling nearby, and a thicket of green vines reached toward the sun, dotted with tangy orange bulbs.

"These sungold tomatoes were toast," Gentry said, sounding almost astonished. "But now look at them. They're coming back. It's like spring again."

Over the past four years, Gentry has transformed two acres of trash-strewn dirt on Long Island's southeast coast into a profitable organic farm by betting big on soil. Instead of pumping her crops with pesticides and petrochemical fertilizer, Gentry grows vetch, a hardy pea-like plant, and rye to cover the exposed soil between the rows of greens intended for harvest. She layers the soil with specially mined rock dust that replenishes minerals and pulls carbon from the air, contributing to the reduction of greenhouse gases in the atmosphere that cause climate change. And in the spring and summer, she uses a system of crop rotation — shifting around where different crops are planted — so that one plant's nutrient needs don't drain the soil. These practices are collectively known as regenerative farming.

Tests of the soil show the organic content is now seven times higher than when she began. The result is produce so flavorful that she can't keep up with the number of restaurants and home cooks looking to buy shares.

Gentry's farm is also resilient, one where healthy soil soaks up rainwater like a sponge and replenishes the crops. She barely missed a delivery after the storm.

At a moment when fires and storms are wreaking havoc from coast to coast, mounting research suggests that practicing the soil techniques Gentry uses on a much wider scale could remove climate-changing gases from the atmosphere and provide a vital bulwark in the fight to maintain a habitable planet. They're part of a mix of solutions experts say are needed to keep global temperatures from surpassing 1.5 degrees Celsius above pre industrial averages, beyond which projections show catastrophic threats to our coasts, ecosystems, and food and water supplies.

Regenerative practices range from growing trees and reverting croplands to wild prairies, to rotating crops and allowing remnants after harvest to decompose into the ground. The techniques, already popular with small-scale organic growers, are steadily gaining traction among big farms and ranches as the chaotic effects of climate change and financial pressure from agribusiness giants eat away at

their businesses. Regenerative farming not only increases agricultural productivity, but also helps mitigate some of the negative effects traditional agriculture has on the climate.

“There are so many wins in regenerative agriculture,” said Maggie Thomas, a former climate policy adviser who serves as political director of the progressive climate group Evergreen Action. “You’ve got a win for farmers. You’ve got a win for soils and the environment. You’ve got a win for better food. There’s no reason not to do it.”

In July, a major new study published in the journal *Nature* found that spreading rock dust on soil at maximum scale in the world’s three largest carbon emitters — China, the United States and India — could collectively remove up to 2 billion metric tons of carbon dioxide from the air per year.

“The more we looked into it, the more it seemed like a no-brainer,” said David Beerling, a soil researcher at the U.K.’s University of Sheffield and the lead author of the study.

That’s a leap Thomas Vanacore took nearly four decades ago. The Vermont farmer and quarryman realized in the 1980s that mineral-rich dust from basalt and shale quarries could replenish nutrients in soil without using synthetic fertilizers, which would appeal to his state’s organic farmers. But as he studied climate change, he also concluded that his product could help pull carbon from the atmosphere, thus reducing human impacts that are resulting in a warming climate.

Positive Article 3

Something New May Be Rising Off California Coast: Wind Farms

By Ivan Penn and Stanley Reed
October 19, 2018

LOS ANGELES — California's aggressive pursuit of an electric grid fully powered by renewable energy sources is heading in a new direction: offshore.

On Friday, the federal Interior Department took the first steps to enable companies to lease waters in Central and Northern California for wind projects. If all goes as the state's regulators and utilities expect, floating windmills could begin producing power within six years. Increasing the amount of energy that is produced by renewable resources such as wind and solar power helps to decrease energy produced by burning fossil fuels, which are a major factor in warming the planet.

California's determination to fully rely on carbon-free electricity by 2045 in order to reduce the negative effects that carbon has on the climate, mandated in a bill signed by Gov. Jerry Brown in September, is forcing the state to look beyond solar power and land-based wind farms to meet the goal.

"We are early in the process here," said Karen Douglas, a member of the California Energy Commission, "but offshore wind has potential to help with our renewable energy goals."

California would not be the first place to develop floating wind turbines in the United States. The University of Maine, with $40 million from the Department of Energy, designed its own floating wind platform and produced a test version that it plans to develop as a commercial project to power 8,000 to 14,000 homes by 2021.

But California is a particularly opportune spot for such a project, given the length of its coast and the size of its population. And the coast offers an added advantage: winds over the ocean tend to pick up strength as the sun sets, just when the contribution of solar power is done for the day.

"California has very good offshore wind," said Walt Musial, a principal engineer and manager of offshore wind efforts at the National Renewable Energy Laboratory.

Offshore wind projects in California will largely benefit from existing power lines to keep costs down. Several power plants along the coast have closed or will be retired because of pollution and other environmental concerns.

It is expected that the wind farms would be about 15 to 30 miles off the coast, making them less visible from land and less of a hazard to seals and migratory birds.

The collective effort of all states to reduce dependence on fossil fuels is needed to help reduce the release of carbon into the atmosphere and the subsequent warming of the planet. Dan Reicher, a

former Energy Department official who has been an adviser to Magellan, said he believed that California was starting one of its greatest initiatives in developing clean power.

“In California, we’re not used to falling behind other states when it comes to renewable energy,” Mr. Reicher said. “That is the case when it comes to offshore wind. I think all of that will change with these floating systems.”

The Bureau of Ocean Energy Management will take public comments over the next 100 days. If all regulatory hurdles are cleared, leases could be signed in 18 months.

Positive Article 4

Clean up climate change? It's just good for business.

By Steven Mufson, Brady Dennis, and Chris Mooney
October 12, 2018

If the world's largest companies live up to the promises they've made to slow climate change, together they could reduce emissions by an amount equal to those of Germany.

The corporate pledges gained new attention this week after an ominous report was issued by the Intergovernmental Panel on Climate Change, which said that government policies alone won't ensure the "unprecedented" societal changes needed over the next decade to stem climate change. That puts the onus on the business sector to clean up a mess it helped create. To a greater extent than ever before, the best interest of many businesses and those of the planet are aligned.

"We've gone from saying 'it would be nice to do, but it would cost us' to saying 'if we don't do it, we won't be able to grow, we won't be able to have tomorrow's economy,' " said Andrew Steer, president of the World Resources Institute (WRI).

Historically, corporations have been complicit in the world's climate problem. One analysis shows that half of the globe's emissions since 1988 are traceable to just 25 private and state-owned fossil fuel corporations. And many have lobbied against policies that would limit the emission of greenhouse gases. They have done so both directly and through support of groups that have cast doubt on the idea of climate change.

Recently, however, there has been a palpable change in the way business leaders talk about climate change.

"Some of my investors and banks asked me what do you want to do: Improve the world or make money? I said, 'Well, both,' " Feike Sijbesma, chief executive of the Dutch multinational company Royal DSM, said.

With trillions of dollars at stake, corporations have forged ahead to create sustainable businesses. They are taking steps to lower their carbon footprints and overhaul their supply chains in a race against rising seas and temperatures. Others are trying to achieve the ultimate goal: pulling carbon dioxide out of the air and using or storing it.

From Apple to Walmart, from Ikea to Google, dozens of firms have embraced renewable energy. UPS is shifting toward electric vehicles. Costco has installed solar systems on top of at least 100 of its warehouse stores, and some locations use solar power in parking lots. Google in 2017 offset all of its office and data center electricity use by adding renewable energy to the grid.

Some of the biggest changes are coming from what companies do not do. Europe's largest bank, HSBC, this year stopped funding new coal-fired power plants, oil-sands development and Arctic drilling, joining a growing number of investors and lenders to shun ambitious fossil fuel projects.

Consumer demand and employee expectations are driving some of the investments. In many cases, companies are finding that their own customers and employees prefer to patronize and work at firms that are responsive to climate issues. And thanks to the falling prices of renewable energy, it can be cheaper to be climate-friendly than not.

Walmart, for example, has installed more than 1.5 million energy-efficient LED light fixtures across more than 6,000 stores, parking lots, distribution centers and corporate offices in 10 countries, driving down lighting costs by hundreds of millions of dollars over the past decade, the company said.

Walmart said it also exceeded its goal to double the efficiency of its trucking fleet by 2015. The retail giant said that by working with equipment manufacturers and others, it saved nearly $1 billion and avoided emissions of almost 650,000 metric tons of carbon dioxide in 2015 compared with 2005.

Many of the nation's biggest utilities have figured out that they can make more by selling less, especially when public service commissions can guarantee them healthy rates of return.

Negative Article 1

Climate change driving entire planet to dangerous 'tipping point'

Stephen Leahy
November 27, 2019

Evidence that irreversible changes in Earth's climate systems are underway means we are in a state of planetary emergency, leading climate scientists warn. A cascade of tipping points could amount to a global tipping point, where multiple earth systems march past the point of no return, they say.

That possibility is "an existential threat to civilization," write Tim Lenton and colleagues in this week's *Nature*.

Such a collapse of Earth's systems could lead to "hothouse earth" conditions with a global temperature rise of 9 degrees F (5 degrees C), sea levels rising 20 to 30 feet, the complete loss of the world's coral reefs and the Amazon forest, and with large parts of the planet uninhabitable.

A global emergency response is required to limit warming to 2.7 degrees Fahrenheit (1.5 degrees Celsius), they warn. "The stability and resilience of our planet is in peril," they say.

"It's a nasty shock that tipping points we thought might happen well into the future are already underway," says Lenton in an interview.

For example, the slow collapse of the West Antarctic ice sheet appears to be in progress. The latest data show that the same thing might be happening to part of the East Antarctic ice sheet, says Lenton, a climate scientist at University of Exeter in Southwest England. If those both melted, they could raise sea levels 21 feet (7 meters) over the next few hundred years.

The idea of tipping points was introduced 20 years ago by the Intergovernmental Panel on Climate Change (IPCC). The loss of the West Antarctic ice sheet and the Amazon rainforest, or extensive thawing of permafrost, as well as other key components of the climate system, are considered "tipping points" because they can cross critical thresholds, and then abruptly and irreversibly change. Just as a 200-year-old tree in a forest can remain standing after 20 blows from a sharp axe, the 21st blow may suddenly topple it.

Tipping points were once thought to be triggered only when global warming was above 9 degrees F (5 degrees C). But IPCC reports in the past year warn that they can happen between 1.8 degree F (1 degree C) and 3.6 degrees F (2 degrees C). Every fractional rise in temperature increases the risk of triggering one of 30 major tipping points. With just 1 degree C of current warming, nine of these are now thought to be beginning to tip. Just as with that metaphorical 200-year-old tree, no one knows if the next axe strike—or degree— will topple it.

The interactions among the elements of our global climate system mean a substantial change in one will affect others. As that 200-year-old tree falls after the 21st blow, it can crash into other trees, knocking them over in a domino-like effect.

Scientists are warning that may be happening in the climate system: Different tipping points are beginning to slowly crash into each other. For example, the loss of Arctic sea ice in summers over the last 40 years means that there is more heat-absorbing open water and 40 percent less reflective ice. That is amplifying regional warming in the Arctic, leading to increased thawing of the arctic permafrost, in turn releasing more carbon dioxide and methane into the atmosphere, adding to global warming.

A hotter Arctic has already triggered large-scale insect disturbances and an increase in fires, leading to a dieback of North American boreal forests. Those forests now may be releasing more carbon then they absorb.

It's already too late to prevent some tipping points from happening, since there is evidence that at least nine have already been breached. "I don't think people realize how little time we have left," said Owen Gaffney, a global sustainability analyst at the Stockholm Resilience Center at Stockholm University. "We'll reach 1.5 C in one or two decades, and with three decades to decarbonize it's clearly an emergency situation," says Gaffney, another co-author of the commentary.

"Without emergency action our children are likely to inherit a dangerously destabilized planet," he said in an interview.

Negative Article 2

How Climate Change Is Clobbering Kids' Health

By Jeffrey Kluger
November 13, 2019

The U.S. has pulled out of the Paris agreement, other nations are observing it only spottily, global temperatures are continuing to rise—and the health of children is being clobbered in the process. In a sweeping study just published in *The Lancet*, investigators from 35 institutions —including the World Health Organization, Imperial College London, The University of York, Yale University and Iran University of Medical Sciences— analyzed the planet's climatological health on 41 indices. They found that while progress is being made, too many trend lines continue to point downward. We will all pay a price for that, but today's children will pay the highest.

"With every degree of warming, we are committing a child born today to a future where their health and well-being will be increasingly threatened," says Dr. Renee Salas of the Harvard University Global Health Institute, lead author of the *Lancet* policy brief that accompanied the study. "Climate change, and the air pollution from fossil fuels that are driving it, threaten a child's health starting in their mother's womb and only accumulate from there."

One of the most damaging examples of that cumulative phenomenon is the microscopic particulate matter produced by burning fossil fuels. The study found that more than 90% of the world's 2.2 billion children are exposed to particles at concentrations above the safe limit defined by the World Health Organization. Drawing their first breath in a world like that leaves them at a higher lifetime risk of developing asthma, pneumonia and chronic obstructive pulmonary disease.

Rising temperatures, the leading indicator of climate change, do their own brand of pediatric damage. Children's bodies are less adept than adults at regulating temperature, and babies rely on caretakers to remove them from the heat and give them water when temperatures rise. This, the study explains, leaves them at significantly greater danger of heat-related electrolyte imbalance, high fever, and kidney and respiratory disease.

In this case, geography is a force multiplier. While the average global temperature has risen 0.2°C compared to a 1983-2005 baseline, the average heat in big cities and other population centers, where most people live—what researchers call the population-weighted temperature—has risen 0.8°C. And in the hottest places, the one great hedge against heat—air conditioning—is often not available.

Childhood nutrition suffers too. Rising temperatures are reducing the duration of the growing season for three key staples—maize, rice and spring wheat— slashing harvests and increasing the risk of famine in vulnerable developing countries. At the same time, rising sea temperatures are leading to a decline in fish stocks, a source of 20% of the protein in the diet of 3.2 billion people. "Globally, children are overwhelmingly the victims of undernutrition," says Salas, "and suffer a range of health harms, such as smaller growth in the womb, stunted development, and lack of critical micronutrients."

Finally, there are the diseases that thrive in a warming world. The most troubling explored in the *Lancet* study are malaria and dengue fever—which, again, take particular aim at children. The investigators found that both diseases are on the rise, more or less in lockstep with climate. The incidence of dengue fever in particular is already as much as 9.8% above pre-2012 baselines.

Climate change is a perversely egalitarian scourge, sparing no one, affecting everyone. But the special toll it takes on children makes it perversely cruel too. In a world that ostensibly prizes justice, it is unjust in the extreme for the people who are the least responsible for causing a problem to suffer from it the most.

Negative Article 3

Melting Antarctic ice will raise sea levels and endanger New York: study

By Chris Ciaccia
September 24, 2020

If the goals of the 2015 Paris Climate Agreement are not met, the Antarctic ice sheet will melt, resulting in global sea levels rising to the point where humanity will have to "give up … New York," according to a new study.

The research, published in Nature, notes that if temperatures rise 35.6 degrees Fahrenheit, ocean levels will rise 8 feet, the temperature limit set by the Paris agreement. Should temperatures rise 4 or 6 degrees Celsius, sea levels would eventually rise 21 feet and nearly 39 feet, respectively.

"Antarctica holds more than half of Earth's fresh water, frozen in a vast ice-sheet which is nearly 5 kilometers thick," study co author Ricarda Winkelmann said in a statement. "As the surrounding ocean water and atmosphere warm due to human greenhouse-gas emissions, the white cap on the South Pole loses mass and eventually becomes unstable."

Winkelmann continued: "Because of its sheer magnitude, Antarctica's potential for sea-level contribution is enormous: We find that already at 2 degrees of warming, melting and the accelerated ice flow into the ocean will, eventually, entail 2.5 meters of global sea level rise just from Antarctica alone. At 4 degrees, it will be 6.5 meters and at 6 degrees almost 12 meters if these temperature levels would be sustained long enough."

"Antarctica is basically our ultimate heritage from an earlier time in Earth's history," study co-author Anders Levermann added. "It's been around for roughly 34 million years. Now our simulations show that once it's melted, it does not regrow to its initial state even if temperatures eventually sank again. Indeed, temperatures would have to go back to pre-industrial levels to allow its full recovery – a highly unlikely scenario. In other words: What we lose of Antarctica now, is lost forever."

"In the end, it is our burning of coal and oil that determines ongoing and future greenhouse-gas emissions and therefore, if and when critical temperature thresholds in Antarctica are crossed. And even if the ice loss happens on long time scales, the respective carbon dioxide levels can already be reached in the near future. We decide now whether we manage to halt the warming."

A separate study published in February suggested that if global temperatures were to rise 0.5 degrees Celsius over the next 50 years, approximately half of the world's species would become locally extinct. If temperatures were to rise 2.9 degrees Celsius, 95 percent of the species would become locally extinct.

In March, another study suggested that almost half of the world's sandy beaches could be gone by 2100 if climate change continues.

In August, researchers found that 28 trillion tons of ice, primarily from the Arctic sea, Antarctic ice shelves and mountain glaciers, had been lost over the past 23 years, “a direct consequence of climate warming.”

In May 2019, a separate study suggested climate change could raise sea levels by as much as 7 feet by 2100.

Negative Article 4

Climate Change Is Likely to Devastate the Global Food Supply

By Amanda Little
August 28, 2019

The most troubling paradox of the 21st century may be that the human population is expected to climb to 9.7 billion by midcentury — yet the global food supply is predicted to plummet.

The Special Report on Climate Change and Land released earlier this month by the United Nations' International Panel on Climate Change, penned by experts in more than 50 countries, details in stark terms "the risk to millions of people from climate extremes, desertification, land degradation and food and livelihood insecurity." Another recent IPCC report predicted a 2 to 6 percent decline in global crop yields every decade going forward — that's potentially millions of acres phasing out annually — due to drought, heat, flooding, superstorms, weather volatility, shifting seasons, insect infestations and other symptoms of a warming planet.

According to Jerry Hatfield, the director of the U.S. Department of Agriculture's National Laboratory for Agriculture and the Environment, the single biggest threat of climate change is the collapse of food systems: "Other threats — flooding, storms, forest fires — may be more sudden and severe in certain regions, but disruptions in food supply will affect virtually everyone."

Disruptions in supply are already evident almost everywhere food is grown. Last month, the heat wave that swept Europe scorched old vineyards and new cornfields alike. When Bordeaux reached a record 106 degrees Fahrenheit, France's Minister of Agriculture said the country's coveted wine production would decline up to 13 percent in 2019. The soy and corn farmers in the American Midwest, meanwhile, faced a very different problem: sodden fields from unusually heavy spring rains were too wet to plant, resulting in billions of dollars of lost crops. Climatic pressures in recent years have also damaged or destroyed millions of acres of olive groves in Italy, citrus and peach orchards in Florida and Georgia, apple and cherry orchards in Wisconsin and Michigan, avocado farms in Mexico, coffee and cacao farms in dozens of equatorial nations. Water-intensive dairy and livestock operations are suffering the world over.

While threats to food production are varied and region-specific, a single story connects them: Climate change is becoming something we can taste. This is now a kitchen-table issue, literally and otherwise.

Climate change also intensifies the existing problems in industrial food production, many of which are (in an ironic twist) themselves root causes of climate change. Food waste, for example: more than a third of all food grown globally rots on the field or in transit or is thrown out. Rampant soil degradation has led to the overuse of synthetic fertilizers that, in turn, evaporate into the air to form nitrous oxide, a potent greenhouse gas. Pesticides have been causing mass die-offs of bees that play Oscar-caliber supporting roles as pollinators in food production; now climate change is making life even harder for these beneficial insects.

We have good reason to believe we're headed toward nothing. By the middle of this century, a 2014 IPCC report reads, the world may reach "a threshold of global warming beyond which current agricultural practices can no longer support large human civilizations."

Appendix D: OLS Regression Results

Table A1: OLS Regression Results – Effect of Positive (vs. Negative) Treatments on Changes in Outcomes Weeks 1-5 (continued on next page)

	(1)	(2)	(3)	(4)	(5)
VARIABLES	Concern	Importance	Efficacy	Society	Consequences
Treatment	-0.0732	-0.113	0.765***	0.602***	-0.350***
	(0.0886)	(0.0700)	(0.120)	(0.105)	(0.0952)
Female	0.0119	-0.0179	0.00779	-0.0406	0.193*
	(0.0914)	(0.0723)	(0.124)	(0.109)	(0.0982)
Education	0.00591	-0.0466	-0.0485	-0.0467	-0.0222
	(0.0420)	(0.0331)	(0.0571)	(0.0501)	(0.0452)
Age	0.0664	0.0802**	0.0649	0.155***	-0.0376
	(0.0420)	(0.0332)	(0.0569)	(0.0500)	(0.0452)
General News	-0.100*	0.0211	0.0567	0.00213	-0.141**
	(0.0595)	(0.0471)	(0.0808)	(0.0708)	(0.0640)
Climate News	-0.0928	-0.0405	-0.0670	0.0437	0.112*
	(0.0577)	(0.0457)	(0.0784)	(0.0687)	(0.0621)
Party	0.0308	0.0209	-0.0659	-0.0118	0.0411
	(0.0325)	(0.0257)	(0.0441)	(0.0387)	(0.0350)
Ideology	0.0140	0.00614	-0.0606*	-0.0182	0.0294
	(0.0260)	(0.0206)	(0.0354)	(0.0310)	(0.0280)
Climate Belief	-0.120*	-0.108**	-0.0847	-0.0613	-0.00149
	(0.0677)	(0.0533)	(0.0918)	(0.0811)	(0.0727)
Income	0.00862	0.0107	0.00688	0.0322**	0.00137
	(0.0136)	(0.0107)	(0.0185)	(0.0161)	(0.0146)
Attn Check	0.0145	-0.0444	-0.201	-0.175	-0.145
	(0.133)	(0.107)	(0.181)	(0.159)	(0.143)
NEP	0.000434	-0.00885	-0.0279*	-0.00888	-0.0130
	(0.0121)	(0.00961)	(0.0165)	(0.0145)	(0.0130)
Constant	0.719	0.643*	0.935	-0.340	0.580
	(0.476)	(0.376)	(0.645)	(0.576)	(0.511)
Observations	483	480	482	483	483
R-squared	0.043	0.060	0.103	0.100	0.055

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(6) Behavior	(7) Petition	(8) Representative	(9) Emissions	(10) Renewable	(11) Tax
Treatment	0.0697	-0.0635	-0.0284	0.0787	-0.0811	0.0233
	(0.103)	(0.135)	(0.129)	(0.0833)	(0.0717)	(0.106)
Female	0.191*	0.131	0.256*	-0.123	-0.0323	0.0495
	(0.106)	(0.139)	(0.133)	(0.0858)	(0.0741)	(0.109)
Education	-0.0906*	-0.164**	0.0251	-0.0706*	-0.0519	0.0316
	(0.0486)	(0.0638)	(0.0611)	(0.0394)	(0.0340)	(0.0501)
Age	0.0218	0.0630	0.0347	-0.0174	-0.0422	-0.0245
	(0.0486)	(0.0638)	(0.0612)	(0.0394)	(0.0340)	(0.0501)
General News	0.107	0.0126	0.0499	0.0751	0.0881*	0.0559
	(0.0690)	(0.0906)	(0.0869)	(0.0558)	(0.0482)	(0.0711)
Climate News	-0.0803	0.0434	0.0838	0.0738	0.0342	-0.149**
	(0.0670)	(0.0879)	(0.0842)	(0.0542)	(0.0467)	(0.0690)
Party	0.0196	-0.00913	-0.0308	0.0334	0.0266	-0.0290
	(0.0377)	(0.0495)	(0.0475)	(0.0305)	(0.0265)	(0.0389)
Ideology	0.00639	0.0379	0.00440	0.0132	-0.0213	-0.0655**
	(0.0302)	(0.0397)	(0.0379)	(0.0245)	(0.0211)	(0.0311)
Climate Belief	0.00436	0.0162	0.0671	0.0549	0.0953*	-0.0621
	(0.0784)	(0.103)	(0.0985)	(0.0645)	(0.0549)	(0.0808)
Income	0.0144	0.0405**	0.0204	0.0294**	0.0211*	0.0150
	(0.0157)	(0.0206)	(0.0198)	(0.0127)	(0.0110)	(0.0162)
Attn Check	-0.00761	-0.148	0.0234	-0.00596	0.0671	0.0232
	(0.155)	(0.204)	(0.194)	(0.127)	(0.109)	(0.159)
NEP	-0.0199	-0.00441	-0.0155	0.00365	-0.00636	-0.00206
	(0.0140)	(0.0184)	(0.0177)	(0.0114)	(0.00987)	(0.0145)
Constant	0.348	-0.168	-0.417	-0.660	-0.265	0.536
	(0.551)	(0.723)	(0.695)	(0.446)	(0.385)	(0.568)
Observations	483	481	482	480	481	484
R-squared	0.029	0.025	0.021	0.039	0.039	0.026

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A2: OLS Regression Results – Effect of Positive (vs. Negative) Treatments on Changes in Outcomes Weeks 1-9 (continued on next page)

VARIABLES	(1) Concern	(2) Importance	(3) Efficacy	(4) Society	(5) Consequences
Treatment	-0.123	-0.224***	0.117	0.0931	-0.362**
	(0.0934)	(0.0850)	(0.131)	(0.0957)	(0.177)
Female	-0.0637	0.0195	-0.0508	0.0358	0.0766
	(0.0959)	(0.0875)	(0.135)	(0.0983)	(0.182)
Education	-0.00650	-0.0326	-0.0331	0.00752	-0.0348
	(0.0435)	(0.0395)	(0.0612)	(0.0445)	(0.0825)
Age	0.0397	0.0393	-0.0263	0.0644	-0.152*
	(0.0430)	(0.0390)	(0.0603)	(0.0440)	(0.0816)
General News	-0.0105	0.0677	-0.116	-0.178***	0.00152
	(0.0616)	(0.0559)	(0.0864)	(0.0631)	(0.117)
Climate News	0.0227	0.000832	0.00140	0.127**	0.270**
	(0.0613)	(0.0558)	(0.0862)	(0.0629)	(0.116)
Party	-0.00840	0.0120	-0.0983**	-0.0221	-0.0993
	(0.0338)	(0.0306)	(0.0474)	(0.0346)	(0.0641)
Ideology	-0.0118	-0.00348	-0.0456	-0.00890	-0.0379
	(0.0269)	(0.0245)	(0.0379)	(0.0276)	(0.0512)
Climate Belief	0.0381	0.0961	-0.144	-0.0272	-0.0219
	(0.0767)	(0.0695)	(0.107)	(0.0786)	(0.145)
Income	-0.0112	0.0165	0.0186	0.0172	0.0392
	(0.0141)	(0.0129)	(0.0200)	(0.0145)	(0.0269)
Attn Check	-0.0770	0.00744	-0.416**	-0.442***	-0.443*
	(0.134)	(0.123)	(0.190)	(0.138)	(0.255)
NEP	0.00305	0.0104	-0.0135	0.00575	0.0178
	(0.0125)	(0.0113)	(0.0176)	(0.0128)	(0.0238)
Constant	0.0778	-0.815*	1.663**	0.0237	-0.227
	(0.509)	(0.462)	(0.714)	(0.522)	(0.966)
Observations	355	352	352	355	354
R-squared	0.014	0.049	0.044	0.065	0.072

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

VARIABLES	(6) Behavior	(7) Petition	(8) Representative	(9) Emissions	(10) Renewable	(11) Tax
Treatment	-0.0648	-0.178	-0.0892	-0.159	-0.0861	0.0102
	(0.121)	(0.144)	(0.147)	(0.0989)	(0.0902)	(0.126)
Female	0.237*	-0.133	-0.0823	-0.0650	-0.165*	-0.227*
	(0.124)	(0.148)	(0.151)	(0.102)	(0.0926)	(0.129)
Education	-0.0653	-0.0276	-0.0419	-0.00834	-0.0727*	-0.0119
	(0.0561)	(0.0671)	(0.0685)	(0.0461)	(0.0420)	(0.0585)
Age	0.0557	-0.0785	0.00803	0.00813	-0.0235	0.00665
	(0.0555)	(0.0664)	(0.0677)	(0.0454)	(0.0415)	(0.0578)
General News	0.0689	0.0616	0.173*	0.0330	0.00276	0.0484
	(0.0796)	(0.0954)	(0.0970)	(0.0651)	(0.0595)	(0.0829)
Climate News	-0.114	0.0133	-0.120	0.102	-0.00979	-0.0808
	(0.0792)	(0.0946)	(0.0966)	(0.0658)	(0.0592)	(0.0826)
Party	0.0123	0.0422	-0.0470	0.0276	0.00148	-0.0601
	(0.0436)	(0.0522)	(0.0532)	(0.0357)	(0.0326)	(0.0455)
Ideology	0.0235	0.0443	-0.0570	-0.0361	-0.0188	-0.0998***
	(0.0348)	(0.0417)	(0.0424)	(0.0285)	(0.0260)	(0.0363)
Climate Belief	0.0592	0.0383	0.0533	0.184**	0.0826	0.262**
	(0.0990)	(0.118)	(0.121)	(0.0821)	(0.0740)	(0.103)
Income	0.0259	-0.00236	0.00279	0.00788	0.0104	-0.00321
	(0.0183)	(0.0218)	(0.0223)	(0.0149)	(0.0136)	(0.0190)
Attn Check	-0.0239	-0.290	-0.0825	-0.367**	-0.0356	-0.0939
	(0.174)	(0.207)	(0.212)	(0.142)	(0.130)	(0.181)
NEP	-0.0128	0.000771	-0.0177	-0.00445	-0.00555	-0.00513
	(0.0162)	(0.0193)	(0.0197)	(0.0132)	(0.0121)	(0.0168)
Constant	-0.184	-0.289	0.479	-0.658	0.325	0.0515
	(0.658)	(0.785)	(0.802)	(0.539)	(0.491)	(0.685)
Observations	355	353	355	353	355	355
R-squared	0.037	0.025	0.022	0.060	0.031	0.054

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1