San Diego's IPCCC: The Implications and Politics of Climate Change Confusion

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ABSTRACT

With climate change poised to play a pivotal role in our lives, understanding how to foster support for climate policy is crucial. In recent years, however, it has become increasingly clear that creating successful climate legislation is a difficult task. One particularly notable obstacle is the public's general misunderstanding of the science of climate change, and many people lack a strong grasp of how climate change works. This study primarily aims to address the question: does increased knowledge about the mechanism of climate change correlate with more desire to enact climate policies? To clarify this link, I conducted a survey in San Diego in which participants provided both qualitative accounts of climate change's mechanism and quantitative Likert scale ratings for their attitudes about specific climate policy choices. I found that (1) participants knew very little about how climate change works and (2) participants' knowledge about climate change is, in fact, related to many of their beliefs about its existence, their willingness to sacrifice in response to legislation about it, and their desire for federal policy to mitigate it, but there are also many other factors (e.g., political party) that can predict attitudes and knowledge about climate change. At the same time, an overwhelming majority of people want more federal effort on climate policy. Ultimately, examining the connection between knowledge and attitudes will help us understand how to increase the support for, and therefore, the effectiveness of, climate policy.

KEYWORDS

Global warming, policy, public understanding of science, ordinal modeling, the greenhouse effect

INTRODUCTION

People and ecosystems around the world have already begun to experience the detrimental effects of anthropogenic climate change (Rosenzweig et al. 2007), which has led to pressure on governments to invest in climate policies. These policies fall into two categories: adaptation and mitigation. While adaptation seeks to lessen the severity of the consequences of climatic shifts, mitigation tackles its drivers by reducing emissions of climate active pollutants (CAPs), sequestering atmospheric carbon, and enacting other related measures (Rogner et al. 2007). Adaptation has attracted enormous attention (Adger et al. 2009), but current efforts are partial at best (Adger et al. 2007). Meanwhile, mitigation has also moved sluggishly, particularly in the United States, where the public is unusually reluctant to believe in and address climate change (Ranney 2012). There have been two major American climate bills passed: the Regional Greenhouse Gas Initiative (RGGI, 2003), which uses a cap-and-trade scheme to lower carbon dioxide emissions primarily from the stationary electricity sector in a coalition of eastern states (Burtraw et al. 2006) and the Global Warming Solutions Act of 2006 (AB 32) in California. AB 32 is the most aggressive and sector-inclusive climate change mitigation bill in the U.S. to date. Recently, however, it was subjected to an electoral challenge and lawsuit. While the lawsuit originated in environmental justice concerns, oil companies were supporters of the ballot issue (Farber 2011, Egelko 2010). The proponents of these two challenges undoubtedly had very different problems with AB 32 (e.g., its ability to reduce local emissions, equity, and effect on profits), indicating that there are many possible barriers to the creation of successful climate policy. Though there are many climate mitigation policy options available to governments (Gupta et al. 2007), we must ask why there have been so few fruitful climate policies passed.

One condition of a climate policy's success is the willingness of a population to vote for it, but there are many potential obstacles that can hinder this support. To begin with, an individual's inclination to even accept the existence of climate change may be governed by nationalistic or religious beliefs (Ranney 2012). Political party, in particular, is a powerful determinant of how people form their beliefs about climate change (Borick and Rabe 2010). Similarly, networks of political principles and social mores sway both voters' perceptions of the risk posed by climate change and their policy preferences (Leiserowitz 2006). Some posit that governments do not want to risk alienating voters and losing support over the implementation of

strict climate measures, which would "force" lifestyle changes (Ockwell et al. 2009). These studies demonstrate that complex social forces can preclude the desire of individuals to pass climate laws. However, there is one more fundamental obstacle that should be considered: knowledge of climate change.

Knowledge, among other social variables, influences the evolution of climate legislation (Selin and VanDeveer 2007), and thus knowledge of climate change may support desire for governmental action on it (O'Connor et al. 1999). However, across the U.S. and the world, there are widespread misconceptions about how climate change "works" (e.g., Leiserowitz 2007, Bord et al. 1998). To combat public confusion over climate change concepts, some have proposed to improve scientific education (Etkin and Ho 2007). However, there is disagreement about whether augmented scientific knowledge actually begets a change in attitudes and behaviors (Sturgis and Allum 2004). Some argue that better education alone should inspire civic action (Seacrest et al. 2000), while others posit that increasing scientific knowledge alone is inadequate to change beliefs (Krosnick et al. 2006). This conflict in the literature is unresolved, but its policy implications are significant. If a positive correlation exists between level of knowledge and desire for climate policy, then environmental education may help increase the desire for climate policy; conversely, if this association does not exist, different approaches must be used to successfully enact climate legislation. However, there has not yet been a focused study on whether a more (or less) complete understanding of the mechanism of climate change is associated with (un)willingness to make policy choices that favor climate legislation. Determining if there is a relationship between knowledge of climate change and policy beliefs will contribute to the salient debate about the importance of environmental education in fostering support for climate policy. This study will thus illuminate the essential, but disputed, question of how to best create climate legislation that the public will support.

My study aims to answer the question of whether increased knowledge about the mechanism of climate change correlates with the desire to enact climate policies. I hypothesize that a positive association exists between these variables. However, because political beliefs are governed by many factors (e.g., age, gender, political party, etc.), it is possible that the connection is not simplistic. I also examine the hypothesis that most people surveyed will know very little about how climate change works; this potential misunderstanding about the mechanism of climate change motivates the ultimate objective of this study, which is to

investigate whether improved environmental education is a promising way to foster support for climate policies. I will thereby contribute to the larger debate about the political implications of the relationship between scientific knowledge and attitudes.

METHODS

Study population

Located in southern California, San Diego is an excellent location for this study because it possesses a demographically diverse population and is not a particularly "green" city. San Diego's residents have varying educational levels, ethnicities, and ages (U.S. Census Bureau 2010). Despite self-labeling as "America's Finest City," San Diego lacks a strong record in environmental policy. Unlike Berkeley, San Francisco, and Oakland, it did not make a *Popular Science* list of America's 50 "greenest cities" (Svoboda et al. 2008), and its city council members received an average grade of C- on environmental issues in 2009 (Joyce 2010). Because San Diego is not an environmentally-conscious bubble, it provided a more representative sample of the United States, in that people there are likely not disproportionately aware of climate change. Moreover, because individuals' interactions with the environment can shape their beliefs about climate change (Borick and Rabe 2010), San Diego's consistently mild climate belies the very real dangers of a warming planet, perhaps causing people in San Diego to be relatively unconcerned with climate change.

Data collection

I used random intercept sampling (by approaching every other person who was sitting down) in parks in different areas of San Diego, California. Working with the realization that San Diego's interior is politically conservative, while the coast is more politically liberal, I went to sites in both of these regions (e.g., Balboa Park near downtown and Santee Lakes in Santee). Through a pilot study, I found that people seemed most willing to take the survey when they were on breaks in the middle of the day, and thus I collected data on weekdays and weekends in 3-hour blocks around noon (e.g., 10am to 1pm and 12pm to 3pm) to obtain the most responses.

To find out if a person was willing to take the survey, I recited the same speech, which deliberately omitted the words "climate change" and "global warming," in order to not bias the sample toward people who already had strong feelings about climate change. I also told the potential participant that they would receive a $5 gift card as compensation. If they were willing, I gave them a clipboard, pen, and survey and left them alone for 10-15 minutes; when they were done, I collected the survey and gave the respondent the gift card. To augment my dataset, I also had the opportunity to visit three classrooms (two basic chemistry classes, which had not had any instruction on climate change, and one general humanities class) at a community college in East County, San Diego. The students volunteered to take the survey during a scheduled break in class; they also received a gift card as compensation. In all, I collected 270 surveys.

To investigate the association between knowledge of the mechanisms of climate change and how much effort participants want the federal government to put into climate policies, the survey contained both quantitative policy preference questions and qualitative open-ended climate change knowledge questions. For this quantitative section, I borrowed the structure and wording of Likert scales from another survey that examined people's environmental policy preferences (Konisky et al. 2008), which used the frame of "effort" to refer explicitly to participants' desire to protect the environment, and not to their feelings about fiscal policy (Konisky et al. 2008). Besides the policy preference items, I used Likert scales to measure the participants' attitudes about the reality of (anthropogenic) climate change (2 questions), the government in general (4 questions), and willingness to sacrifice in response to specific and hypothetical climate policies (4 questions). I also included basic demographic items (e.g., age, political party, highest education level attained, etc.) at the end of the survey (9 questions).

To measure participants' knowledge about climate change, I included open-ended questions about its causes and mechanisms. Because I wanted to know if participants knew the physical and atmospheric mechanisms of climate change, the survey asked participants to write what they think scientists (*not* the participants themselves) believed to be responsible for climate change; participants could thus know this information but also not believe in the reality of anthropogenic climate change. Furthermore, to avoid response bias, I worded all the questions to leave open the possibility that climate change is not occurring. There were four primary knowledge questions concerning climate change's (1) mechanisms, (2) causes, (3) mitigation strategies, and (4) anthropogenic sources. Participants also responded to two questions about

what constitutes a greenhouse gas (GHG). Finally, there was a section that asked participants to rate whether 13 phenomena (e.g., ozone depletion in the upper atmosphere) or human activities were major, minor, or not causes of climate change. See Appendix C for the entire survey.

Data coding

To analyze and categorize the main ideas that the participants referenced in the qualitative knowledge section of the survey, I created coding protocols (Appendix B) for the six knowledge questions. I generated numerous codes to identify which concepts the participants referenced (e.g., ozone depletion, overuse of natural resources, deforestation, the ability to trap heat, etc.). I summarized these individual codes by fitting them into larger "concept groups." In a response, participants received credit for everything they wrote, right or wrong. Because respondents, in general, wrote ideas that fit into more than one main concept group, a particular written answer could be coded into any number of concept groups.

To score the qualitative knowledge responses, I fit each concept group into a 4-point scale (0, 1, 2, 3) that grouped them based upon completeness and accuracy (see Appendix B for the scoring protocol and list of codes and concept groups). Ideas in the most complete groups earned three points, while incorrect concepts earned zero points. For each question, respondents earned the points for the group that received the highest possible credit (e.g., if a response had codes that fell into both 3-point and 2-point overarching concept groups, that response would earn a score of 3). To earn the points associated with a particular concept group, it was only necessary to write one of the codes included in the concept group. With six knowledge questions, there were a total of 18 possible points. I added two bonus points (raising the total to 20) to the mechanism question if the participant attempted to differentiate what type of energy gets "trapped" by the atmosphere when leaving earth. Summing the points for all the questions created the participants' raw knowledge scores. However, I deducted a half a point from this score for every cause of climate change that the participant misidentified as major, minor, or not causes of climate change. Because these concepts are fuzzy and based upon interpretation of "minor" and "major," I only took off credit if the participant was blatantly wrong (e.g., if they said the use of chemical fertilizers is *not* a driver of climate change, I would remove a half point; however, I accepted both "major" and "minor" as plausible responses); this process created the

adjusted knowledge scores. A colleague and I conducted interrater reliability analysis (using Cohen's kappa) to ensure that my coding system was logical and valid.

Data analysis

To examine if increased knowledge about the mechanisms of climate change is correlated with the desire to prioritize climate policy decisions, I used polychoric correlation (with the Polycor package in R) to determine the correlations between the participants' adjusted knowledge scores and their ordinal policy preferences. This analytical method was appropriate because both the Likert scales and knowledge scores are ordinal and I thus needed to use specific ordinal analytical techniques. I also ran these correlations between the adjusted knowledge score and the two general climate change attitude questions.

To summarize the participants' policy preferences, I grouped the 20 policy preference questions by topic and scale. Within the 20 policy preference questions, there are three scales (global, national, and local), and three categories (climate change, resources, and pollution) (this system is based on Konisky et al. 2008). Some of the questions were reverse coded (meaning that a response of "more effort" actually represented a policy choice that was anti-environmental). See Table 9 in Appendix A for the groupings of questions.

Because other factors, besides knowledge, might govern attitudes about climate change or political action (e.g., Konisky et al. 2008, Ranney 2012), I examined if the study sites and demographic variables related to both the participants' knowledge levels and policy preferences. To examine the differences between groups (e.g., how adjusted knowledge scores differ by educational levels), I used Kruskal–Wallis tests of variance. This nonparametric test can use ordinal and nominal data and does not require normal distributions (and is therefore appropriate for Likert scales). Finally, I used χ^2 tests to compare two categorical variables.

Ordinal and linear models

To see if categorical variables (e.g., educational level) or continuous variables (e.g., age) can predict responses to ordinal variables (e.g., accepts anthropogenic climate change on a scale of 1-5), I used ordinal logistic regression. First, I created models with the responses to the

questions about acceptance of global warming and acceptance of *anthropogenic* global warming as the outcomes. For these models, I converted all the variables to factors (except age and adjusted knowledge score, which were treated as continuous); the initial model included age, American citizenship status, educational level, gender, political party affiliation, religion, desire for children, and adjusted knowledge score as predictors. Because many other studies have used these demographic variables as predictors, I have also used them to make this study more comparable, even though it would be possible to include many other predictor variables in the models (e.g., the RTMD constructs—for comparison, I also ran a few models with some RTMD constructs included; these models are not the focus of the results that follow). To determine which predictors were significant, I ran an analysis of deviance test for the initial model and then deleted the predictor with the highest p-value. I continued this process until all the predictors included in the model were significant. If, at the point when all the predictors were significant or marginally significant, and there were two marginally significant predictors left, I deleted the marginally significant predictor with the largest p-value. Furthermore, because I suspected that political party was an important player (as in other studies; e.g., Borick and Rabe 2010), I would leave it in the model until the end. If it was still not significant, I would delete it then.

Similarly, to see what variables predicted the adjusted knowledge score of a participant, I created a linear model with the adjusted knowledge score as the outcome (for this model, the adjusted knowledge score was scaled from 20 to 5 to make it more easily comparable with the Likert scales). I used the same set of initial predictors as the general beliefs about climate change models described above, but I also included acceptance of global warming and acceptance of anthropogenic global warming as predictors. Furthermore, to see which variables predicted willingness to sacrifice in response to climate change legislation, I created another set of ordinal models. I started with the same set of predictor variables as for the models described above, but I now also included satisfaction level with the federal government's environmental policies and trust in the federal government as predictors. I used the same process of elimination of the factor with the highest p-value to include only significant predictors in the model.

To determine which variables predicted a participant's policy preferences, I created 20 ordinal models, one for each policy preference question. To identify which variables were significant predictors of policy preferences, I followed the same process of exclusion (as

described above) of the least significant predictor variable. For these models, the initial predictors were the same as those for the willingness to sacrifice models.

Finally, to estimate effect size, I ran a linear model for each of the ordinal models described above. Each variable included in the linear models was a significant predictor in each outcome's respective ordinal model; though demographic variables remained factors, the Likert scale items were treated as continuous variables for the purposes of estimation. To make the effect size easier to interpret, I changed the scale of the adjusted knowledge score from 20 to 5. I ran all analyses in R, R Commander, or Excel.

RESULTS

The results that follow demonstrate three main points: (1) participants' knowledge of the mechanism of climate change was low, (2) participants' adjusted knowledge scores often significantly related to their other attitudes about climate change (e.g., whether the federal government should put in effort to reduce America's GHG emissions), and (3) other demographic variables (e.g., political party or educational attainment) were also often significant predictors. This section begins by summarizing participants' responses to the survey questions (e.g., basic demographics, trends in answers to the knowledge questions, and attitudes about the policy preference questions), and then moves on to describing the results of the correlations, models, and other statistical tests.

Study population

I found that the demographic variables of the participants were similar at the five major sites of my study, with some statistically significant differences. There were statistically-significant differences based on location for education level, χ^2 (28, N=268) = 78.44, p <0.001, age group, χ^2 (20, N=261) = 75.14, p <0.001, gender, χ^2 (4, N=268) = 11.01, p = 0.027, political party affiliation, χ^2 (28, N=267) = 49.42, p = 0.0075, and religious affiliation, χ^2 (36, N=268) =52.46, p = 0.038. In Table 1, I summarize the demographic statistics for all the participants (Tables referenced, but not shown, in this section are in Appendix A).

Results of the climate change knowledge responses

Knowledge of climate change's causes (question 3)

Participants referenced many concepts in their written explanations of the causes of climate change, but there were commonly cited ideas. Almost 30% of the participants referenced greenhouse gases (GHGs) as causing climate change; about 19% wrote about large scale human consumption (e.g., deforestation, livestock production, fossil fuel usage—see coding and scoring protocol in appendix B for full list of codes and groupings into concept groups). Over half of the participants cited industrialization and its consequences as causes of climate change. However, there were also misconceptions present. For example, about 14% of respondents talked about ozone depletion as a cause of climate change, and about another 10% reported that they did not know what caused climate change (Table 2). After I grouped the concepts and assigned scores to them (on a scale of 0-3), I found that the median score for this question was 2 points, while the mean was 2.04 points (see Table 3 for a full summary of the scores by question).

Knowledge of climate change's mechanisms (question 4)

While many people could give a correct cause of climate change, far fewer could identify the basic mechanism (Table 4). About 8% of the participants knew that greenhouse gases "trapped" heat (and an additional 4% knew that general emissions or pollution "trapped" heat), thus raising temperatures. However, only 1.5% of participants attempted to differentiate between the energy that enters and leaves the atmosphere. Ultimately, *not one* participant thoroughly and correctly described how infrared light is emitted by the earth and how it is absorbed by greenhouse gases. Many participants continued to give causes as the mechanism (e.g., saying that deforestation causes climate change, but with no explanation of *how*). On the other hand, 15.6% of participants believed that ozone depletion or a hole in the atmosphere was letting more heat in, thus warming the planet. Furthermore, about 32% of participants said that they did not know how climate change worked. The median score for this question was 0 points, and the mean was 0.65 points (Table 3).

Table 4. Percent of participants referencing listed concepts when asked about how climate change works (question 4)

Concept	**Complete mechanism**	**Attempts to differentiate types of energy**	**Something is "trapping" heat, but lacks specificity**	**GHGs augment heat, but lacks explanation *how***	**Tangential mechanism**	**Causes as mechanism (i.e., lacks explanation *how*)**
Percentage	7.8	1.5	4.1	4.4	8.5	24.4
Concept	**No mechanism given, but acknowledges change**	**Mechanism with "hole" misconception**	**Climate change is not real**	**I do not know**	**Left blank/ irrelevant answer**	
Percentage	5.6	15.6	1.5	31.5	5.6	

Note: percentages do not add to 100 because participants often referenced more than one concept. The scoring protocol in Appendix B lists all the individual concepts that are included these groupings.

Knowledge of climate change mitigation strategies (question 5)

I also found that many people knew effective ways to mitigate climate change (Table 2). About 30% of participants described changing human behaviors that directly emit greenhouse gases (e.g., switching to "green" energy or transportation); about 19% of participants thought that we should lower GHG emissions to slow climate change, and around 26% of participants thought that we should deal with the consequences of industrialization to mitigate climate change. Only 1.1% thought that we cannot stop climate change, and 1.5% thought that climate change was not real or not a problem. The median score for this question was 3 points, with a mean of 2.20 points (Table 3).

Knowledge of climate change's anthropogenic sources (question 6)

Similarly, I found that many people were able to provide scientifically-sound responses of anthropogenic sources of climate change (Table 2). Over half of the participants described the consequences of industrialization (e.g., driving cars, industrial or household pollution, industrial production), and about 31% reference human consumptive practices (e.g., deforestation) as human-induced causes of climate change. Only 7% of participants reported that they did not know how humans influenced climate change, and only 1.1% of participants claimed that climate change was natural and not influenced by people. For this question, the median score was 2 points; the mean score was 2.09 points (Table 3).

Knowledge of greenhouse gases' function (question 7)

Very few people were able to correctly describe how greenhouse gases work (Table 5). While 48.1% of participants reported that they did not know what differentiates a GHG from other types of gases in the atmosphere, 12% of participants knew that GHGs "trapped" heat. About 6% of people thought that GHGs depleted the ozone layer. Another 16% of participants gave incorrect explanations of the nature of GHG (e.g., they are artificial, from plants, or "harmful" in general). The median score for this question was 0, while the mean was 0.50 points (Table 3).

Knowledge of an example of a greenhouse gas (question 8)

Even if people did not know how GHGs worked, many were able to give a correct example of a GHG (Table 5). While about 34% of participants reported that they did not know, 37% could provide a valid answer; around 14% of participants could identify a correct source of GHGs (e.g., car exhaust), though they could not necessarily name a specific gas. About 7% gave an incorrect example of a GHG (e.g. O_2). The median score for this question was 2 points, and the mean was 1.41 points.

Overall knowledge

The median of the total "raw" knowledge score – meaning that this score combines the scores from all six questions but does not include the half-point deductions from incorrect responses to the separate "major, minor, or not" causes of climate change questions – was 9 points (mean 8.9 points); the median for the adjusted knowledge scores (which include those deductions) was 6.5 points (mean 6.6 points) (Table 3).

When I conducted interrater reliability analysis, I found that there was substantial agreement between the other evaluator's and my coding. For each of the five primary coding schemes listed in Appendix B, $\kappa \geq 0.646$ (average $\kappa = 0.743$). Table 6 summarizes the kappa values for each individual coding system.

Policy preference results

I found that participants, in general, wanted more federal effort on environmental issues (Table 7). When the responses "a lot more effort" and "moderately more effort" are combined, 14 of the 20 questions had over 60% of participants responding that they wanted "more effort." Of the remaining six questions, four were reverse coded so that "more effort" was actually an anti-environmental statement. The remaining two issues on which most participants did not want "more effort" were taxing gasoline and creating more nuclear power plants. For the five issues that were directly related to climate change (creating international treaties to limit GHG emissions worldwide, creating alternative energy programs, reducing America's GHG emissions, lowering government regulation on GHG emissions–which was one of the reverse coded questions–and creating more public transportation), the percent of participants wanting more effort were, respectively, 73.7%, 88.9%, 77.8%, 27.0%, and 70.0% (Table 7).

Furthermore, 80.4% of participants agreed with the statement, "I am certain that global warming (i.e., climate change) is actually occurring"; 77.0% of participants agreed with the statement "human activities are a significant cause of global warming" (Table 7). On the other hand, results were mixed for the "willingness to sacrifice" questions, with only 19.6% of participants willing to vote for a policy that dramatically lowered GHG emissions, but doubled the price of gas. Similarly, only 26.7% of respondents were willing to vote for a policy that dramatically reduced GHG emissions and caused the U.S. to decline in relative economic power among the world's countries. However, about 60.7% of participants would vote for a policy that dramatically reduced GHG emissions, but increased the income tax rate by 1% for all Americans; about 50% of participants would vote for a policy that dramatically reduced GHG emissions but increased sales taxes in California by 1%. Trust in and satisfaction with the federal government were clearly low, with only 11.9% of participants satisfied with its current environmental policy efforts and only about 16.3% agreeing with the statement "I trust the federal government" (Table 7).

When asked if a specific phenomenon or activity is a cause of climate change, participants held many misconceptions (Table 8). For example, just 6.7% of participants knew that ozone depletion in the upper atmosphere was not a cause of climate change. Only about 30% and 28%, respectively, knew that livestock production and use of residential heating and cooling

were major causes of climate change. However, 74.1% and 77.4% of participants knew that, respectively, deforestation and emissions from industry or business were major causes of climate change.

Knowledge and policy preference correlation results

I found that the adjusted knowledge scores were often significantly and positively correlated with the desire for effort on environmental policy decisions (Table 9). Only for the four issues that were reverse coded were the ρ values negative, and three of these four were significantly correlated with knowledge ($p<0.05$). In other words, all of the correlations fell in the predicted positive or negative direction. Of the five climate change issues (one of which was one of the reverse questions), four were significantly correlated with the adjusted knowledge score, while one (desire for public transport) was not correlated with knowledge. Out of the remaining 12 policy preferences items, five were significantly correlated with knowledge. Similarly, the correlation between the adjusted knowledge score and the responses to "I am certain that global warming (i.e., climate change) is actually occurring" was significant ($\rho = 0.32$, $p <0.001$), as was the correlation between adjusted knowledge and the responses to the statement "Human activities are a significant cause of global warming" ($\rho = 0.27$, $p <0.001$).

Results of Kruskal-Wallis test concerning knowledge

I found that there were statistically significant differences in knowledge based on demographic variables (Table 10). Through Kruskal-Wallis tests of variance, I saw that there were significant differences in adjusted knowledge score based on religion, educational level, desire for children, and political party. Knowledge scores were not statistically different based on location, age group, and gender. In Table 10, I present the results of the Kruskal-Wallis tests and the mean adjusted knowledge score for each level of the groups tested.

I also found that attitudes about climate change are generally not significantly different based upon the knowledge score for *just* the mechanism question alone (Table 11). While acceptance of the reality of climate change was significantly and positively correlated with the knowledge score the participant earned on the question which asked only about the "physical,

chemical, or biological *mechanism* of global warming" (ρ=0.172, p=0.0331), acceptance of *anthropogenic* climate change was not significantly correlated with this score (ρ=0.114, p=0.151). When the mechanism question's knowledge score was converted to a categorical variable and compared to the willingness to sacrifice questions, there was only one statistically significant relationship between it and the willingness to sacrifice question about doubling the price of gas; thus, through Kruskal-Wallis tests, I determined that mechanistic knowledge alone did not *necessarily* relate to the belief in (anthropogenic) climate change and willingness to sacrifice. However, it is worth noting that, in general, more mechanistic knowledge accompanied more willingness to vote for a policy that required a sacrifice.

Ordinal and linear model results

For the ordinal model with the participants' responses to the statement "I am certain that global warming is occurring" as the outcome, I found that the adjusted knowledge score, political party, educational level, and American citizenship status were significant predictors of certainty in the reality of global warming (Table 12). Increasing a point in knowledge (when scaled to 5) indicated increasing by about 0.16 points in acceptance. Independents and Republicans were the two significant levels within political party and both had lower acceptance than the mean; on the other hand, having a bachelor's degree indicated a higher level of acceptance. Interestingly, being an American citizen indicated less acceptance than the mean. Similarly, for the ordinal model with the participants' responses to the statement "Human activities are a significant cause of global warming" as the outcome, I found that the adjusted knowledge score, political party, educational level, and gender were significant predictors (Table 13). Republicans and men had estimates that were significantly lower than the mean.

For the linear model with the adjusted knowledge score the outcome, I found that religion, gender, educational level, political party, certainty that global warming is occurring, and age were significant predictors of climate change knowledge (Table 14). Being a Green party member predicted high knowledge, while being a Republican predicted knowledge lower than the mean. Unsurprisingly, it seems like that the more years of schooling a person has, the more knowledge they have (e.g., people without a high school degree had the lowest knowledge). As expected, believing in climate change was positively correlated with knowledge (slope=0.111).

Table 13. Analysis of deviance of ordinal model with belief in anthropogenic global warming as the outcome (Significance codes: 0 *** 0.001 ** 0.01 * 0.05 ‘ 0.1) Note: **bold** values indicate significance, p<0.05; *italicized* values indicate marginal significance, p<0.1

Factor	Logistic Regression χ2(df)	Pr(> χ2)		Lm estimate (p-value)
			Mean	**3.969 (<0.001***)**
Adjusted Score	**5.371 (1)**	**0.0205 ***	*slope*	*0.136 (0.0580 ‘)*
Political Party	**14.222 (7)**	**0.0474 ***	None	4.099 (0.524)
			Decline	3.782 (0.445)
			Green	3.608 (0.405)
			Independent	*3.524 (0.0640’)*
			Other	3.516 (0.237)
			Republican	**3.348 (0.00542**)**
			Libertarian	*3.147 (0.0860’)*
Educational Level	**15.307 (7)**	**0.0323 ***	*Doctorate*	*4.791(0.0508’)*
			Professional	4.535(0.157)
			Masters	*4.471 (0.0558’)*
			< High school	4.384 (0.501)
			Bachelors	4.307 (0.175)
			Some college	4.127 (0.485)
			High school	3.643 (0.295)
Gender	**4.786 (1)**	**0.0287 ***	**Male**	**3.606 (0.0142*)**

Table 14. Linear model of adjusted knowledge score (Significance codes: 0 *** 0.001 ** 0.01 * 0.05 ‘ 0.1)

Factor	Level	Mean (p-value)
	Mean	**2.200 (<0.001 ***)**
Political party	**Green**	**3.27 (0.0363**)**
	Libertarian	*2.952 (0.0940’)*
	Other	2.318 (0.726)
	None	2.098 (0.573)
	Decline	1.958 (0.548)
	Independent	1.954 (0.498)
	Republican	*1.831 (0.0569’)*
Highest educational level attained	**Doctorate**	**3.44 (<0.001***)**
	Masters	*2.627 (0.0661’)*
	Professional	2.558 (0.326)
	Bachelors	2.214 (0.947)
	Some college	1.901(0.0133)
	High school	**1.248 (<0.001***)**
	< High school	**0.819 (0.00796**)**
Gender	**Male**	**2.479 (0.0288*)**
Age	**Slope**	**-0.0083 (0.0390*)**
Religion	Atheist	1.824 (0.227)
	Decline	*1.71 (0.0802’)*
	Jewish	1.526 (0.139)
	Christian	**1.466 (0.00118**)**
	Other	**1.444 (0.0179*)**
	Spiritual but not religious (SBNR)	**1.412 (0.00178**)**
	Buddhist	**0.85 (0.0112*)**
	Muslim	**0.258 (<0.001***)**
	Hindu	N/A; only one obs.
I am certain that GW is occurring	**Slope**	**0.111 (0.0494*)**

For the ordinal models with each question about willingness to sacrifice in response to climate legislation as the outcomes, I found that political party affiliation and acceptance of anthropogenic climate change were always significant predictors. Republicans were always a significant level, and were consistently less willing to sacrifice than the average person. Conversely, there were strong positive relationships between willingness to sacrifice and acceptance of anthropogenic climate change. Satisfaction level with the federal government and adjusted knowledge score were significant for two of the sacrifice questions, but not significant for the other two (Tables 15-18).

In response to the sacrifice of doubling the price of gas, educational level attained, age, political party, and acceptance that climate change was anthropogenic were (marginally) significant predictors of how willing a person would be to vote for such a policy. While Green party members were significantly more willing than the average participant, Republicans were significantly less willing. Older people were less willing to sacrifice, as there was a significant negative relationship present. Finally, there was a significant positive relationship between willingness to sacrifice and belief that climate change was anthropogenic (Table 16).

Table 16. Analysis of deviance of ordinal model for willingness to sacrifice (doubling the price of gas) as the outcome (Significance codes: 0 *** 0.001 ** 0.01 * 0.05 ‘ 0.1)

Factor	**Logistic Regression χ2(df)**	**Pr(> χ2)**		**Lm estimate (p-value)**
			Mean	**2.0224 (<0.001 ***)**
Age	**5.213(1)**	**0.0224 ***	**Slope**	**-0.00839 (0.0472 *)**
Political Party	**27.493(7)**	**<0.001 *****	**Green**	**3.235 (0.00375**)**
			Other	1.876 (0.679)
			Independent	1.697 (0.159)
			None	*1.691 (0.0906’)*
			Decline	*1.609 (0.0810’)*
			Libertarian	1.532 (0.275)
			Republican	**1.073 (<0.001***)**
Educational Level	*13.940(7)*	*0.0523 ‘*	Doctorate	2.597 (0.139)
			Masters	2.362 (0.177)
			High school	2.216 (0.511)
			Professional	1.873 (0.702)
			Bachelors	1.815 (0.381)
			Some college	1.770 (0.242)
			< High school	1.676 (0.536)
Attitude about anthropogenic CC	**32.163(4)**	**<0.001 *****	**Slope**	**0.282 (<0.001 ***)**

Finally, for the ordinal models with each of the 20 “policy preference questions” as the outcomes, there were a wide variety of significant predictors (Table 19-38). For climate change

issues, political party, belief in anthropogenic climate change, adjusted knowledge score, and satisfaction with the federal government's environmental policy efforts were often (but not always) predictors. When political party was significant, Independents or Republicans were often significant levels, and, for the most part, they had lower desire to enact climate policies. Similarly, for the pollution and resource issues, political party, educational level, age, satisfaction with the federal government, and belief in (anthropogenic) climate change were often significant predictors. Adjusted knowledge score also predicted some outcomes but not others.

For example, for the policy of reducing America's GHG emissions, political party, adjusted knowledge score, and acceptance of anthropogenic climate change were (marginally) significant predictors. In this case, there were positive relationships between desire for policy and both the adjusted knowledge score and the belief in anthropogenic climate change. Independents had significantly lower desire for policy than the mean (Table 19). Because there was no one set of consistent predictors for all the policy preference models, I will refrain from summarizing their effect sizes here, though more detail can be found in Appendix A, Tables 20-38.

Table 19. Analysis of deviance of ordinal model with desire to make policy that reduces America's greenhouse gas emissions as the outcome (Significance codes: 0 *** 0.001 ** 0.01 * 0.05 ' 0.1)

Factor	**Logistic Regression χ2(df)**	**Pr(> χ2)**		**Lm estimate (p-value)**
			Mean	**2.579 (<0.001 ***)**
Adjusted Score	**4.627(1)**	**0.0315 ****	**slope**	**0.110 (0.0379*)**
			Green	2.953 (0.275)
			Libertarian	2.5945 (0.968)
			Other	2.4939 (0.780)
Political Party	*12.257(7)*	*0.0924 '*	Decline	2.478 (0.605)
			None	2.4791 (0.531)
			Republican	2.311 (0.138)
			Independent	**2.140 (0.0239*)**
Attitude about Anthropogenic CC	**37.951(4)**	**<0.001 *****	**Slope**	**0.385 (<0.001***)**

At the same time, when three politically central RTMD constructs (belief in evolution, creation, and nationalism) were added into the models, they were often significant predictors, and replaced some of the originally significant predictor variables. For instance, when the belief of evolution and creation variables were added into the set of predictors for the model of participants' belief in the reality of global warming, political party, American citizenship status,

and educational level were still (marginally) significant predictors. However, the adjusted knowledge score was replaced by belief in evolution and creation (cf. Table 12 and Table 39). A similar effect can also be seen in Table 40. In Table 41, I just used just the mechanistic knowledge score as the outcome; gender, educational level, age, and belief in creation were significant predictors. However, nationalism was not a significant predictor in these models. Finally, all 15 correlations between the RTMD constructs fell in the predicted direction, and 13 out of 15 were significant, $p < 0.01$ (Table 42).

DISCUSSION

To improve our collective understanding of how to foster public support for climate policy, this project set out to determine if knowledge about how climate change works is related to environmental policy preferences. My study showed that people in San Diego, California have limited knowledge of climate change and when we look specifically at knowledge of the mechanisms of climate change, this information deficit becomes even more pronounced. Perhaps more important than simply noting this dearth of understanding, however, is the finding that knowledge often positively relates to policy preferences, willingness to sacrifice in response to climate legislation, and attitudes about the reality of (anthropogenic) climate change.

The limited extent of climate change knowledge

Building on many other researchers' work that demonstrates that there are widespread misunderstandings of climate change, I have shown that participants clearly did not have a strong grasp of how climate change works (e.g., Bord et al. 1998, Seacrest et al. 2000, Leiserowitz 2007). However, these studies largely did not examine mechanistic knowledge (i.e., how and why climate change actually occurs), but rather looked at if people knew the causes, effects, and mitigation strategies. The concept of the greenhouse effect was first introduced to science in the 19th century (Rodhe et al. 1997), and is, in itself, no more controversial within the scientific community than gravity. Because climate change is perceived as uncertain, one wonders what part of climate change skeptics doubt, given that its main mechanism, the greenhouse effect, is relatively undisputed. The causes, effects, and mitigation strategies are therefore the seemingly

more controversial parts, and have received more attention in the literature. However, the question remains: why are people unable to describe the principle mechanism of perhaps the greatest environmental challenge facing us today, particularly because its scientific basis is reasonably certain? Interestingly, when specifically prompted to explain how climate change works, it seems that in place of understanding the greenhouse effect, many are thinking of another ecological problem – the phenomenon of the ozone hole. The ozone hole gained prominence in the public's mind because it is "easy" to understand using metaphors and presents a "hot crisis," in that it represents a looming and personal risk. Climate change, on the other hand, does not lend itself to metaphors and is largely perceived as a problem of the future. This dichotomy might explain the public's vastly dissimilar reactions to these two environmental issues (Ungar 2000). However, for island nations (e.g., Kiribati), it is easily argued that climate change is, in fact, a "hot crisis." Therefore, the real distinction between the public's responses to these two issues may be that the solution to climate change is much more complex and potentially difficult to achieve than that of the ozone hole, which "only" required the discontinuation of the use of CFCs. Addressing climate change, on the other hand, requires many different inputs, one of which is likely restructuring the use of fossil fuels, a foundation of global economies. However, even if people lack a complete understanding of climate change, their respective levels of knowledge can predict their attitudes toward it.

The relationship between climate change knowledge and political preferences

Demographic variables, such as highest level of education attained, political party affiliation, age, and gender often predicted attitudes about climate policy, (anthropogenic) climate change's reality, and the level of willingness to sacrifice in response to climate policy. The fact that attitudes are related to demographic variables implies that there are many determinants of attitudes and beliefs about climate change. At the same time, even if other factors are involved, knowledge and attitudes can still be linked, and experimenter-scored knowledge was, in fact, a common predictor of attitudes.

There have been many studies that have sought to examine the connection between knowledge and attitudes, and their results are often somewhat contradictory. The "knowledge deficit model" posits that lack of knowledge causes the public's fears and doubts about science;

the "contextualist model," on the other hand, indicates that knowledge is not the only factor that is important in determining attitudes about science (Sturgis and Allum 2004). Supporting the deficit model, one study found that knowing what causes climate change is a strong predictor of whether a person wants to change their behavior to address it (Bord et al. 2000). Conversely, another study suggested that though positive correlations exist between knowledge and attitudes about climate policies, the connection is not necessarily that simple – rather, knowledge, certainty, and risk perception all interact to form beliefs (Krosnick et al. 2006). Although the knowledge deficit model has been determined to be too simplistic (Miller 2001), and the contextualist model has taken its place, the fact that other variables are involved does not necessarily lessen the importance of knowledge in determining political attitudes; after all, we did see a significant positive relationship between knowledge and both the acceptance of climate change and the desire for governmental effort on specific climate policies. On a more practical level, we know that (lack of) knowledge, among other social variables, influences the evolution of climate legislation (Selin and VanDeveer 2007, Skolnikoff 1999); thus, it appears that knowledge and acceptance of science reinforce each other, even if there are other forces at play.

However, when the relationship between *mechanistic* knowledge and attitudes is examined, the result becomes more complicated. Because the knowledge scores for just the mechanism question did not significantly relate to acceptance or policy preferences, it appears that knowledge of the mechanism, when viewed alone, does not necessarily relate to climate change beliefs. Though this effect might be a result of the fact that not one participant completely knew the mechanism, it seems rash to conclude that simply giving people the mechanism will make them *automatically* accept climate change. However, other studies (e.g., Ranney et al. 2012a, Ranney et al. 2012b) have shown that giving students a brief description of the mechanism as an intervention between a pre- and post-test increased their acceptance; thus, short-term gains in knowledge can positively change attitudes. Likewise, I found that the adjusted knowledge score was positively correlated with acceptance of (anthropogenic) climate change. It thus appears that there is a positive relationship between these two variables, though other factors (e.g., temporal effects, personal experiences, risk perceptions, and political climates) must play a role. For instance, although short-term changes in attitudes and knowledge about climate change resulted from watching *An Inconvenient Truth*, some desire for climate action was lost after a month (Nolan 2010); however, it is worth noting that this study was under-

powered, so its conclusions must be interpreted cautiously. Acceptance levels are also linked to time-related personal experiences, such as the belief that one has recently seen evidence of global warming (Krosnick et al. 2006). Individuals' interactions with and observations about the environment and weather can also shape their beliefs about climate change (Borick and Rabe 2010). Surprisingly, one study found that people who are more informed about climate change are actually less worried about it and trust in climate scientists is negatively correlated with concern about climate change (Kellstedt et al. 2008). These findings show that concern about the risks of climate change is related to more than just knowledge about it. All or some of these non-knowledge factors may explain why mechanistic knowledge was not significantly related to acceptance. Finally, it appears that political ideologies play a large role in how people think about climate change.

The politicized climate of global warming

I found that political party was one of the most common predictors of environmental policy preferences, knowledge, willingness to sacrifice, and general attitudes towards climate change. Other studies have supported my findings that political party has a large part in creating climate change beliefs (e.g., Borick and Rabe 2010). This speaks to the political nature of climate change in America, where it is often not perceived as a "scientific" issue, but rather a political one (Skolnikoff 1999). Indeed, in America, public opinion about climate change is increasingly divided, despite the overwhelming scientific consensus about its reality (Weber and Stern 2011). It is disconcerting that responses to climate change seem to be determined, not by carefully considered and learned beliefs, but rather by set ideological positions with little room for conscious thought. This tendency is explained by Reinforced Manifest Destiny Theory, which proposes that Americans' beliefs about climate change are related to their nationalistic and religious tendencies (Ranney 2012). Political ideology (e.g., how conservatism relates to nationalism), represented by political party, also taps into this explanatory relationship.

Potential for changing climate knowledge and attitudes

It is important to note that this study was purely observational, and the results do not imply that more knowledge about climate change *causes* more desire on climate policy. Rather my results suggest that climate change knowledge, attitudes, policy preferences, and demographics interact. However, recent studies (Ranney et al. 2012a, Ranney et al. 2012b) shows that increasing knowledge does, in fact, cause positive attitude shifts about climate change. Moreover, I found that far more people accept (anthropogenic) climate change than have complete understandings of the mechanism, implying that acceptance is not solely contingent upon knowledge. Recent surveys have also shown that the majority of those surveyed wanted political action on climate change (Krosnick and MacInnis 2012) and that an overwhelming majority (83%) believed that warming has occurred; similarly, 72% believed that warming (if it has happened) was "partly" or "mostly" a result of human activities (Krosnick and MacInnis 2011). These findings suggest that there is not yet a ceiling on public acceptance of climate change and desire for political action, both of which can likely be augmented by increasing knowledge of climate change through public education programs (cf. Etkin and Ho 2007, Bord et al. 2000, Seacrest et al. 2000).

Limitations

Because I surveyed park visitors and community college students in San Diego, this study is not necessarily a representative sample of the United States. There is the possibility that park visitors, as evidenced by their spending leisure time outside, are more aware of environmental issues. Furthermore, the same effect may be true in community college students, who exist in a learning environment. People in San Diego might likewise possess attitudes that are not generalizable to the citizens of the United States as a whole. Moreover, the coding protocol, though it achieved high interrater reliability, was based upon an inherently subjective system – every effort was made to be consistent, but due to time and resources limitations, I was unable to have a second coder recode the entire dataset; this limitation could bias my results. Statistically, though the ordinal models used in this paper yielded statistically significant results, there are some assumptions that should be addressed, but are beyond the scope of this project. Some of the levels within the demographic variables were also very small (e.g., Hindus), perhaps limiting the

power of the statistical tests. Lastly, by providing gift cards as compensation for taking the survey, I might have biased the sample to people who wanted gift cards.

Future directions

To replicate the results that knowledge of climate change does indeed relate to policy preferences, we need a nationally representative reproduction of this study. We could also confirm that increasing knowledge levels *causes* more desire for effort on climate policy by using this study's survey as a pre- and post-test surrounding a text intervention that would give a brief, but detailed, overview of the greenhouse effect. Further research could also focus on how including the RTMD constructs in all the models could change what variables are significant predictors, thereby informing what types of questions future surveys should ask. Finally, using software-based coding could increase the objectivity of the coding process.

Broader implications

If San Diego park visitors and community college students are at all representative of the United States, it seems that (1) people know very little about the mechanism of climate change and (2) knowledge about climate change relates to both a person's desire for policy to address it and their acceptance of it. For this reason, scientific education programs focusing on increasing knowledge of climate change could help increase acceptance and desire for climate policy. However, knowledge is not the sole determinant of climate change attitudes. This study therefore both provides support for the contextualist model and reinforces the knowledge-attitude link. Importantly, participants clearly wanted more effort on climate policy issues and predominately accepted anthropogenic climate change, demonstrating that the creation of policy that mitigates global warming is still a real possibility. However, we have seen that successful and thoughtful climate policy is rare, both in America and around the world. Therefore, the problem may not lie in fostering public desire, which seems to already exist, but rather in fostering politicians' desire to dislodge climate change from its ideological niche; this is perhaps an even more daunting task.

ACKNOWLEDGEMENTS

There are many people without whom this project would not have been possible. Many thanks to my mentor Michael Ranney, for endless support and patience; thanks also to the team of ES 196 instructors, Seth Shonkoff, Melissa Eitzel, Tina Mendez, and Kurt Spreyer, the members of workgroup Hervey, and to Dav Clark, Daniel Reinholz, Roxana Farjadi, Amanda Cain and the rest of the Reasoning Group for helping me to hone ideas and to refine statistical methods. I am indebted as well to Lauren Barth-Cohen, my interrater extraordinaire, and to SURF's Timo Rodriguez and donors. A big thanks to Mimi Zhou for being my thesis-writing motivation buddy. Finally, thanks to my friends and family for still supporting me no matter how much complaining was going on. This project received approval of exempt review status from CPHS.

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