

Effect of Climate Change Education on Perception towards Climate Change

W241

Anup Jha, Christian Millsop, Anusha Praturu

Abstract

Climate change is one of the most debated subjects of our contemporary world. While some believe in anthropogenic causes of climate change, others believe that humans have no causal role in climate change. They all rely on spreading education to help their cause.

Does education on climate change actually cause changes in perception towards climate change in the subjects receiving education? This question cannot be answered by the observational data and so a field experiment is prescribed. In this experimental project we study the impact of the educational videos of both sides, namely the side which believes in anthropogenic climate change and one which does not, on subjects' perception towards the issue of climate change.

We do this by recruiting people in the USA through Amazon Mechanical Turk, and show them educational videos on climate change. Some are shown videos which support the idea of anthropogenic cause of climate change while some are shown videos denying human's hand in climate change and the rest are shown videos on cleaning computers as a placebo. After watching the videos the subjects are asked to fill a survey questionnaire on how they feel about climate issues. The intervention was showing educational videos on climate change and then we measure outcomes across climate awareness, climate skepticism, and placebo groups and then calculate the treatment effect between groups. Both linear regression and proportional odds logistic regression models were used to analyze the experiment, however, we discovered that the proportional odds logistic regression model was invalid due to rejection of the proportional odds assumption.

We bucketed our six outcome questions into three outcome categories, anthropogenic primary cause of climate change, urgency of climate change, and whether personal action is required to alleviate climate change. For the climate awareness intervention, we only found a statistically significant average treatment effect in one bucket for one question regarding a primarily anthropogenic for climate change. For the climate skepticism treatment, we found statistically significant average treatment effects in three questions, one per bucket. When comparing the effectiveness of awareness versus skepticism treatments, we found that the skepticism treatment was more effective at changing perceptions of a primarily anthropogenic cause of climate change.

Introduction

The world is currently divided into two groups: one which acknowledges that climate change is real and other which calls climate change a hoax. The election of leaders such as President Trump have increased the legitimacy and political clout of climate change skepticism. Political leadership on this issue has significant impact, such as the withdrawal from climate accords and conferences, which has reduced the checks and balances on the corporations which are polluting the environment. So a pertinent question among scientists is how do we increase the number of people in the group which agree that climate change is real and a threat to our existence.

According to a global survey, *Global survey: Where in the world is most and least aware of climate change?*¹, one third of the world's adult population has not even heard of the term climate change. The awareness was abysmal in the developing and underdeveloped countries. A more alarming finding by the survey was that among the developed countries where the awareness was high, the concern was still low. According to the survey in the US only 64% of the people who were aware of climate change were concerned about climate change and thought of it as a threat.

The researchers in the climate change field think that the silver bullet through which humanity can overturn the threats of climate change is education and awareness. Each one of us has to take action to curb down our carbon footprint. Before anybody takes a corrective action she should be convinced about the threat climate change poses. Above all if we have to make any progress climate change should not be considered a hoax. There are anti-climate change awareness program also wildly popular which poses additional challenge for humanity. General public has been bombarded with several conflicting views on the topic and one view lowers the efficacy of the other. In such situations public generally turn to their leaders and idol figures for their views. So in the current political landscape it is paramount that effective ways of making people aware should be adopted by the climate change supporters.

How much does awareness and education help? Is it really helpful in changing somebody's perspective on climate change or people who have formed perception cannot be changed? With current leader's speeches and other powerful people who consider climate change not a threat would awareness program fare well? Can the awareness program swing someone from a non-believer into believer group? How effective is the awareness program when compared to anti-climate change propaganda? These are some of the questions which can be answered through field experiment as we want to access the causal effect of the educational program on the outlook of people towards environment.

Experiment Design

Research Question

In our quest to find the efficacy of the climate education the central causal research question which we want to find answers for is: **Can climate change education influence subjects' perception on the topic?** Perception itself is a very broad term and represents long term mental state which impacts behavior subconsciously. Through our experiment we want to learn about the immediate effects of the education on the topic and does it have enough power to nudge someone's perception, at least in the short term.

Hypotheses

We formulate our investigation in terms of three hypotheses. Each of these hypotheses are framed in terms of the null hypothesis, that treatment has no effect.

- Climate awareness treatments don't encourage the perception that climate change is urgent and anthropogenic.
- Climate skepticism treatments don't discourage the perception that climate change is urgent and anthropogenic.
- Climate awareness treatments are equally as effective as climate skepticism treatments in influencing subjects' perceptions.

Rejection of any of these hypotheses indicates that climate education can be an effective tool in changing population perceptions regarding anthropogenic climate change.

Experiment Overview

To test the hypotheses we conducted an experiment recruiting subjects from the USA on the Amazon Mechanical Turk. We employed randomized, placebo-controlled trials in the experiment. We compared the differences in outcomes between treatment (awareness or skepticism) and placebo groups. All the participants were randomly assigned either to awareness, skepticism, or placebo group. The awareness group is shown two videos which support the claim that climate change is real and caused by humans. The skepticism group is shown two videos which supports the claim that climate change is not caused by humans. The placebo group is shown two videos about computer basics. After the subjects watch the videos they are presented with a questionnaire which captures the responses on a Likert scale for the questions corresponding to their perception towards climate change. The broad dimensions which the questionnaire captures the response for are:

- Primary causes of climate change
- Urgency of climate change

- Type of action needed to alleviate climate change

The subjects also answered a few demographic and personal questions about them which was used as covariates when models were created for analysis.

Recruitment Process

We recruited participants from Amazon Mechanical Turk for the experiment. Each participant was paid 1 dollar upon successful completion of the survey. We also conducted a pilot study on friends/family and professional networks to check if the experiment was well designed or not in terms of randomization and outcome and covariate capture.

Experiment Tools

The subjects were recruited at Amazon Mechanical Turk but the experiment was run on Qualtrics. Qualtrics was used to design the experiment. The experiment consisted of watching a couple of videos and answering survey questions. Qualtrics randomization procedure was used to create assignment of subjects to treatment/anti-treatment or placebo group. Randomization was done such that equal number of participants are there in three groups. It was made sure that subjects can only advance to survey questions once they have watched the videos using timing constraints. Time taken by the participants in answering the survey questions was also captured.

Treatment

Treatment in the different groups was watching a couple of short videos. Videos averaged 5 minutes in length. The link of the videos have been added to the appendix section.

Climate Awareness



Climate Skepticism



Placebo/Control



Outcome and Covariate Variables

There were 6 outcome questions asked via survey after treatment:

1. Human activity is primarily responsible for climate change.
2. Climate change is a serious threat to humans.
3. Individuals actions or lifestyle changes would not help in reducing the effects of climate change.
4. Broader scale changes, such as raising taxes on the commodities which release greenhouse gases, are necessary to alleviate the effects of climate change.
5. There is no need for a binding international agreement to regulate greenhouse gas emissions.
6. I intend to make changes to my own lifestyle to help alleviate the effects of climate change.

Note that questions 3 and 5 above were phrased negatively in order to reduce the appearance of bias in the survey. Response values on these questions were reversed during analysis.

Answers to all six outcome questions were measured on a Likert scale of:

- Strongly agree
- Somewhat agree
- Neither agree nor disagree
- Somewhat disagree
- Strongly disagree

After being surveyed on the outcome questions, participants were also asked to answer several covariate questions including:

- Age
- Education
- Gender
- Climate disaster vulnerability
- Income
- Political affiliation
- Community size
- Pre-experiment perception
- Reliability of educational material

Pilot Study

Prior to executing the experiment, we performed a pilot study on friends and family. This study was important to verify experimental instrumentation (Qualtrics), quality of treatment and measurements, and to estimate statistical power requirements.

We were able to confirm that our controls for timing and randomization in Qualtrics were effective. There was an unexpected issue affecting playback of treatment videos in Microsoft Edge browsers that we were able to resolve prior to running the experiment.

The pilot confirmed that the Likert scale was an appropriate choice for the survey questions. We found that participants used the full range of the scale. Upon review of the survey questions though, we found that some had ambiguous phrasing which we corrected. The climate awareness videos were also modified post-pilot to ensure that each group (awareness, skepticism, placebo) had equal length videos.

We calculated the power from the results of pilot which suggested that if the treatment effect is about 0.5 and standard deviation is 1.2 then we would need a sample size of 181 for a power of 80%. From the pilot study we also found that variance of the outcome variable was about the same in all the three groups so we decided to have an equal number of subjects in each group to get tighter standard error estimates.

Analysis

Post-experiment, data from Qualtrics was exported as CSV for analysis in R. We had a total of 570 observations across the three groups.

Randomization Check

As a first step towards analysis of treatment effect we checked if the randomization resulted in covariate balance in all groups.

We first checked that ANOVA test is not significant when comparing models as:

$$treatdummy = \beta_0 + \epsilon$$

$$treatdummy = \beta_0 + \beta_1 * Age + \beta_2 * Education + \beta_3 * Gender + \beta_4 * Climate disaster vulnerability + \beta_5 * Income + \beta_6 * Political affiliation + \beta_7 * Community size + \beta_8 * Pre Experiment Perception + \epsilon$$

For the treatment group we get the following from ANOVA test:

Analysis of Variance Table

```
Model 1: treat_dummy ~ 1
Model 2: treat_dummy ~ Age_factor + Education_factor + Gender_factor +
          LivingAreaAffected_factor + ClimateChangeAwareness_factor +
          PreTreatment_factor + Income_factor + PoliticalView_factor +
          Community_factor
Res.Df   RSS Df Sum of Sq      F Pr(>F)
1     223 55.960
2     193 48.386 30    7.5742 1.0071 0.4629
```

For the anti-treatment group we get the following from ANOVA test:

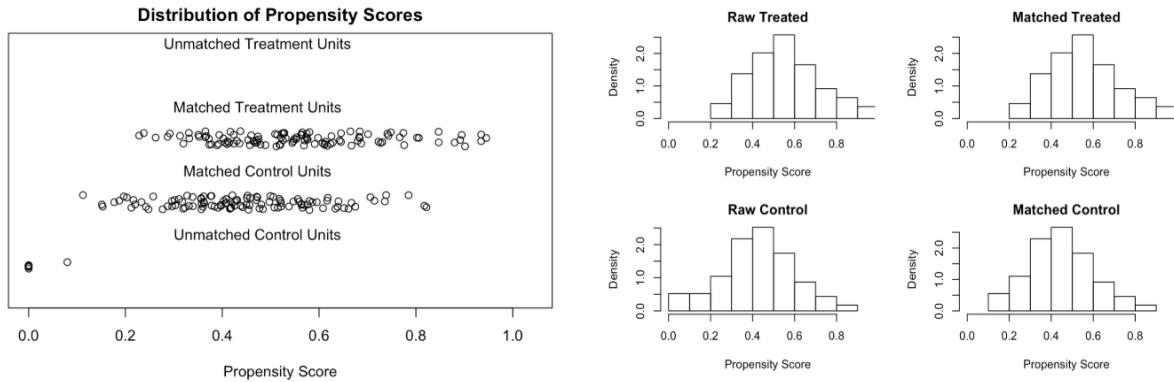
Analysis of Variance Table

```
Model 1: treat_dummy ~ 1
Model 2: treat_dummy ~ Age_factor + Education_factor + Gender_factor +
          LivingAreaAffected_factor + ClimateChangeAwareness_factor +
          PreTreatment_factor + Income_factor + PoliticalView_factor +
          Community_factor
Res.Df   RSS Df Sum of Sq      F Pr(>F)
1     234 58.723
2     204 51.030 30    7.6931 1.0251 0.4371
```

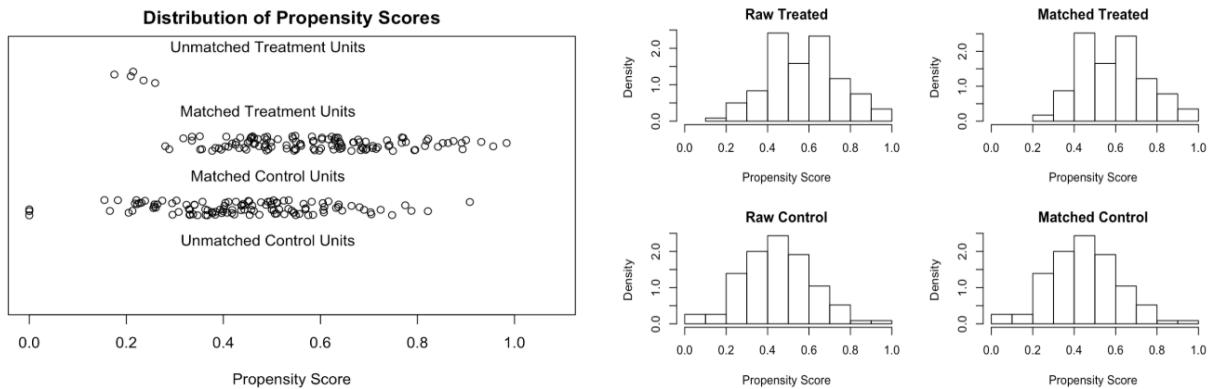
We find that the F-Tests indicate that randomization is indeed balanced across covariates. The covariates were not statistically significant in predicting whether an observation belonged to treatment or placebo.

We also employ the distribution of propensity score to find if the covariates are balanced in different groups. We compare the distribution of propensity score between treated and control. Propensity score is the probability with which subjects are assigned to control or treatment based on covariates. The matching of subjects between treatment and control is done using distance algorithm on covariates.

Awareness Group



Skepticism Group



We find that the distribution of propensity score is very similar between control and treatment which means that the randomization was successful.

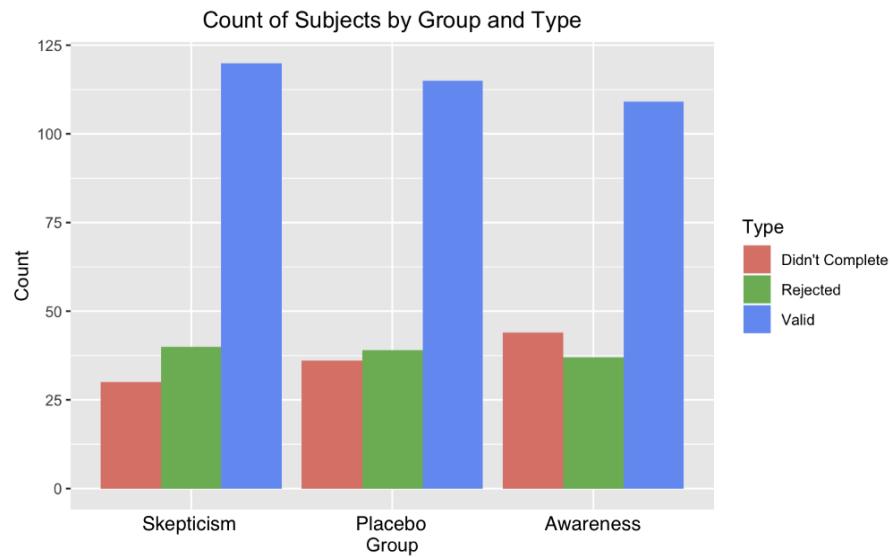
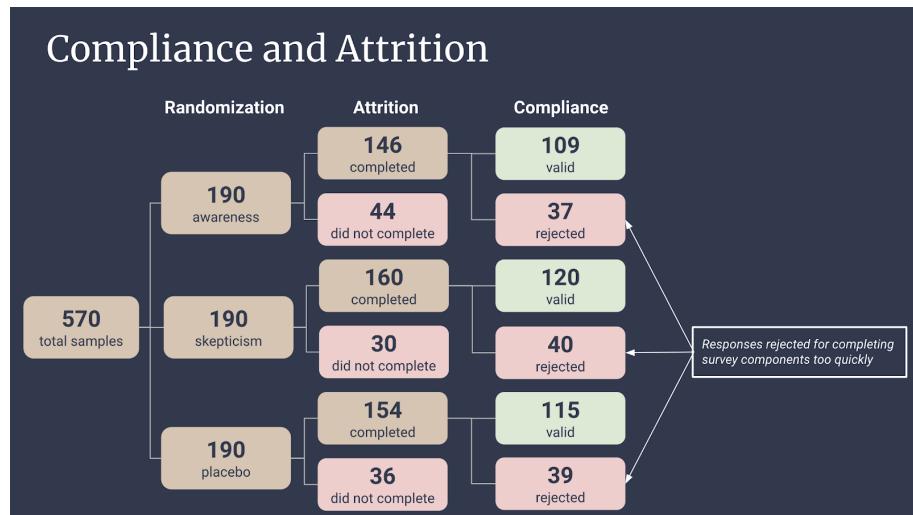
Compliance and Attrition

In our experiment we experienced both attrition and non-compliance. Out of an initial population of 570 participants, 344 completed the experiment.

Attrition is defined as a participant who begins the experiment, is randomized into a treatment group and begins treatment, and then fails to complete the post-treatment survey. 110 participants attrited from the experiment.

Non-compliance is defined as a participant who takes less than a minimum amount of time to respond to the post-treatment survey. The time limit was established during experimental

design by repeatedly timing how long it took to read and answer each question. 116 participants did not comply. Responses from non-compliers were omitted from the analysis.



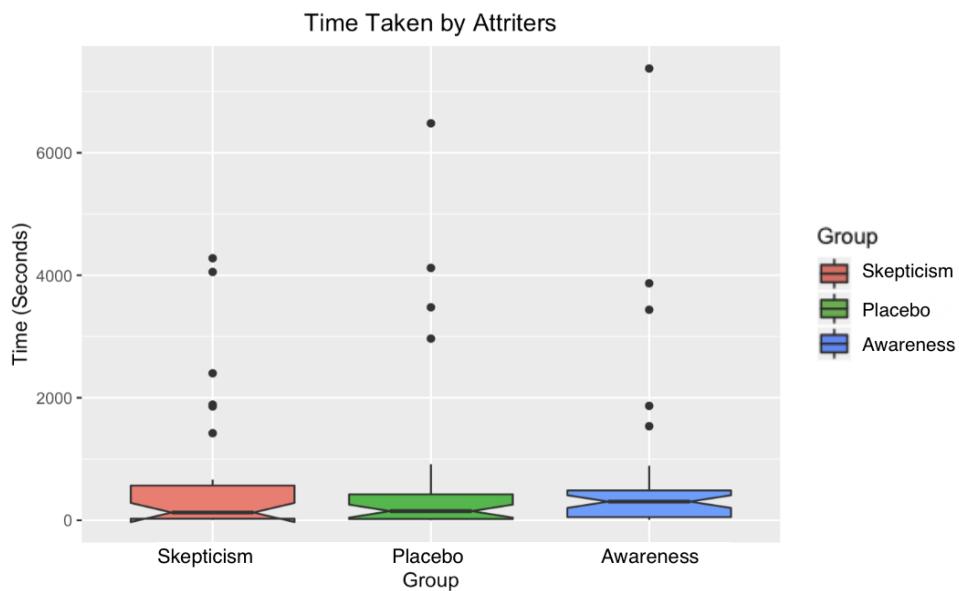
We find that about the same rate of attrition and compliance among treatment groups. We also ran the Chi-squared test if there is a differential attrition/compliance in awareness vs skepticism vs placebo group and we found that the Chi-squared test tells us that there is no differential attrition/compliance among the groups as the p-value doesn't come significant at level of .05.

	Didn't Complete	Rejected	Valid
Skepticism	30	40	120
Placebo	36	39	115
Awareness	44	37	109

Pearson's Chi-squared test

```
data: d_attrition_summary_table
x-squared = 3.3407, df = 4, p-value = 0.5025
```

We also argue that the attrition/compliance is not related to the potential outcome we are measuring as the people who attrit or not comply just don't complete the survey or not follow survey requirements irrespective of whether they intrinsically support climate change facts or not. So we assume that MIPO (missingness is independent of potential outcomes) is true in our experiment and the estimates we get after ignoring attrition is an unbiased estimate of the treatment effect.



We see from the above plot that subjects who attrit in different groups have about the same distribution for time taken. The confidence intervals around the medians in different groups are overlapping. So most of the attritors attrit as soon as they find that the survey involves watching videos while some others keep their browser open but never complete. This adds confidence to MIPO assumption which we are making.

We have a placebo design in place so for calculating the CACE (Complier Average Causal Effect) we compare the outcomes of compliers in the awareness/skepticism and control group.

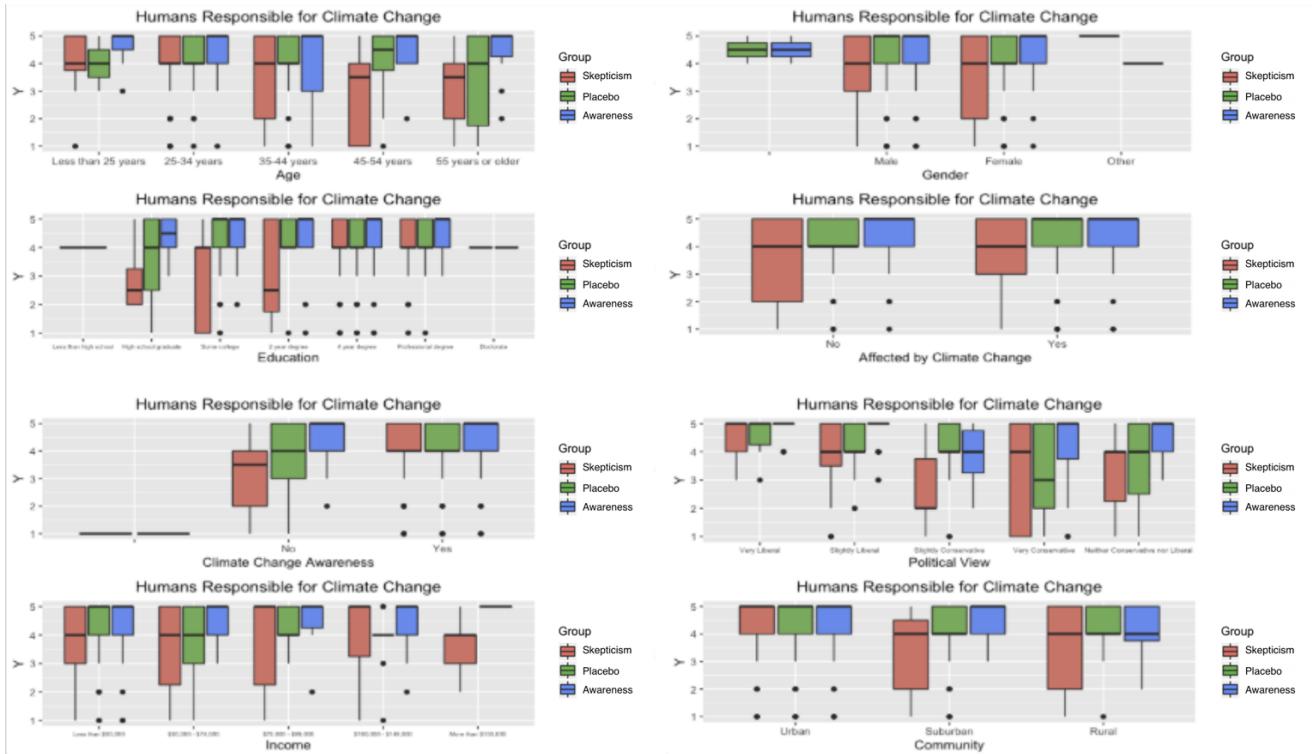
Exploratory Data Analysis

In the experiment we measure 6 different outcomes after treatment. These 6 different outcomes represent three different dimensions of the perception towards climate change. The dimensions and the outcomes we measure are:

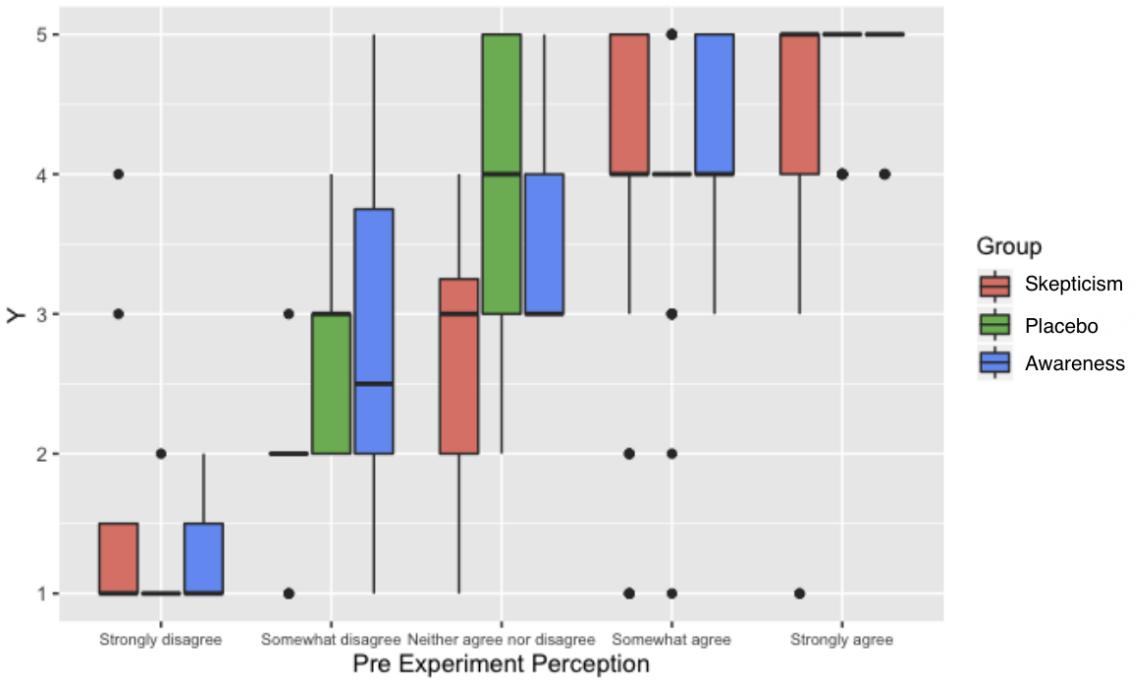
- Primary causes of climate change
 - **Y1:** Human activity is primarily responsible for climate change.
- Urgency of climate change
 - **Y2:** Climate change is a serious threat to humans.
 - **Y6:** I intend to make changes to my own lifestyle to help alleviate the effects of climate change.
- Type of action needed to alleviate climate change
 - **Y3:** Individuals actions or lifestyle changes would not help in reducing the effects of climate change.
 - **Y4:** Broader scale changes, such as raising taxes on the commodities which release greenhouse gases, are necessary to alleviate the effects of climate change.
 - **Y5:** There is no need for a binding international agreement to regulate greenhouse gas emissions.

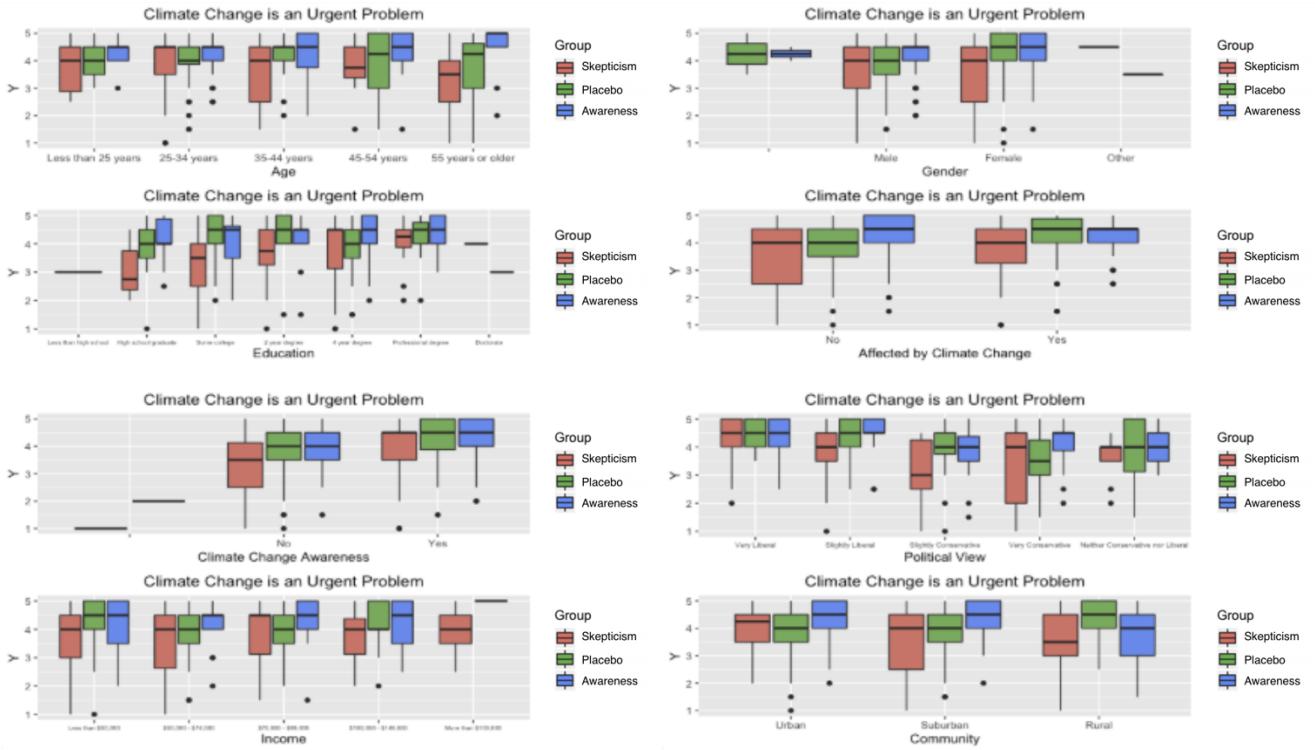
We also capture other attributes of the subject such as Age, Gender, etc. as detailed below. Let us check how the covariates are related to the outcome variables. We code the Likert scale output for the outcome as 1 to 5 for Strongly Disagree to Strongly Agree. The coding is done such that 5 means most concerned about climate change while 1 means least concerned.

We look at the relation of covariates to outcome dimensions by taking mean of the outcome values of the questions belonging to the dimension and plotting it against the covariates values.

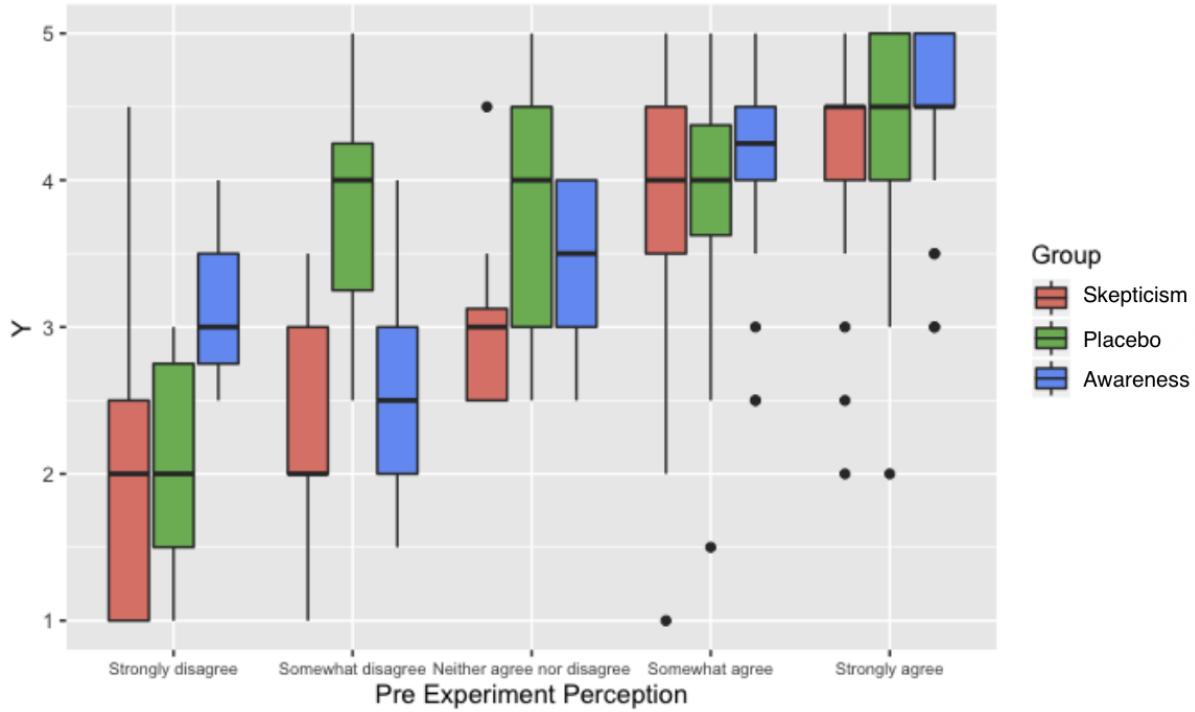


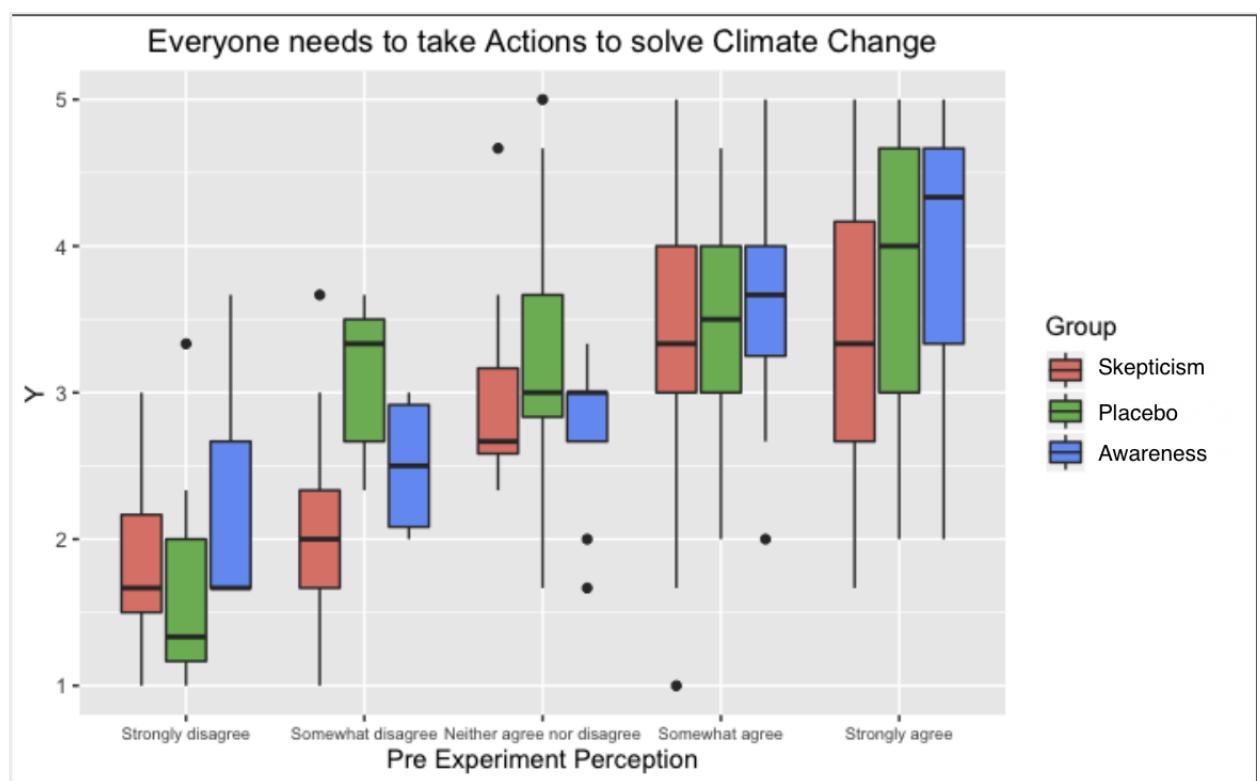
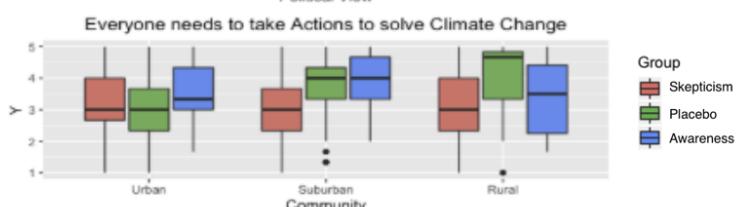
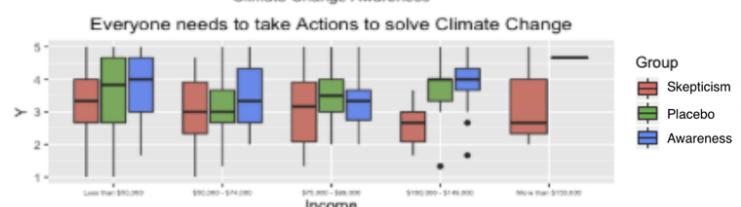
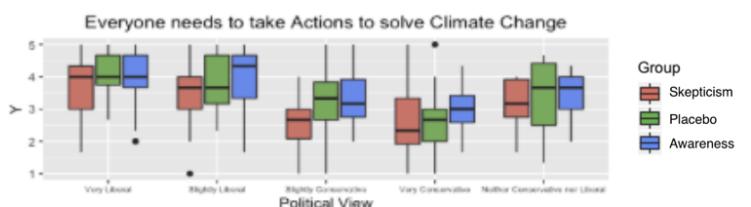
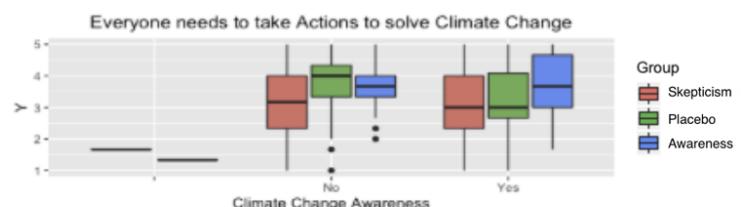
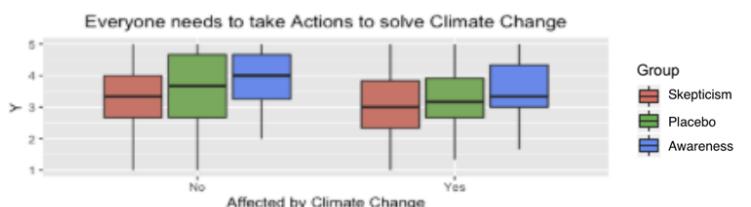
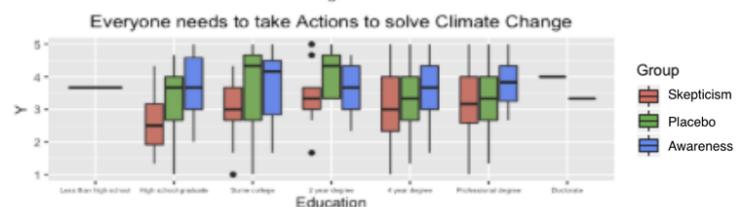
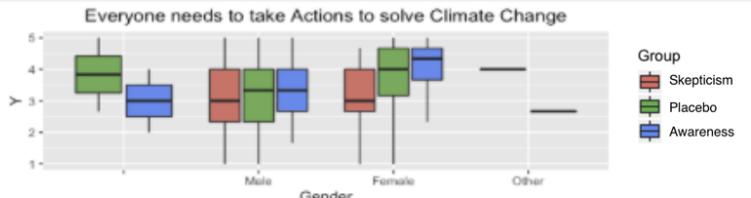
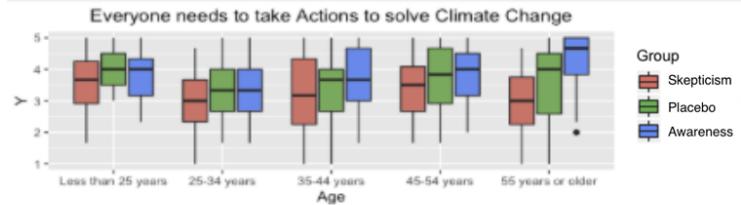
Humans Responsible for Climate Change





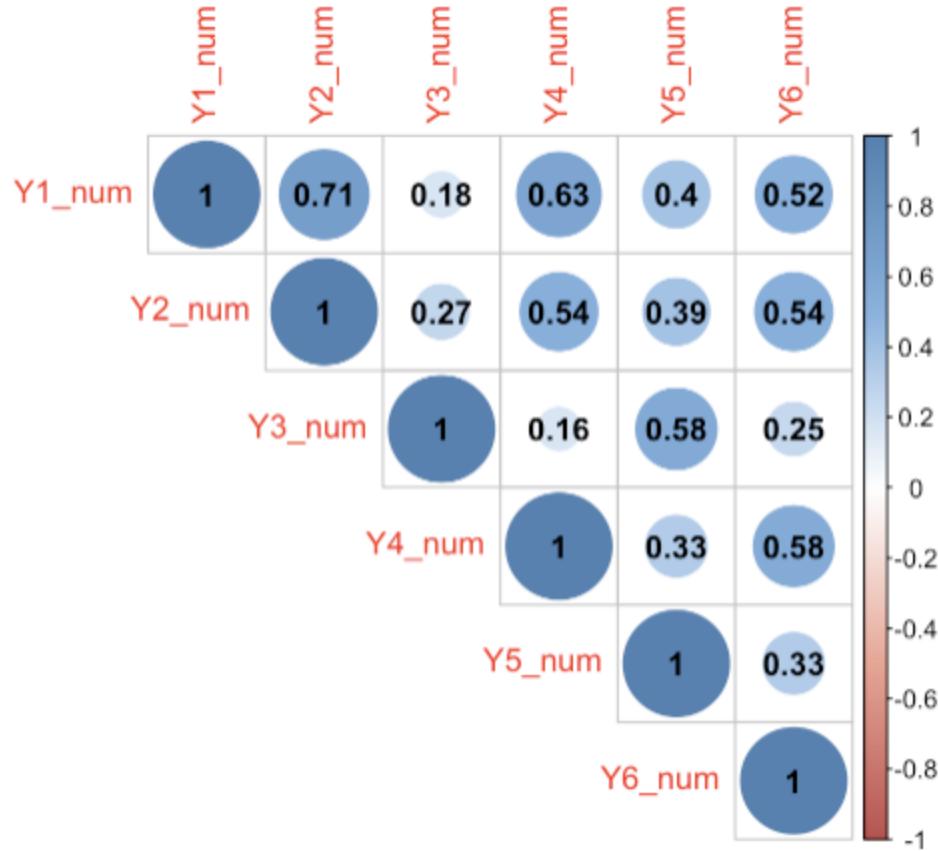
Climate Change is an Urgent Problem





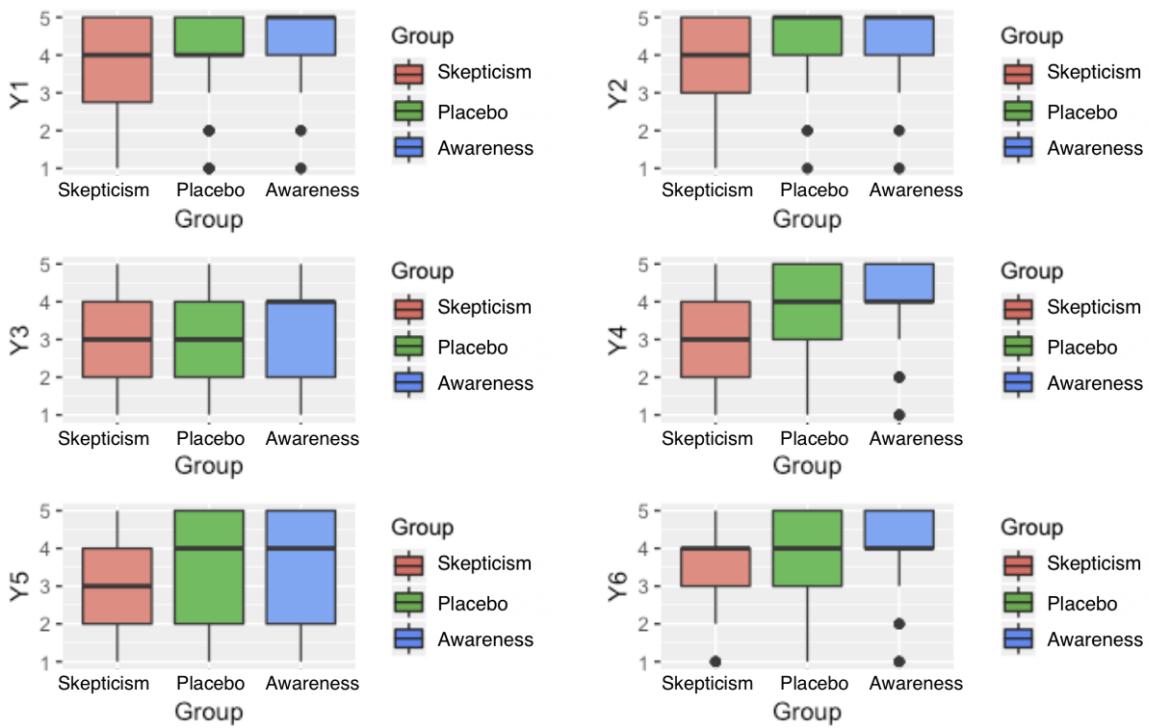
We see from the EDA that Pre-Experiment perception is the only covariate which has strong relation with every outcome in all the groups. When doing our analysis we would be using this covariate as control as that would give us smaller standard errors for the estimation of treatment effect.

Let us also check if there is a correlation between the outcomes for the subjects.



We see from the correlation plot that as expected all the outcomes are positively correlated which means if a subject positively agrees with climate change science on one outcome then she is also likely to agree on other outcomes. But the correlation is not very strong, which means people have different levels of agreement on different topics related to climate change.

Now let us check the distribution of the outcomes in different groups to get an idea of treatment effect by comparing the means in different groups.



From the above plot we see that treatment has marked effect on Y1 while antit-treatment has marked negative effect on Y2,Y4 and Y5 outcomes.

Estimation of Treatment Effect

For estimating the Average Treatment Effect (ATE) of the educational videos we take two approaches.

In one approach we convert the Likert scale outcomes into interval data from 1 to 5 . Here the assumption is that the distance between each of the outcome Likert scale options is 1. Once we convert the outcomes into an interval we use linear regression models to estimate the ATE.

In our second approach we take the outcomes as ordinal values and use proportional odds logistic regression (POLR) to estimate the ATE. Although this avoids the scale assumption, it decreases the interpretability of our results.

Linear Models

We saw from the EDA that the covariate which explains the outcome best is "Pre-Experiment Perception" which is a likert scale variable where we asked the respondent about how strongly

do they agree on anthropogenic cause of climate change. In our models we name this covariate PreTreatment and control for it.

Treatment Effect of Climate Change Support Videos

We modelled each of the outcome variables using separate linear models.

The form of each model is:

$$Y = \beta_0 + \beta_1 * treatDummy + \beta_2 * PreTreatment + \epsilon$$

Table 1:

	Dependent variable:					
	Y1_num (1)	Y2_num (2)	Y3_num (3)	Y4_num (4)	Y5_num (5)	Y6_num (6)
treat_dummy	0.204** (0.085)	0.023 (0.096)	0.137 (0.174)	0.040 (0.128)	0.094 (0.185)	0.134 (0.142)
PreTreatmentSomewhat agree	0.292 (0.221)	0.274 (0.182)	0.046 (0.282)	0.636** (0.277)	0.611** (0.310)	0.508* (0.268)
PreTreatmentSomewhat disagree	-1.040*** (0.374)	-0.890** (0.421)	0.052 (0.370)	-0.366 (0.451)	-0.457 (0.339)	0.046 (0.456)
PreTreatmentStrongly agree	1.041*** (0.205)	0.748*** (0.163)	0.298 (0.282)	1.191*** (0.265)	0.945*** (0.313)	0.981*** (0.255)
PreTreatmentStrongly disagree	-2.576*** (0.245)	-1.540*** (0.424)	-0.956** (0.393)	-1.605*** (0.495)	-0.926* (0.483)	-0.940* (0.494)
Constant	3.715*** (0.207)	4.033*** (0.165)	3.115*** (0.264)	3.194*** (0.264)	2.798*** (0.292)	3.200*** (0.246)
Observations	224	224	224	224	224	224
R ²	0.675	0.421	0.047	0.357	0.131	0.195
Adjusted R ²	0.668	0.408	0.025	0.343	0.111	0.176
Residual Std. Error (df = 218)	0.616	0.696	1.291	0.941	1.364	1.029
F Statistic (df = 5; 218)	90.660***	31.697***	2.138*	24.244***	6.591***	10.537***

Note:

*p<0.1; **p<0.05; ***p<0.01

From the model we get that only for Y1 (Are humans responsible for climate change) the treatment effect is .204 and is statistically significant. For all other outcomes the treatment effect is not statistically significant.

We also created models for heterogeneous treatment effects. Here we also include an interaction term between treatment indicator and the pre-treatment Covariate.

The model is:

$$Y = \beta_0 + \beta_1 * treatDummy + \beta_2 * PreTreatment + \beta_3 * treatDummy * PreTreatment + \epsilon$$

Table 2:

	<i>Dependent variable:</i>					
	Y1_num	Y2_num	Y3_num	Y4_num	Y5_num	Y6_num
	(1)	(2)	(3)	(4)	(5)	(6)
treat_dummy	-0.556 (0.371)	-0.244 (0.308)	-0.267 (0.447)	-0.333 (0.504)	-0.800 (0.495)	-0.578 (0.456)
PreTreatmentSomewhat agree	-0.176 (0.301)	0.102 (0.254)	-0.178 (0.422)	0.343 (0.398)	0.308 (0.439)	0.180 (0.365)
PreTreatmentSomewhat disagree	-1.286*** (0.408)	-0.419 (0.506)	0.305 (0.490)	-0.333 (0.680)	-0.419 (0.497)	0.390 (0.485)
PreTreatmentStrongly agree	0.788*** (0.273)	0.597** (0.235)	0.099 (0.429)	1.109*** (0.373)	0.482 (0.449)	0.668* (0.349)
PreTreatmentStrongly disagree	-2.857*** (0.309)	-1.705*** (0.565)	-1.124** (0.573)	-1.905*** (0.586)	-1.562*** (0.605)	-1.752*** (0.554)
treat_dummy:PreTreatmentSomewhat agree	1.138*** (0.408)	0.415 (0.361)	0.553 (0.529)	0.688 (0.548)	0.828 (0.573)	0.837 (0.521)
treat_dummy:PreTreatmentSomewhat disagree	0.675 (0.816)	-0.970 (0.825)	-0.471 (0.705)	0.000 (0.939)	0.086 (0.584)	-0.613 (0.893)
treat_dummy:PreTreatmentStrongly agree	0.699* (0.377)	0.361 (0.320)	0.495 (0.528)	0.264 (0.528)	1.134** (0.578)	0.799 (0.493)
treat_dummy:PreTreatmentStrongly disagree	0.746 (0.573)	0.483 (1.016)	0.457 (0.746)	0.905 (1.403)	1.895* (1.061)	2.530*** (0.762)
Constant	4.000*** (0.267)	4.133*** (0.223)	3.267*** (0.371)	3.333*** (0.360)	3.133*** (0.389)	3.467*** (0.317)
Observations	224	224	224	224	224	224
R ²	0.698	0.454	0.057	0.370	0.154	0.250
Adjusted R ²	0.685	0.431	0.018	0.343	0.118	0.219
Residual Std. Error (df = 214)	0.600	0.682	1.296	0.941	1.359	1.002
F Statistic (df = 9; 214)	54.890***	19.780***	1.443	13.962***	4.313***	7.934***

Note:

*p<0.1; **p<0.05; ***p<0.01

We get from the above results that indeed the treatment has varying effects on subjects with different pre-treatment values. We see for the question Y1 (Are humans responsible for the Climate Change) subjects who "Somewhat agree" in pretreatment were to get a treatment effect of 0.582 (-0.556 + 1.138). We also see that the treatment has heterogeneous statistically significant effect on outcomes Y5 and Y6 for the people who strongly disagree to anthropogenic cause of climate change before treatment. Specifically people who strongly disagree in before getting treated agree more by the amount of 1.095 (-0.8 + 1.895) and 1.952 (-.578 + 2.530) for

outcome Y5 and Y6 respectively. Hence making the educational videos very effective for people who don't believe in anthropogenic causes of climate change.

Treatment Effect of Anti-Climate Change Support Videos

We modelled each of the outcome questions using linear models.

The formula for each model is

$$Y = \beta_0 + \beta_1 * treatDummy + \beta_2 * PreTreatment + \epsilon$$

Table 3:

	Dependent variable:					
	Y1_num (1)	Y2_num (2)	Y3_num (3)	Y4_num (4)	Y5_num (5)	Y6_num (6)
treat_dummy	-0.273** (0.119)	-0.411*** (0.122)	-0.225 (0.172)	-0.492*** (0.136)	-0.111 (0.176)	-0.101 (0.130)
PreTreatmentSomewhat agree	0.314 (0.263)	0.427* (0.232)	0.016 (0.311)	0.458* (0.276)	0.253 (0.307)	0.379 (0.238)
PreTreatmentSomewhat disagree	-1.333*** (0.287)	-0.865** (0.341)	-0.356 (0.364)	-0.925** (0.359)	-0.697** (0.340)	-0.367 (0.322)
PreTreatmentStrongly agree	1.126*** (0.245)	0.959*** (0.219)	0.067 (0.314)	1.040*** (0.263)	0.470 (0.317)	0.786*** (0.226)
PreTreatmentStrongly disagree	-2.115*** (0.347)	-1.396*** (0.435)	-0.932** (0.391)	-1.549*** (0.363)	-1.510*** (0.370)	-1.462*** (0.367)
Constant	3.660*** (0.237)	3.882*** (0.207)	3.252*** (0.286)	3.345*** (0.261)	3.169*** (0.289)	3.383*** (0.221)
Observations	235	235	235	235	235	235
R ²	0.546	0.409	0.046	0.398	0.143	0.269
Adjusted R ²	0.536	0.397	0.026	0.385	0.125	0.253
Residual Std. Error (df = 229)	0.890	0.900	1.303	1.013	1.335	0.989
F Statistic (df = 5; 229)	55.165***	31.753***	2.231*	30.306***	7.672***	16.834***

Note:

*p<0.1; **p<0.05; ***p<0.01

From the model we get that for Y1, Y2 and Y4 the treatment effect are -.273, -.411 and -.492 respectively, and are statistically significant. For all other outcomes the treatment effect is not statistically significant.

We also created models for heterogeneous treatment effects. Here we also include an interaction term between treatment indicator and the pre-treatment covariate.

The model is

$$Y = \beta_0 + \beta_1 * treatDummy + \beta_2 * PreTreatment + \beta_3 * treatDummy * PreTreatment + \epsilon$$

Table 4:

	<i>Dependent variable:</i>					
	Y1_num	Y2_num	Y3_num	Y4_num	Y5_num	Y6_num
	(1)	(2)	(3)	(4)	(5)	(6)
treat_dummy	-1.250*** (0.474)	-1.133** (0.461)	-0.267 (0.584)	-0.458 (0.478)	-0.008 (0.540)	-0.342 (0.344)
PreTreatmentSomewhat agree	-0.176 (0.301)	0.102 (0.254)	-0.178 (0.422)	0.343 (0.398)	0.308 (0.439)	0.180 (0.365)
PreTreatmentSomewhat disagree	-1.286*** (0.408)	-0.419 (0.506)	0.305 (0.490)	-0.333 (0.680)	-0.419 (0.497)	0.390 (0.485)
PreTreatmentStrongly agree	0.788*** (0.273)	0.597** (0.235)	0.099 (0.429)	1.109*** (0.373)	0.482 (0.449)	0.668* (0.349)
PreTreatmentStrongly disagree	-2.857*** (0.309)	-1.705*** (0.565)	-1.124** (0.573)	-1.905*** (0.586)	-1.562*** (0.605)	-1.752*** (0.554)
treat_dummy:PreTreatmentSomewhat agree	1.245** (0.526)	0.853* (0.503)	0.360 (0.649)	0.191 (0.538)	-0.137 (0.608)	0.445 (0.424)
treat_dummy:PreTreatmentSomewhat disagree	0.382 (0.588)	-0.350 (0.710)	-0.997 (0.721)	-0.926 (0.782)	-0.475 (0.677)	-1.054* (0.564)
treat_dummy:PreTreatmentStrongly agree	0.972* (0.498)	0.956** (0.484)	-0.056 (0.651)	-0.154 (0.513)	-0.054 (0.625)	0.313 (0.386)
treat_dummy:PreTreatmentStrongly disagree	1.732*** (0.671)	0.830 (0.932)	0.374 (0.828)	0.655 (0.723)	0.062 (0.765)	0.627 (0.727)
Constant	4.000*** (0.267)	4.133*** (0.223)	3.267*** (0.371)	3.333*** (0.360)	3.133*** (0.389)	3.467*** (0.317)
Observations	235	235	235	235	235	235
R ²	0.572	0.440	0.065	0.415	0.145	0.299
Adjusted R ²	0.554	0.418	0.027	0.392	0.111	0.271
Residual Std. Error (df = 225)	0.872	0.884	1.301	1.008	1.346	0.977
F Statistic (df = 9; 225)	33.361***	19.659***	1.735*	17.766***	4.250***	10.688***

Note:

*p<0.1; **p<0.05; ***p<0.01

We get from the above results that indeed the treatment has varying effects on subjects with different pre-treatment values. We specifically see that for Y4 outcome the treatment effects are

no more statistically significant. We also see that for outcome Y1 and Y2 people who strongly agree with anthropogenic causes of climate change believes less in anthropogenic cause of climate change(Y1) and its urgency on the scale of -0.278 (-1.25 + .972) and -0.177 (-1.133 +.956) respectively.

Comparing treatment Effect of Pro-Climate vs Anti-Climate Change Educational Videos

Since we got Y1 outcome as significant for both pro-climate change and anti-climate change we also want to compare if the skepticism videos efficacy is same as awareness videos.

To do this we first duplicate the placebo records. One set belongs to skepticism group and other to the awareness group. We create a dummy variable AntiTreatGroup (representing the skepticism group) to reflect the group of the records. The value is 1 when the group is skepticism and 0 when the record is for the awareness group. Then we estimate the model as:

$$Y1 = \beta_0 + \beta_1 * treat_dummy + \beta_2 * AntiTreatGroup + \beta_3 * treat_dummy * AntiTreatGroup + \beta_4 * PreTreatment + \epsilon$$

Table 5:

<i>Dependent variable:</i>	
	Y1_num
treat_dummy	0.208** (0.084)
AntiTreatGroup	0.000 (0.090)
PreTreatmentSomewhat agree	0.302* (0.169)
PreTreatmentSomewhat disagree	-1.223*** (0.219)
PreTreatmentStrongly agree	1.082*** (0.156)
PreTreatmentStrongly disagree	-2.304*** (0.223)
treat_dummy:AntiTreatGroup	-0.487*** (0.145)
Constant	3.688*** (0.160)
Observations	459
R ²	0.604
Adjusted R ²	0.598
Residual Std. Error	0.768 (df = 451)
F Statistic	98.258*** (df = 7; 451)

Note: *p<0.1; **p<0.05; ***p<0.01

We get from the above that the skepticism in indeed more effective than awareness videos on Y1 outcome as the treat_dummy:AntiTreatment has coefficient of -0.487 while treat_dummy is 0.208 and both are statistically significant. The baseline of skepticism is same as awareness as the coefficient of AntiTreatment is 0. So effectively the Treatment effect of skepticism videos is $-0.487 + 0.208 = -0.279$. The treatment effect of awareness videos is 0.208 . So the difference between the effect of awareness vs skepticism videos is -0.071 .

This tells us that skepticism videos are more effective in dissuading someone than awareness videos persuading someone from agreeing that climate change is caused by humans. Although this is marginal difference as the robust standard error of treatment effect is .084 so the difference is less than 1 standard error.

Proportional Odds Logistic Regression (POLR) Models

The POLR models are similar to multinomial logistic regression (MLR) models except that they take into account the ordered-ness of the outcome categories. The POLR formulation is this, where Y is the outcome category level (eg. Strongly disagree) and j is in the set {1,2,3,4,5} (ie. one per outcome category level).

$$\text{logit}(P(Y \leq j)) = \beta_{j0} + \beta_1 x_1 + \cdots + \beta_p x_p.$$

<https://stats.idre.ucla.edu/r/faq/ologit-coefficients/>

A POLR model can be understood in two main ways, either as a set of joint probability distributions or as a set of regression lines.

Each outcome category has its own joint probability distribution with the explanatory variables. These distributions are ordered according to the ordinal specification and typically overlap. This understanding lends itself well to the interpretation that unit changes in the explanatory variables change the odds of being in being one probability distribution or another. Moving left or right along the x-axis causes the probability of some categories to rise and others to fall.

The regression plot has $j-1$ lines, where j is the number of outcome categories. Each line represents the boundary between all levels above and all levels equal to or below the specified categories. Only one set of coefficients is fit for all of the category boundaries, which means that POLR makes a proportional odds assumption similar to the parallel lines assumption.

The proportional odds assumption can be tested using a likelihood ratio test (LRT) between the POLR model and a non-proportional odds model. Since POLR is a nested model of MLR, we can use these two for comparison. The null hypothesis that we test is that each coefficient has the same value for all outcome categories.

Please note that there are slight naming differences between these models and the linear regression models. The “treat_dummy” variable is called either “GroupTreatment” or “GroupAntiTreatment,” representing the awareness and skepticism groups, respectively.

Treatment Effect of Climate Change Awareness Videos

When controlling for PreTreatment sentiment of participants towards anthropogenic climate change, we find that only question 1 has a statistically significant effect at the p<0.05 level. Testing the proportional odds assumption for model 1 yielded a p-value of 0.15, which fails to reject the null hypothesis that the assumption is valid.

The interpretation of the treatment effect is that: participants who were exposed to the awareness treatment were 2.25 (ie. $\exp(.809)$) times more likely to agree that “human activity is primarily responsible for climate change” than those participants exposed to the placebo treatment.

Although the treatment effect was statistically significant, the effect size is smaller than all levels of the PreTreatment sentiment effect size. PreTreatment sentiment was statistically significant for all sentiment levels. The correlation between covariate effect and sentiment direction is as expected. Those that, prior to treatment, agreed with anthropogenic climate change were more likely to agree to question 1. Those that previously disagreed were more likely to disagree. The effect sizes are also consistent with the strength of the agreement or disagreement. Stronger sentiments had larger effect sizes.

Table 6: POLR Treatment

	Dependent variable:					
	Y1 (1)	Y2 (2)	Y3 (3)	Y4 (4)	Y5 (5)	Y6 (6)
GroupTreatment	0.809** (0.316)	0.198 (0.290)	-0.154 (0.240)	0.101 (0.256)	-0.179 (0.242)	0.265 (0.252)
PreTreatmentSomewhat agree	0.862* (0.498)	0.826* (0.469)	-0.084 (0.404)	1.031** (0.440)	-0.671* (0.405)	0.877** (0.426)
PreTreatmentSomewhat disagree	-2.173*** (0.730)	-1.602** (0.693)	-0.067 (0.565)	-0.567 (0.632)	0.362 (0.549)	0.253 (0.643)
PreTreatmentStrongly agree	3.597*** (0.553)	2.508*** (0.483)	-0.552 (0.395)	2.371*** (0.445)	-1.421*** (0.407)	1.942*** (0.424)
PreTreatmentStrongly disagree	-5.981*** (1.163)	-2.681*** (0.752)	1.160* (0.634)	-3.163*** (0.924)	1.316* (0.692)	-1.325* (0.698)
Observations	224	224	224	224	224	224

Note:

*p<0.1; **p<0.05; ***p<0.01

Understanding that PreTreatment sentiment is apparently more important than the treatment, we also explore the heterogeneous treatment effect (HTE). The effect size is much larger and the standard error is smaller, however the treatment effect is in the opposite direction. The treatment group is now 5.88 times *less* likely to support question 1. Based upon these results, we would not expect to be able to convince anyone that has a negative PreTreatment sentiment with our awareness intervention.

However, when verifying the proportional odds assumption for this model, the p-value is 0.04, which rejects the null hypothesis and suggests that separate coefficients must be fit for each outcome category. It suggests that different responses (eg. Strongly agree, Strongly Disagree) have different treatment effects. The causal interpretation is not clear. Although correlation between treatment effect and PreTreatment sentiment would have a clear conclusion, the correlation between treatment effect and post-treatment sentiment is not actionable.

Table 7: POLR Treatment with HTE

	Dependent variable:					
	Y1 (1)	Y2 (2)	Y3 (3)	Y4 (4)	Y5 (5)	Y6 (6)
GroupTreatment	-1.753** (0.840)	-0.750 (0.807)	0.363 (0.696)	-0.635 (0.752)	0.823 (0.705)	-0.913 (0.724)
PreTreatmentSomewhat agree	-0.530 (0.658)	0.254 (0.619)	0.249 (0.556)	0.496 (0.590)	-0.323 (0.538)	0.281 (0.573)
PreTreatmentSomewhat disagree	-3.150*** (0.937)	-0.982 (0.941)	-0.270 (0.758)	-0.419 (0.871)	0.404 (0.733)	0.658 (0.822)
PreTreatmentStrongly agree	2.448*** (0.672)	1.968*** (0.627)	-0.243 (0.550)	2.117*** (0.586)	-0.792 (0.534)	1.413** (0.560)
PreTreatmentStrongly disagree	-7.331*** (1.449)	-3.218*** (0.939)	1.503* (0.814)	-3.984*** (1.231)	2.535*** (0.962)	-2.883*** (0.913)
GroupTreatment:PreTreatmentSomewhat agree	3.237*** (1.003)	1.343 (0.938)	-0.713 (0.809)	1.200 (0.875)	-0.853 (0.814)	1.442* (0.855)
GroupTreatment:PreTreatmentSomewhat disagree	1.837 (1.391)	-1.354 (1.383)	0.470 (1.126)	-0.186 (1.240)	-0.158 (1.091)	-1.076 (1.252)
GroupTreatment:PreTreatmentStrongly agree	3.041*** (1.044)	1.297 (0.944)	-0.649 (0.788)	0.654 (0.841)	-1.421* (0.804)	1.348* (0.815)
GroupTreatment:PreTreatmentStrongly disagree	2.789 (1.815)	1.104 (1.459)	-0.791 (1.300)	2.081 (1.863)	-2.867** (1.428)	3.936*** (1.428)
Observations	224	224	224	224	224	224

Note:

*p<0.1; **p<0.05; ***p<0.01

Treatment Effect of Climate Skepticism Videos

The POLR models show a statistically significant treatment effect for questions 2 and 4. However, when the proportional odds assumption is tested via the LRT, the p-value is approximately 0. The POLR models are not valid analyses of the treatment effect.

Table 8: POLR AntiTreatment

	Dependent variable:					
	Y1 (1)	Y2 (2)	Y3 (3)	Y4 (4)	Y5 (5)	Y6 (6)
GroupAntiTreatment	-0.418 (0.267)	-0.780*** (0.267)	0.333 (0.235)	-0.835*** (0.252)	0.157 (0.236)	-0.308 (0.244)
PreTreatmentSomewhat agree	0.619 (0.454)	0.793* (0.437)	-0.013 (0.419)	0.710* (0.429)	-0.288 (0.405)	0.760* (0.420)
PreTreatmentSomewhat disagree	-1.974*** (0.563)	-1.287** (0.563)	0.441 (0.524)	-1.450** (0.576)	0.750 (0.506)	-0.530 (0.541)
PreTreatmentStrongly agree	2.806*** (0.490)	2.307*** (0.462)	-0.137 (0.415)	1.818*** (0.434)	-0.779* (0.410)	1.506*** (0.416)
PreTreatmentStrongly disagree	-4.122*** (0.815)	-2.382*** (0.674)	1.198** (0.582)	-2.697*** (0.693)	2.157*** (0.631)	-2.681*** (0.681)
Observations	235	235	235	235	235	235

Note:

*p<0.1; **p<0.05; ***p<0.01

The LRT p-values for the significant HTE models (1 and 2) are again approximately 0.

Table 9: POLR AntiTreatment with HTE

	Dependent variable:					
	Y1 (1)	Y2 (2)	Y3 (3)	Y4 (4)	Y5 (5)	Y6 (6)
GroupAntiTreatment	-2.229*** (0.812)	-1.981** (0.789)	0.376 (0.755)	-0.826 (0.760)	0.044 (0.724)	-0.691 (0.726)
PreTreatmentSomewhat agree	-0.475 (0.604)	0.169 (0.566)	0.258 (0.557)	0.480 (0.583)	-0.335 (0.544)	0.296 (0.579)
PreTreatmentSomewhat disagree	-2.307*** (0.816)	-0.743 (0.852)	-0.265 (0.761)	-0.432 (0.868)	0.445 (0.738)	0.680 (0.820)
PreTreatmentStrongly agree	2.219*** (0.628)	1.696*** (0.583)	-0.250 (0.552)	2.045*** (0.577)	-0.838 (0.541)	1.407** (0.562)
PreTreatmentStrongly disagree	-5.730*** (1.248)	-2.802*** (0.884)	1.505* (0.813)	-4.203*** (1.225)	2.584*** (0.964)	-3.452*** (0.948)
GroupAntiTreatment:PreTreatmentSomewhat agree	2.536** (0.923)	1.586* (0.886)	-0.513 (0.852)	0.438 (0.863)	0.114 (0.819)	0.956 (0.844)
GroupAntiTreatment:PreTreatmentSomewhat disagree	1.040 (1.104)	-0.361 (1.155)	1.107 (1.068)	-1.558 (1.174)	0.531 (1.028)	-1.714 (1.098)
GroupAntiTreatment:PreTreatmentStrongly agree	1.638* (0.935)	1.587* (0.910)	0.196 (0.845)	-0.418 (0.852)	0.138 (0.823)	0.322 (0.815)
GroupAntiTreatment:PreTreatmentStrongly disagree	3.240** (1.586)	0.905 (1.329)	-0.560 (1.168)	2.284 (1.480)	-0.670 (1.276)	1.381 (1.277)
Observations	235	235	235	235	235	235

Note:

*p<0.1; **p<0.05; ***p<0.01

Comparing Treatment Effect of Climate Awareness vs Climate Skepticism Educational Videos

To directly compare the treatment effects, we have formulated Y1 with both groups in the same POLR model. The significance and direction of the coefficients agree with what we presented in Tables 6 and 8. However, the LRT for the proportional odds assumption has a p-value of 0.001, which rejects the null hypothesis. We should be very cautious about drawing any conclusions regarding the ATE based upon this model.

Table 10: POLR Treatment vs AntiTreatment

	<i>Dependent variable:</i>	
	Y1	
GroupAntiTreatment	-0.318 (0.228)	
GroupTreatment	0.504** (0.244)	
PreTreatment	1.782*** (0.389)	
PreTreatmentSomewhat agree	1.053*** (0.377)	
PreTreatmentSomewhat disagree	-1.713*** (0.479)	
PreTreatmentStrongly agree	3.278*** (0.407)	
PreTreatmentStrongly disagree	-4.012*** (0.707)	
Observations	460	

Note:

*p<0.1; **p<0.05; ***p<0.01

Conclusions

We find from our experiment that we can **reject** all three null hypotheses:

- Climate awareness treatments don't encourage the perception that climate change is urgent and anthropogenic.
- Climate skepticism treatments don't discourage the perception that climate change is urgent and anthropogenic.
- Climate awareness treatments are equally as effective as climate skepticism treatments in influencing subjects' perceptions.

We also find that climate skepticism videos are more effective than climate awareness videos. So as a policy we would like to suggest to the firms investing in creating awareness about climate change to create and advertise more videos where the climate change skepticism theories are debunked as it would be more impactful.

As a further experiment to improve confidence in our results we should also conduct experiments with a large pool of videos and a larger pool of participants to make sure that we are comparing apples to apples in terms of quality of videos and educational material across treatment groups. In the current experiment we had only 2 videos for each group and our results might be biased if the quality of these videos are vastly different in terms of its impact on the audience. We would also plan to move the PreTreatment sentiment question to before our treatment interventions.

We discovered that the POLR models were generally invalid for our experimental analysis due to rejection of the proportional odds assumption. Relaxing this assumption by using an MLR model might be effective, however the interpretability of our results would vastly decrease. Using the MLR model we would be able to calculate the ATE per post-treatment outcome category. This is not enough information for us to make our understanding of the causal effect actionable. For example, it would only allow us to say that for someone that Agrees after treatment, they were likely Somewhat disagree prior to treatment.

In this experiment we have attempted to capture the short term causal effect of educational videos on perception towards climate change issue but as a follow up we would like to perform a study which aims at studying the long term impact of educational videos on the topic. We would also like to study the effect of periodically providing education on climate change to the perception towards the issue of climate change.

References

1. <https://www.carbonbrief.org/global-survey-where-in-the-world-is-most-and-least-aware-of-climate-change>
2. <https://www.cnn.com/2018/10/07/world/climate-change-new-ipcc-report-wxc/index.html>
3. <https://climate.nasa.gov/>

Appendix

Links to Awareness Videos:

https://drive.google.com/file/d/1wG_eC37d07SFCQ2PbdBbBzilGbDn-bmv/preview

https://drive.google.com/file/d/1xdJHa-QT_Nli97eHDF5CTpL1MV3dxuX/preview

Links to Skepticism Videos:

https://drive.google.com/file/d/1sbr_RayZAXYGC5sn6AEwP_ielvBuML3p/preview

<https://drive.google.com/file/d/16aBs8hhwGWTczG4IJTHirssP7HtAcrE/preview>

Links to Placebo Videos:

<https://drive.google.com/file/d/1ETsbu5MC7XQxFX6IEqSgVuIYTEGWjTKy/preview>

<https://drive.google.com/file/d/1z4O3taWOLjOpA1erM366SZHWMriETJVx/preview>

Qualtrics Randomization:

The screenshot displays the Qualtrics Randomizer configuration interface. It shows three distinct branches for randomizing different treatment groups:

- Treatment Group:** Randomly presents 1 of the following elements.
 - Set Embedded Data:** Group = Treatment
 - Show Block: Block 1 (2 Questions)**
 - Show Block: Block 4 (2 Questions)**
- AntiTreatment Group:** Randomly presents 1 of the following elements.
 - Set Embedded Data:** Group = AntiTreatment
 - Show Block: Block 2 (2 Questions)**
 - Show Block: Block 5 (2 Questions)**
- Placebo Group:** Randomly presents 1 of the following elements.
 - Set Embedded Data:** Group = Placebo
 - Show Block: Block 6 (2 Questions)**
 - Show Block: Block 8 (2 Questions)**

Each branch includes options for adding new elements, moving, duplicating, collapsing, or deleting existing ones.

Qualtrics Questionnaire :

1 Human activity is primarily responsible for climate change.

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree

2 Climate change is a serious threat to humans.

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree

3 Individuals actions or lifestyle changes **would not** help in reducing the effects of climate change.

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree

4 Broader scale changes, such as raising taxes on the commodities which release greenhouse gases, are necessary to alleviate the effects of climate change.

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree

5 There is **no need** for a binding international agreement to regulate greenhouse gas emissions.

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree

6 I intend to make changes to my own lifestyle to help alleviate the effects of climate change

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree

7 The information conveyed in the video(s) presented is generally accurate.

Strongly agree
 Somewhat agree
 Neither agree nor disagree
 Somewhat disagree
 Strongly disagree