GLEE
Goff Lab for Experimental Economics
Bates College, Lewiston, Maine

Pre-Analysis Plan

Project Title: Seeing Green: Do Visual Representations Matter in Economic Games

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I. Research Question and Hypotheses:

We use a within-subjects experimental design to examine whether the use of images to represent a forested landscape affects participants' behavior in an online forest management game. Environmental images are known to impact pro-environmental behavior and instructions can affect the way people play economic games. Given this, we expect that individuals will be more sensitive to forest loss when their harvesting decisions are accompanied by an image of their remaining forested land.

Hypothesis 1: The use of a visual representation will influence participants' harvesting behavior by increasing awareness of environmental loss. Participants will therefore harvest fewer trees in stage 2 compared to stage 1.

Hypothesis 2: The use of a visual representation will have a sustained effect on decision making even after it is removed. Participants will therefore continue to harvest fewer trees in stage 3 than in stage 1.

We also consider that the use of a visual representation of the forested land may simply help participants better understand the game. We use additional questions to control for this possibility.

II. Experimental Methods:

A. Participants & Recruitment

Participants are US residents recruited from CloudResearch Connect. We sample participants equally by residence type (rural-suburban-urban). This results in over-sampling of rural participants relative to the US population.

Power Analysis

Using data from a pilot study performed in late fall 2024, estimated average conserved forested land is 13 acres with a standard deviation of 13 acres. Assuming differences in means with paired samples, if we want to be able to identify an average treatment effect of approximately 2 acres (effect size of approximately 0.16), we will need approximately 310 participants in our study ($\alpha = 0.05, power = 0.80$) (gpower 3.1.9.7).

Attrition

Note that participants who do not pass the attention check directly after providing consent are automatically removed from the study. Additionally, participants who do not correctly answer a comprehension check question correctly after three attempts are also automatically removed from the study. Attrition in the context of this online survey experiment occurs when participants stop the experiment before receiving the end-of-survey message with completion code. New participants are recruited by the research platform until the desired number of completions are met. Data for participants who do not complete the study are not used in analyses.

B. Materials & Methods

Experimental conditions

We use a within-subjects experimental design. Participants receive the control condition in stages 1 and 3 and the treatment in stage 2.

Control condition: Participants are told how many acres of forested land they have remaining

Treatment condition: Participants are told how many acres of forested land they have remaining and are provided with a visual representation of their remaining forested land

Incentives

Participation in this study is designed to take approximately 15-20 minutes to complete. Participants receive $3.50 for completing the survey. Participants also earn a bonus of up to $6.48 based on the decisions they make in the experiment.

The bonus is determined by the number of forested acres harvested during the randomly chosen payment round (participants play 3 rounds of the game, only 1 is randomly chosen for payment). For each forested acre harvested, participants receive 9 experimental points. At the end of the study, participants receive $0.01 for every point earned. The maximum amount of forested land that can be harvested in the study is 72 acres. This means that a maximum of 648 points ($6.48) can be earned.

In addition to direct monetary compensation, participants are also able to provide support to a tree-planting charity. For every 10 acres of forested land remaining at the end of the final round of the payment stage, 1 tree will be planted by the tree-planting charity. Tree plantings are aggregated across all participants in the study, so participants can contribute partial trees to the total (e.g., if they have 14 acres remaining, they contribute 1.4 tree plantings).

Experimental procedures

The study proceeds as follows:

1) Participants choose this study from the list of available studies on CloudResearch Connect and click a link that directs them to the online survey experiment hosted on Qualtrics.
2) After providing consent, participants encounter an attention-check question.
3) Participants who pass the attention check, receive information about how the forest management game is played.
4) Participants are presented with two comprehension check multiple choice questions to assess whether they understand how the game works.
5) Participants who answer each of the comprehension-check questions correctly within the three attempts allowed, go on to participate in a practice stage.
6) Participants then encounter Stages 1 - 3 of the game.
7) Finally, participants complete a brief survey about their attitudes, experiences, and sociodemographics.

Game Play:

The forest management game is played in 3 stages of 5 rounds each. Participants begin each stage with 40 acres of forested land. In each round, participants decide how many acres of their forested land to harvest. They receive 9 points per acre harvested. At the end of rounds 1 - 4, forested land regrows at a rate of 1 acre per every 4 acres of forested land remaining. A full 4 acres must be present in order to regrow an acre of forest (e.g., if 11 acres of land remain as forests, only 2 acres of forests will regrow). Forests do not regrow after participants make their Round 5 decision. At the start of each round, participants are told how many acres of forested land they have remaining and are asked to report how many acres they would like to harvest.

In Stage 2, participants receive a visual representation of their forested land in addition to being told the number of forested acres remaining.

One of the three stages played is chosen at random to determine the participant's bonus payment. The stage is referred to as the payment stage.

At the end of each stage, participants are provided with information about the total acres harvested and the total number of forested acres remaining.,They are also told the total number of points they would earn and total number of tree-plantings that would occur should the current stage be chosen as the payment stage.

Survey:

After completing the land management game, participants are asked to complete a survey about their environmental attitudes, exposure to nature, and sociodemographic information. They are also asked to report whether the visual representation in stage 2 affected their understanding of the game play or their harvesting behavior, whether they believe games such as this can help us understand real world conservation behavior, and whether their own behavior in the game is a realistic representation of how they might behave if they were a forest landowner.

At the end of the survey, participants are informed of the stage that was randomly selected for payment, the bonus payment they have earned, and the number of tree plantings they have contributed. Payment is made through CloudResearch Connect.

III. Empirical Methods

A. Data Management and Summary Statistics

Outcome variables

$totalharvest_{ij}$ is the total number of acres harvested by individual i in stage j where $j = \{1,2,3\}$
$forest_{ij}$ is the number of forested acres remaining for individual i at the end of stage j where $j = \{1,2,3\}$

$harvest_{it}$ is the number of acres harvested by individual i at time t where $\{t \in \mathbb{Z} \mid 1 \leq t \leq 15\}$ (in stage j; $j = \{1,2,3\}$, round k; $k = \{1,2,3,4,5\}$)

Covariates

Gender (man=1, not a man=0), educational attainment (bachelors+=1, less than bachelors=0), age, conservatism (1=progressive, 11=conservative), authoritarianism (libertarian=1, authoritarian=11), environmental attitudes (see below), exposure to nature (see below), residence type (rural, suburban, urban), beliefs about how beneficial the tree plantings will be

Benefits of tree plantings:

Participants are asked to report how beneficial they believe the tree plantings will be to themselves (benefit_me) and to others (benefit_others) on a scale from 0 (not at all beneficial) to 10 (very beneficial).

Environmental attitudes:

For each of the following, participants provide answers on a scale from 0 - 10.

1) People should be monetarily compensated for their conservation behavior (0 = strongly disagree, 10 = strongly agree)
2) To what extent do you feel personally responsible for protecting the environment? (0 = not at all responsible, 10 = very responsible)
3) Individuals can make a significant impact on environmental issues through their daily actions. (0 = strongly disagree, 10 = strongly agree)
4) How willing are you to pay slightly more for environmentally friendly products? (0 = not at all willing, 10 = very willing)
5) Climate change is a serious problem. (0 = strongly disagree, 10 = strongly agree)

Exposure to nature:

1) From the main living space in your home, is the view outside the window(s) mostly of concrete, buildings, etc. or mostly of natural elements like trees, grass, etc.? (1 = mostly concrete, buildings, etc., 7 = mostly trees, grass, etc.)
2) Please consider your neighborhood/the area where you live. How would you describe the neighborhood/area, in general? (1 = mostly concrete, buildings, etc., 7 = mostly natural elements like trees, grass, etc.)
3) Does your home have access to a yard with trees, grass, a garden or other natural "green" elements (like bushes)?
4) Does your home have access to a yard with a pond, lake, stream or other natural "blue" elements (like a river)?
5) There is a park or nature preserve in my local area that is easily accessible. (1 = strongly disagree, 7 = strongly agree)
6) There are pleasant natural features in my local area. (1 = strongly disagree, 7 = strongly agree)
7) I feel safe being outdoors in the place where I live. (1 = strongly disagree, 7 = strongly agree)

Impressions of the visual representation in Stage 2:

At the end of the study participants are asked to report their agreement with the following statements:

1) The image used in Stage 2 to represent my forested land improved my understanding of the game. (*understanding*)
2) The image used in Stage 2 to represent my forested land affected my harvesting choice. (*choices*)

Scale construction

We perform factor analysis on the five environmental attitudes questions to determine if scale construction is appropriate. In addition, we create an exposure to nature scale using questions 1, 2, 5, 6, and 7 above.

B. Analysis

Empirical specifications

Our first analysis uses differences in means for paired samples to determine the effect of the visual representation, ignoring intra-stage dynamics. Both total harvest amount ($totalharvest_{ij}$) and remaining forested acres ($forest_{ij}$) are compared for $j = \{1,2\}$. Similarly, we test for a sustained effect of the visual representation by making comparisons for $j = \{2,3\}$.

We also use implement Model 1 with random effects Tobit regression with censoring at 0 and 40 to identify the treatment effect on conservation behavior while controlling for a set of covariates.

(1) $$forest_{ij}^{*} = \beta_0 + \sum_{j=2}^{J} \gamma_j \, Stage_{ij} + \boldsymbol{X}_{ij}'\beta + \alpha_i + \varepsilon_{ij}$$

where,

Stage 1, Round 1 serves as the baseline,

$Stage_{jit}$ is an indicator for Stage j. The coefficient γ_j when $j = 2$ identifies the treatment effect,

$\boldsymbol{X}_{it}'$ is a vector of covariates,

α_i are participant-level random effects,

ε_{it} is the error term, and

standard errors are clustered at the participant level.

Further, we use a variation of a dynamic panel data model with system GMM estimators to examine harvesting behavior across all stages and rounds while preserving our ability to use time-invariant variables such as environmental attitudes, gender, political ideology, etc.

(2) $$harvest_{it} = \beta_0 + \beta_1 F_{it} + \sum_{j=2}^{J} \gamma_j \, Stage_{jit} + \sum_{k=2}^{K} \delta_k \, Round_{kit} + \sum_{j=2}^{J} \sum_{k=2}^{K} \lambda_{jk} \, (Stage_{jit} \times Round_{kit}) + \boldsymbol{X}_{it}'\beta + \alpha_i + \varepsilon_{it}$$

where,

Stage 1, Round 1 serves as the baseline,

F_{it} is the number of forested acres available to harvest at the start of the round,

$Stage_{jit}$ is an indicator for Stage j. The coefficient γ_j when $j = 2$ identifies the treatment effect,

$Round_{kit}$ is an indicator for Round k,

λ_{jk} identifies the effect of being in Stage j, Round k and allows us to identify round-level treatment effects,

$\boldsymbol{X}'_{it}$ is a vector of covariates,

α_i are participant-level random effects,

ε_{it} is the error term, and

standard errors are clustered at the participant level.

Notes:

We use F_{it} as our lagged variable instead of the previous round's harvest amount for two reasons. First, regrowth of the resource occurs. Second, behavior is thought to be more a function of the state of the resource than of behavior in the prior round.

Identifying mechanisms for treatment effect

We recognize that the presence of a treatment effect could come from two sources: i) viewing the visual representation influences preferences for conservation and therefore behavior in the game, or ii) the visual representation of the forested land improves understanding of the game, allowing individuals to better align their behavior with their preferences. The latter explanation suggests that preferences for conservation are homogenous across participants which is unlikely.

We control for changes in stated understanding between stages 1 and 2. We also control for participant's stated beliefs about how the visualization affected their understanding of the game.

Exclusions

We include data for all participants who successfully complete the study.

Dimensions of heterogeneity

We test for heterogeneity in response to the treatment (presence of the visual representation) by:

i) Gender: Women respond more positively to images that evoke empathy and frames emphasizing ethical duty (Swim et al. 2018). We expect that women will be more likely than non-women to react to the visualization with an increase in conservation behavior.

ii) Environmental attitudes: Participants who are highly pro-environmental are unlikely to experience a big change in response to the visualization due to high baseline conservation.

iii) Nature exposure: Participants with regular exposure to nature may have a stronger attachment and therefore may conserve more at baseline (Mackay & Schmitt 2019). This means that they may be less likely to respond to the visual representation due to high baseline conservation.

iv) Stated beliefs about the effect the visual representation had on understanding and behavior.

Robustness checks

To rule out that those with less understanding are driving results, we perform all analyses again using only those who did not require a third chance to correctly answer the comprehension questions.

IV. Additional Experimental Details and Analyses

We are also interested in whether individuals believe that these sorts of games can tell us anything about real world behavior. We ask all participants to rate their agreement with the following:

The way people play this game can help us to understand conservation behavior in the real world. (*conserve_real*)

The choices I made in this game are a good representation of how I might make these decisions if I were a forest landowner. (*represent_me*)

We plan to perform an exploratory analysis to determine what factors and characteristics correlate with beliefs about the external validity of the experiment.