Global Climate Change and Human Behavior: Decreasing Energy Consumption

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Abstract

To decrease carbon dioxide emissions per capita and hopefully reduce the problem of climate change, many scientists have addressed supply-side methods using carbon-reduction technologies such as carbon capture and storage. But with increasing population and rising energy demand in developed and developing countries, it is unclear whether supply-side methods alone can make sufficient progress toward solving the problem. This thesis investigates demand-side management methods to facilitate a reduction in carbon emissions. The thesis consists of three main studies. First, I design and implement intervention experiment to facilitate a decrease in energy consumption. Second, I use surveys to understand when and why an individual would accept voluntary actions, soft regulations or hard regulations to curb fossil fuel consumption. Third, I show how lay perceptions of energy consumed by different every-day behaviors differ from actual energy consumption data.

My first experiment was an eight-week intervention study that examined whether holding people accountable for their behaviors leads to energy conservation (n=100). The intervention asked participants for reasons why they did or did not engage in energy conserving behaviors, with questions focusing on household operations, transportation, and food purchases. Results show that the intervention, in general, did not facilitate behavior change in these sectors. However, an important finding is that participants erroneously perceived there is not much difference in energy saved by several different behaviors. Furthermore, 60% of participants perceived a change in their own behavior over the course of the study even though no overall behavior change occurred. This result could imply that participants have optimistic illusions regarding their own behavior change.

My second experiment was a study on preferences to change behavior. Pittsburgh residents (n = 209) reported their preferences for voluntary actions, soft regulations, and hard regulations to (a) limit the number of SUVs and trucks and (b) increase green energy use for household energy consumption. These two goals were presented in one of two motivating frames, as addressing either environmental or national security issues. For the

goal of limiting SUVs and trucks, results indicated that participants favored voluntary actions over hard regulations, and soft regulations over voluntary actions. For the goal of increasing green energy, results indicated that participants preferred both voluntary actions and soft regulations over hard regulations, but had no significant preference between voluntary actions and soft regulations. Participants' environmental attitudes (as assessed using the New Ecological Paradigm scale) had a strong positive relationship with support for regulatory strategies intended to change the behaviors in question. Women were more likely to support voluntary actions than men. The loss of personal freedom was frequently mentioned as a reason for saying no to hard regulations.

My third experiment studied how participants (*n*=505) perceive energy consumption and savings for household, transportation, and recycling behaviors. Participants' showed a tendency to overestimate energy consumption and savings for low-energy behaviors and underestimate energy consumption and savings for high-energy behaviors. On average, participants underestimated the amount of energy used or saved by different behaviors. Pro-environmental attitudes and higher numeracy scores were associated with more accurate perceptions of energy consumption. However, participants who reported engaging in a greater number of environmental behaviors had less accurate perceptions of energy consumption. On average, participants reported that engaging in energy-conserving behaviors would not be difficult for any of the behaviors considered.

Have patience with everything that remains unresolved in your heart.
Try to love the questions themselves,
like locked rooms and books written in a foreign language…
At present you need to live the questions.
Perhaps you will gradually,
without even noticing it,
live your way into the answer.

Rainer Maria Rilke
Letters to a Young Poet
(1903)

This thesis is dedicated to my father and mother,
Zahid and Jumana,
who sacrificed much to ensure I would not have to.

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Chapter 1. Introduction

1.1 Motivation

Of all of the United States greenhouse gas emissions, 82% are carbon dioxide emissions related to energy consumption (EIA, 2006). Past and future anthropogenic carbon dioxide emissions are contributing to global climate change (Hansen et al., 1981; IPCC, 2007). The increasing airborne carbon dioxide concentration could negatively impact our way of life if no action is taken in the near future (Stern, 2006). To decrease carbon dioxide emissions per capita, many scientists have addressed supply-side methods using carbon-reduction technologies such as carbon capture and storage. But with increasing population and rising energy demand in developing countries, it is unclear whether supply-side methods alone, in their current stage of development, can make sufficient progress toward solving this problem. Investigating demand-side methods to reduce emissions is also crucial and is an area ripe for research.

Many climate change scientists recommend an 80% emission reduction of 2000 levels by 2050 in order to stabilize carbon dioxide concentrations. This level of reduction is recommended because simply holding carbon dioxide emissions constant will not stabilize concentrations as the lifetime of carbon dioxide in the atmosphere is on the order of 100 years (Archer, 2005). In their attempt to address this issue, Pacala and Socolow (2004) devised fifteen stabilization "wedges" to achieve a concentration of carbon dioxide below double of pre-industrial concentrations by 2054 (i.e., holding emissions constant at 7GtC/year for the next fifty years to achieve a concentration of 450-550 ppm, where the current concentration of carbon dioxide is ~375 ppm). Each wedge represents an activity that reduces carbon emissions world wide. The first of the wedges they explored is 'efficiency and conservation' where they stated "improvements in efficiency and conservation offer the *greatest* potential to provide wedges" (Pacala & Socolow, 2004). Additionally, Hansen *et al*. (1981) recommended that "an appropriate strategy may be to encourage energy conservation and develop alternative energy sources, while using fossil fuels as necessary" during the next decades. However, within the realm of efficiency and conservation, little attention has been paid to what may be among the most important factors influencing carbon dioxide emissions, namely that of human behavior.

Efficiency and conservation are often mentioned together but there is a distinction in their definition. Energy efficiency is the ability to use less energy to produce the same amount of useful work (alternatively, the ratio of effective output to the total input energy in a system) (National Energy Policy Development, 2001). For instance, using a better technology to provide the same service, such as using solid state lighting rather than incandescent lighting, leads to significant energy savings (Steigerwald et al., 2002). Conservation, on the other hand, can be defined as careful utilization of natural resources in order to prevent depletion, an example of which is turning off the lights when not in use (National Energy Policy Development, 2001). Modifying human behavior is needed to implement both efficiency and conservation on an individual level, as we need to understand how to make individuals adopt better technologies but also to how to change their lifestyles to ones that conserve energy.

The significance of decreasing energy consumption by using efficient technologies and conservation in individual behavior is of special importance in the United States because the average person living here contributes about 20 tons of CO_2 per year, the sixth largest CO_2 emissions per capita worldwide (World Resources Institute, 2002). The three sectors of largest CO_2 emissions for individuals in the United States are household operations (responsible for 35% of total CO_2 emissions), transportation (responsible for 32%), and food (responsible for 12%) (Brower & Leon, 1999).

To understand how to modify individual behavior, a review of examples from the fields of environmental science and medicine, with human health being a strong motivator to change, holds many successful examples. Research shows how to successfully modify addictive behaviors such as alcohol abuse, smoking, obesity and opiate use (Prochaska et al., 1992). An overview of how to encourage conservation behavior by De Young (1993) suggests that persuasion, coercion, incentives, education, and decreasing physical barriers can all facilitate behavior change. A taxonomy of behavioral interventions by Geller

(1989) includes two categories: (1) antecedent interventions (including education, commitment, and prompting) and (2) consequence procedures (reinforcement and punishment). In the area of behavior change and energy consumption, Pallak *et al.* (1980) used commitment, an example of an antecedent intervention, to decrease energy consumption in homes. In their Iowa study, homeowners who made public commitments to decrease their energy consumption had lower rates of increase in natural gas and electricity consumption than those who committed privately or did not commit.

1.2 Challenges to behavior change

Changing individual behavior has proved to be difficult and not necessarily intuitive. Alfredsson (2004) found that adopting "greener travel" reduced personal car mileage and increased use of public transportation. However, the monetary savings from this change were used to buy other goods, leaving no net decrease in the household's total CO_2 emissions. Additionally, research has shown that people prefer increasing wage profiles, i.e., they want to make more money tomorrow than they do today (Loewenstein & Sicherman, 1991). This can then lead to preferences for increasing consumption, as we can assume people with higher wages want to consume more tomorrow than they do today.

With respect to climate change, 'diffusion of responsibility' also plays a major role, where the presence of other bystanders means that responsibility is thought of as being shared by all onlookers and reduces the need for personal action (Darley & Latane, 1968). Therefore the more onlookers at the emergency, the less likely will any one bystander intervene or act. In conjunction with this idea is that altering one's behavior to mitigate climate change can be viewed as a 'social dilemma', where each individual has a higher payoff if they do not act than if they cooperate, but everyone is better off if everyone cooperates than if they do not (Dawes & Messick, 2000). This can be viewed as similar to the 'free rider' problem, which states that we are better off if everyone acts, but if everyone else acts and you do not, you still reap the advantages of the collective action at no personal cost to yourself. These problems, although hard to overcome, make our challenge ever more interesting.

1.3 Thesis Overview

This thesis includes three separate studies that aim to address the challenges of behavioral change. Chapter 2 entitled ‘Decreasing demand: Attempting to facilitate energy conservation by changing individual behavior’ is a study that uses an accountability intervention to decrease energy consumption over the course of eight weeks. Chapter 3 entitled ‘Preferences for change: Do individuals prefer voluntary actions, soft regulations, or hard regulations to decrease fossil fuel consumption?’ investigates when and why individuals would accept different types of voluntary actions and regulations to decrease fossil fuel consumption. Chapter 4 entitled ‘Lay perceptions of energy consumption’ maps lay perceptions of energy consumption to actual energy consumption by a variety of everyday behaviors, so that practitioners can clearly understand what misperceptions need to be corrected to facilitate climate change mitigation.

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Chapter 2. Decreasing demand: Attempting to facilitate energy conservation by changing individual behavior[1]

2.1 Abstract

This eight-week long intervention study examined whether focusing attention on energy conserving behaviors leads to energy conservation (*n*=100). The intervention asked participants for reasons why they did or did not engage in energy-conserving behaviors, with questions focusing on transportation, household operations, and food purchases. Results showed that the intervention, in general, did not facilitate major behavior change in these sectors. However, one specific behavior had a significant positive change with a relatively large effect size: after the intervention, the treatment group stated that they consciously paid more attention to the packaging of the products they bought, compared with two control groups. Independent of group assignment, participants changed their overall behaviors to those that were energy conserving and had tuned their cars during the course of the study. Additionally, participants erroneously perceived that there is not much difference in how much energy is saved by several different behaviors. Furthermore, 60% of participants perceived a change in their own behavior over the course of the study even though no overall behavior change occurred. This result could imply that participants have optimistic illusions regarding their own behavior change.

Keywords: Individual behavior change, Energy conservation, Intervention, Attention-focusing, Cognitive dissonance, Longitudinal self-report.

2.2 Introduction

Anthropogenic carbon dioxide emissions are contributing to global climate change (Hansen et al., 2008; IPCC, 2007), and could negatively impact our way of life if no action is taken in the near future (Stern, 2006). To decrease carbon dioxide emissions per capita, many scientists have addressed supply-side methods using carbon-reduction

[1] This paper is currently being reviewed by the Journal of Industrial Ecology

technologies such as carbon capture and storage. But with increasing population and rising energy demand in developing countries, it is unclear whether supply-side methods alone, in their current stage of development, can make sufficient progress toward solving this problem. Investigating demand-side methods to reduce emissions is also crucial and is an area ripe for research.

Reducing CO_2 emissions is of special importance in the United States because the country has only 5% of the world's population and produces 25% of the world's total CO_2 emissions (EPA, 2000).Of the United States greenhouse gas emissions, 82% are carbon dioxide emissions related to energy consumption (EIA, 2006).The average person living in the United States contributes about 20 tons of CO_2 per year, the sixth largest CO_2 emissions per capita worldwide (World Resources Institute, 2002). The three sectors of largest CO_2 emissions for individuals in the United States are transportation (responsible for 32%), household operations (responsible for 35% of total CO_2 emissions), and food (responsible for 12%) (Brower & Leon, 1999).

In their attempt to address stabilization of carbon dioxide concentrations, Pacala and Socolow (2004) devised fifteen stabilization "wedges" to achieve a concentration of carbon dioxide below double of pre-industrial concentrations by 2054. Each wedge represents an activity that reduces carbon emissions world wide. The first of the wedges they explore are 'efficiency and conservation' where they state "improvements in efficiency and conservation offer the *greatest* potential to provide wedges". However, within the realm of efficiency and conservation, little attention has been paid to what may be among the most important factors influencing carbon dioxide emissions, namely human behavior.

An overview of how to encourage conservation behavior by De Young (1993) suggests that persuasion, coercion, incentives, education, and decreasing physical barriers can all facilitate behavior change. A taxonomy of behavioral interventions by Geller (1989) includes two categories: (1) antecedent interventions (including education, commitment, and prompting) and (2) consequence procedures (reinforcement and punishment). In the area of behavior change and energy consumption, Pallak *et al.* (1980) used commitment, an example of an antecedent intervention, to decrease energy consumption in homes. In their Iowa study, homeowners who committed publicly to decreasing their energy consumption had lower rates of increase in natural gas and electricity consumption than those who committed privately or did not commit.

Changing individual behavior has proved to be difficult and not necessarily intuitive. Alfredsson (2004) found that adopting "greener travel" reduced personal car mileage and increased use of public transportation. However, the monetary savings from this change were used to buy other goods, leaving no net decrease in the household's total carbon dioxide emissions. With respect to climate change, 'diffusion of responsibility' also plays a major role, where the presence of other bystanders means that responsibility is considered to be shared by all onlookers and reduces the need for personal action (Darley & Latane, 1968). In conjunction with this idea is that changing one's behavior to mitigate climate change can be viewed as a 'social dilemma', where private interests are at odds with collective interest (Dawes & Messick, 2000).

Research has shown that individuals prefer soft regulations and voluntary actions to curb fossil fuel consumption rather than hard bans that curb their behaviors (Attari et al., 2008). Given the current state of the law, the United States imposes very little restriction on individual consumer behavior to curb energy consumption. In this exploratory study, we investigate how to encourage self-regulation by *focusing attention* on behaviors that can conserve energy. Baumeister and Vohs (2004) state that attention is a key process for individuals to self-regulate their behaviors. Paying attention to specific actions may lead to improved judgments and to better decision making. In this study, we examine whether it also leads to behavior that is more energy-conserving. Focusing on specific behaviors may make these behaviors seem more salient, possibly increasing the likelihood of implementation. The attention-focusing intervention we use is non-intrusive, simple, subtle, and can be easily implemented. By asking participants why they do not engage in conserving behaviors may lead to *inconsistent cognition*, which arises from behaviors that compromise the participant's preferred assessment of being a highly moral and competent individual. The theory of cognitive dissonance (Festinger, 1957), states that inconsistencies may serve as a driving force that compels an individual to act out new behaviors, so as to reduce the amount of dissonance (or conflict) between the cognitions. Dissonance reduction protects a person's feeling of self worth and self esteem. As a result of our intervention, cognitive dissonance may arise due to focusing attention on energy conserving behaviors that participants have not incorporated. We hypothesize that participants will incorporate conserving behaviors to reduce dissonance. However note that when internal conflict arises between the attitude that the participant needs to incorporate the behavior and the actual behavior, the attitude can be altered rather than the behavior to reduce dissonance (Carver & Scheier, 1981).

Changing behavior to reduce dissonance may be less likely when more effort is required (Harmon-Jones & Mills, 1999). For this reason, we investigated the participants' perceived effort to change. We also investigated participants' perceived energy saved for a variety of energy-conserving behaviors to test if perceptions of energy savings closely match actual energy savings.

Thus, the overall goals of this study were (a) to evaluate an attention-focusing intervention to facilitate energy conservation over time compared to two control groups, (b) to measure perceptions of effort needed and energy saved for a variety of energy-conserving behaviors, and (c) to determine participants' perceptions of their own attitude and behavior changes caused by the study.

2.3 Method

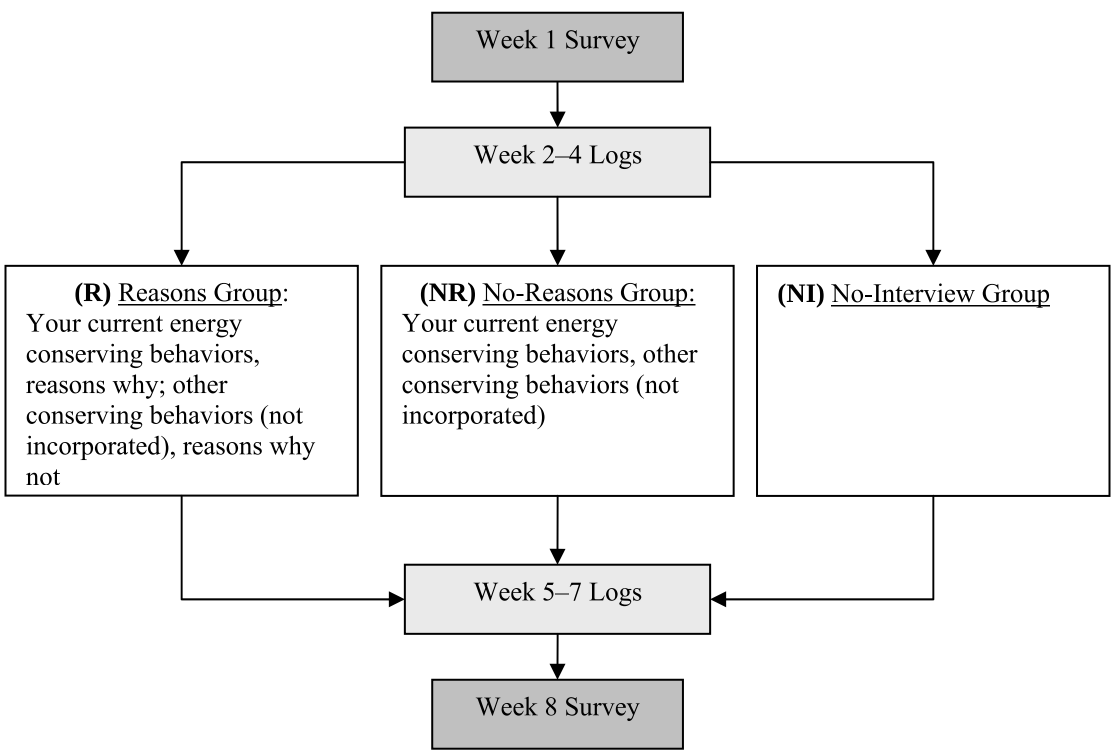
2.3.1 Participants

Staff members were recruited from Carnegie Mellon University in Pittsburgh, Pennsylvania, reflecting a sample of convenience (n=124). Of the original participants, 100 remained for the whole duration of the study (attrition rate = 19%). The study was conducted between October and December of 2006. Upon completion of the study, participants were paid $20 in total, i.e., $2 per week and $4 on completion.

2.3.2 Procedure

All participants completed one survey in week 1 and three logs in weeks 2–4 prior to the intervention, and three logs in weeks 5–7 and one survey in week 8 after the intervention, as shown in Figure 2.1. The intervention consisted of a telephone interview in week 4. Week 1 and Week 8 surveys were designed to detect relatively long-term behavior change, while week 2–7 logs were designed to detect relatively short-term behavior change. An example of a relatively long-term behavior change is buying compact fluorescence light bulbs, while an example of a relatively short-term behavior change is turning off the faucet while brushing one's teeth. Surveys and logs were web-based and accessed by participants via the Internet.

Figure 2.1. Overview of the experimental design, showing the three groups: reasons group (R), no-reasons group (NR), and no-interview group (NI).



In the two surveys (Week 1 and Week 8, shown in Appendix A.1), participants were asked questions about transportation, household operations, lifestyle and food purchases, and environmental activism, as shown in Table 2.1. Responses options for these questions were dichotomous (yes/no) or categorical (selecting choices from a menu)[2]. Next, participants were asked about the perceived effort required and perceived energy saved for ten different behaviors and opinion questions about attitudes towards climate change and energy conservation. Response options for perceived effort, perceived energy, and the opinion questions were elicited on a seven-point likert scale. The range of options for perceived effort was 0 (Extremely easy to adopt) to 6 (Extremely hard to adopt), the range for perceived energy savings was 0 (Would not save any energy) to 6 (Saves a lot of energy), and the range for the opinion questions was 0 (completely disagree) to 6 (completely agree). Participants then reported their gender, age, political party affiliation (Democrat, Republican, Not sure, None, or Independent), political views (with five response options ranging from extremely liberal to extremely conservative), highest level of education completed, and family income before tax. The Week 8 survey additionally asked participants whether their attitudes and behaviors had changed over the course of the study via open ended questions.

Table 2.1. Week 1 and Week 8 Survey questions

Transportation	Household Operations	Lifestyle and Food	Environmental activism	Effort and Energy	Opinion
Number of vehicles owned or leased by the household?	Number of people in your household?	Do you hold any socially or environmentally conscious mutual funds?	Have you ever signed up to reduce junk mail?	Taking one less automobile trip per week.	Climate change (also referred to as global warming) is a real phenomenon.
For the vehicle you use most, what is the gas mileage?	How many CFL bulbs or fluorescent linear bulbs have you installed?	This past year, did you eat seasonally?	This past year, did you plant any trees?	Taking one less round-trip flight per year.	Unless everyone else conserves energy, I will not conserve energy.
For the vehicle you use most, is the engine tuned at least once a year?	How far do you live from work?	Are you a member of community-supported agriculture?	Are you currently a member of any environmental organization?	Never idling your vehicle for more than 2 minutes.	It important for individuals to reduce how much energy they use.
	Floor area of your home?	This past year, did you shop at any thrift stores?	This past year, did you donate money to any environmental organizations?	Reducing the time spent in the shower by 2 minutes.	Humans have the right to consume as much energy as they like.

[2] The response options have been omitted for brevity; the original survey is shown in Appendix A.

	Do you consider the energy efficiency for when buying large appliances?		This past year, did you send a letter to any political official about environmental or energy issues?	Buying at least half of your fresh fruits and vegetables from Pennsylvania growers.	I would like to give up some of my possessions voluntarily in order to live a simpler life.
For the vehicle you use most, do you check if the tires are properly inflated at least four times a year?	Do you consider the energy efficiency when buying for small appliances?			Bringing your own bags to the grocery store.	The current American lifestyle can be sustained with the natural resources we have.
	Which of the water-saving devices do you have in your home? (front-loading washer, water saving faucets, low flush toilet)			Always recycling your aluminum cans.	The government has an important role to play in promoting energy conservation.
	Have you ever had an energy audit of your home?			Reducing your electricity use at home by 10%.	One person’s actions to conserve energy will not make much of a difference.
	This past year, did you weatherize your home?			Walking, bicycling, or taking public transportation (or a combination) rather than driving, once a week.	Current climate change (also referred to as global warming) is caused by human activities.
	Does your home have any double-paned windows?			Turning off the faucet when you brush your teeth.	Conserving energy takes too much effort.
	Have you ever bought renewable energy?				I would like to exercise self-discipline in trying to reduce my consumption .

	There is nothing I can change in my lifestyle that will decrease the amount of energy I use. Regardless of what other people do, I want to conserve energy.

Week 2–7 logs, shown in Appendix A.2, were identical to each other and contained questions about transportation, household operations, lifestyle and food, and environmental activism, specific to the previous day or week, as shown in Table 2.2. For example, one of the transportation questions was "Today, how did you arrive at work?" with the following possible responses: walk; bicycle; bus; motorcycle; carpool (with others from the community); car, truck, or van (with others in your household); car, truck, or van (alone); did not travel to work; and other.

Table 2.2. Week 2–7 log questions

Transportation	Household Operations	Lifestyle and Food	Environmental activism
Today, how did you arrive at work?	This past week, what percentage of the time did you turn off the lights when last to leave the room?	This past week, did you buy any fruits or vegetables from the farmers market?	This past week, what percentage of the time did you recycle aluminum cans that you used?
Today how did you or will you leave work?	The last time you brushed your teeth, did you turn off the faucet while brushing?	This past week, did you buy any locally produced fruits and vegetables at the grocery store?	This past week, did you have any conversations with friends or colleagues about energy or climate-change issues?
Yesterday, how did you arrive at work?	This past week, how many baths did you take?	This past week, did you buy a product because it had less packaging than the other choices available?	Yesterday, did you change your actions in any way that would either increase or decrease your energy use?
Yesterday, how did you leave work?	This past week, how many showers did you take?	This past week, did you bring your own bags when you went shopping?	This past week, did you change your actions in any way that would either increase or decrease your energy use?

This past week, did you walk, bicycle, or take public transportation to any destination rather than driving?	The last time you showered, how many minutes did you spend in the shower?
This past week, did you run several of your errands together so that you could take fewer trips?	Last night, did you turn down the heat?
This past week, did you carpool anywhere?	Last night, what was your thermostat setting?
This past week, did you idle your car for more than 2 minutes?	Today, what was your thermostat setting?
	This past week, did you unplug the following appliances: TV, VCR or DVD, Stereo, Microwave, Toaster oven, Computer?

The interview in Week 4, transcript shown in Appendices A.3 and A.4, was conducted by telephone and recorded for future analysis. Participants were randomly assigned to one of three groups as shown in Figure 2.1: the reasons group (R), the no-reasons control group (NR), and the no-interview control group (NI). The telephone interview of participants in the reasons group (R) began with an open-ended question, “What do you currently do to conserve energy?” In responding, participants were asked to focus on things they had done in each of the three sectors. For each of the behaviors that the participants mentioned, they were asked to provide reasons why they engaged in them. They were then asked if there were any other things they could do to conserve energy, generally, and also in the three sectors. Finally, they were asked to provide reasons why they were not engaging in each of the behaviors they mentioned. The telephone interview of participants in the no-reasons group (NR) were asked the same questions, except they were not asked for reasons why they did and did not engage in energy-conserving behaviors they mentioned. Four interviewers each conducted equal numbers of R and NR interviews.

2.4 Results

A logistic regression predicting attrition from participants' demographic data and group assignment showed no significant difference between participants who left the study and those who were retained (maximum rescaled R^2 = 0.11 and the likelihood ratio yields a non-significant prediction of the dependent variables $\chi^2 = 8.75$, $p = 0.46$, $df = 9$).

2.4.1 Short-Term Behavior Change: Week 2–7 Logs

All responses in the logs were coded on a scale of 0 (does not engage in the energy-conserving behavior) to 1 (engages in the energy-conserving behavior). Coding was adapted for questions that were not dichotomous. For example, the responses to the question "Today, how did you arrive at work?" were coded as 1 if the participant chose walk, bicycle, or did not travel to work; 0.5 if the participant chose motorcycle, carpool (with others from the community), or car, truck, or van (with others in your household); or 0 if the participant chose car, truck, or van (alone).

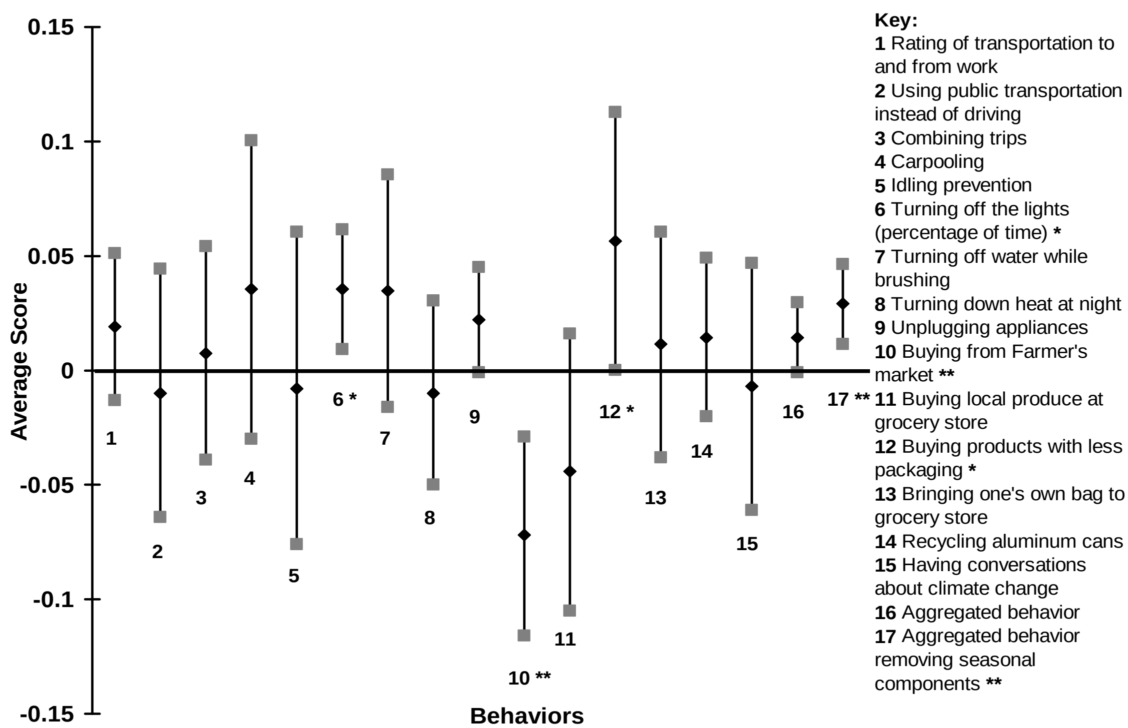
The standardized Cronbach's alpha for behaviors within each category of transportation, household operations, and food purchases, were positively correlated to each other and ranged from 0.02 to 0.74 (an alpha value of 0.7 or higher indicates that the scale is internally consistent). Due to the range of Cronbach's alpha, changes in individual behaviors were calculated in addition to aggregated scores. To examine whether behaviors changed, we computed three types of *difference variables* for the behaviors. The first reflects the difference between a participant's average value of each specific behavior in the Week 5–7 post-intervention logs and his or her average value of this behavior in the Week 2–4 pre-intervention logs. For example, the difference variable for carpooling was calculated as:

$$Carpooling = (1/3[carpooling_{log\ 5} + carpooling_{log\ 6} + carpooling_{log\ 7}] - 1/3[carpooling_{log\ 2} + carpooling_{log\ 3} + carpooling_{log\ 4}]) \quad \textbf{(2.1)}$$

Second, the *Aggregate behavior* difference variable reflects the difference between the Week 5–7 average of an individual's transportation, household, and food scores and his or her Week 2–4 average for these scores. The three sectors were weighted equally in computing the aggregate difference score. Third, we calculated *Aggregated behavior removing seasonal components* by first removing two variables from the food aggregation (*Buying from farmer's market* and *Buying local produce at grocery store*) and removing one variable from the household aggregation (*Turning down the heat at night*). We then re-calculated the average of the participant's transportation, household, and food scores, again with equal weighting. These variables were removed from the aggregate score because we expected these three behaviors to worsen post-intervention because of the decline of available local produce at the end of the growing season and because of significantly colder weather.

To examine whether there was overall behavior change over time independent of group assignment, a t test was computed for each difference variable, collapsing data across the intervention and control groups. Doing so could help identify other factors that may have been responsible for behavior change. As Figure 2.2 shows, four difference variables were significant at $p < 0.05$. Two variables, *Buying from farmer's market* (10) and *Aggregated behavior removing seasonal components* (17), were significant after a Bonferroni correction. To avoid spurious positives (Type I errors), the correction lowers the alpha level to account for the total number of comparisons being performed. Significance for *Aggregated behavior removing seasonal components* implies that, on average, more participants changed overall behaviors to those that were energy conserving, independent of group assignment. The negative result for *Buying from farmer's market* may be attributed to the fact that the farmer's markets closed about the same time as the intervention occurred.

Figure 2.2. Means along with lower and upper 95% confidence limits for each specific difference variable from the behaviors in the Week 2–7 logs. The asterisks denote significant results from the *t* test: * $p < 0.05$ and ** $p < 0.003$ (Bonferroni corrected *p* value).



To investigate the effects of the intervention and of that of simply conducting the telephone interviews, two contrast codes were created to differentiate between the three groups, as shown in Table 2.3. These contrast codes have exactly zero correlation with one another when the number of participants is the same in each group. To determine the effect of the intervention, we needed to assess if there were any differences between the reasons group (R) and the other two groups (NR and NI). To determine the effect of conducting the telephone interviews, we needed to assess if there were any differences between the no-reasons group (NR) and the no-interview group (NI).

Table 2.3. Contrast codes created to investigate the effect of the intervention.

	Group		
Contrast Code	**NI**	**NR**	**R**
R vs. others	- 1/3	- 1/3	2/3
NR vs. NI	- 1/2	1/2	0

Thus, we regressed each of the difference variables onto the two contrast codes:

$$\textit{Difference Variable} = b_0 + (b_1 \times (R\ vs.\ others)) + (b_2 \times (NR\ vs.\ NI)) + e \quad \textbf{(2.2)}$$

Note that even though some of the behaviors were initially dichotomous, i.e., their response options were yes/no, they were no longer dichotomous once we had computed the difference variables by averaging the results over multiple logs. Therefore, we used linear regression rather than logistic regression in these analyses. A *t* test was computed for each coefficient b_0, b_1, and b_2, as shown in Table 2.4. A significant *t* value for the first contrast code, *R vs. others,* indicates a difference between the reasons group (R) and the two control groups (NR and NI). Similarly, a significant *t* value for the second contrast code, *NR vs. NI*, indicates a significant difference between the no-reasons group (NR) and the no-interview group (NI). Finally, b_0 can be interpreted as approximately the average of all participants' scores for each difference variable. Therefore the values of the difference variables and their significance levels in Table 2.4 are similar to those in Figure 2.2.

Table 2.4. Results of regressing each short-term difference variable onto the two contrast codes for the logs.

	Intercept		R vs. others		NR vs. NI	
Difference Variable	B_0	*T* **value**	b_1	*t* **value**	B_2	*t* **value**
1. Rating of transportation to and from work	0.020	1.22	-0.005	-0.16	-0.028	-0.69
2. Using public transportation instead of driving	-0.015	-0.55	-0.119	-2.07 *	-0.058	-0.88
3. Combining trips	0.012	0.53	-0.045	-0.91	0.002	0.04
4. Carpooling	0.035	1.05	-0.073	-1.03	-0.013	-0.16
5. Idling prevention	0.002	0.05	0.066	0.95	-0.235	-3.01 *
6. Turning off the lights (percentage of time)	0.036	2.65 *	-0.009	-0.32	-0.008	-0.23
7. Turning off faucet while brushing one's teeth	0.036	1.40	0.088	1.62	-0.114	-1.82
8. Turning down heat at night	-0.010	-0.50	-0.069	-1.58	0.059	1.19
9. Unplugging appliances	0.022	1.87	0.037	1.50	0.030	1.04
10. Buying from Farmer's market	-0.073	-3.27 **	-0.037	-0.78	0.028	0.51
11. Buying local	-0.045	-1.48	-0.143	-2.24 *	0.086	1.14

produce at grocery store						
12. Buying products with less packaging	0.057	2.09 *	0.224	3.87 **	0.019	0.29
13. Bringing one's own bag to store	0.013	0.52	0.021	0.40	-0.130	-2.15 *
14. Recycling aluminum cans	0.013	0.76	-0.008	-0.22	-0.071	-1.64
15. Having conversations about climate change	-0.015	-0.60	-0.003	-0.06	0.122	1.91*
16. Aggregated behavior	0.014	1.84	-0.009	-0.52	-0.014	-0.74
17. Aggregated behavior removing seasonal components	0.029	3.35 **	0.020	1.07	-0.045	-2.11*

Note: Asterisks denote significance level: * $p < 0.05$; ** $p < 0.05/n = 0.05/17 = 0.003$ (Bonferroni corrected alpha level)

The value of b_1 for the *Buying products with less packaging* variable is 0.224, indicating a positive 22 percentage-point difference between the R group and the other two groups. This result implies that participants in the reasons group reported consciously buying products with less packaging after the intervention; relative to the two control groups -- the difference remained significant after the Bonferroni correction.

To assess the effectiveness of the intervention in changing *Buying products with less packaging*, we calculated the effect size for the observed difference. The Cohen's *d* effect size is measured when comparing the means of two groups. Cohen (1992) states that effect sizes of 0.2 are small, 0.5 are medium, and 0.8 are large. Cohen's *d* for the *Buying products with less packaging* difference variable of the reasons group (R) compared to the no-reasons group (NR) was 0.74. The Cohen's *d* of the reasons group (R) compared to the no-interview group (NI) was 0.71 indicating a medium to large effect size ($d > |0.5|$).

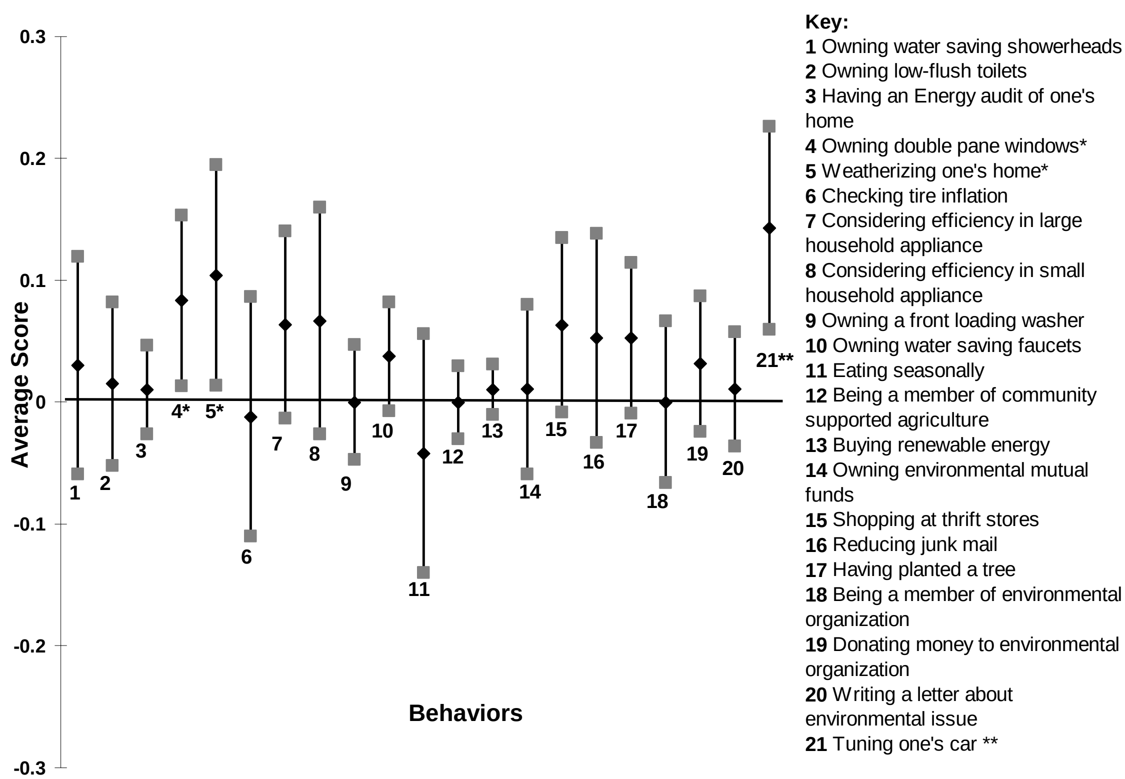
2.4.2 Long-Term Behavior Change: Week 1 and Week 8 Surveys

Similar analysis was conducted for this section, where paired *t* test on aggregated behaviors showed no significant change ($\alpha = 0.05$, all t's < 1.72 and all p's > 0.09). Again difference variables were used to investigate changes in specific behaviors. An example of a difference variable to assess long-term behavior changes is:

$$\textit{Eating seasonally} = (\textit{Eating seasonally})_{\textit{Week 8}} - (\textit{Eating seasonally})_{\textit{Week 1}} \qquad \textbf{(2.3)}$$

There are three difference variables significant at the 0.05 alpha level, as shown in Figure 2.3: *Owning double-pane windows, Weatherizing one's home,* and *Tuning one's car*.

Figure 2.3. Means along with lower and upper 95% confidence limits for each specific difference variable from the behaviors in the Week 1 and 8 surveys. The asterisks denote significant results from the *t* test: * $p < 0.05$ and ** $p < 0.0018$ (Bonferroni corrected *p* value).



Results of regressing each long-term difference variable onto the two contrast codes are shown in Table 2.5. There were no significant results for the coefficients b_1 and b_2 after the Bonferroni correction. In other words, there were no significant differences in long-term behavior changes between the reasons group (R) and the other two groups or between the no-reasons group (NR) and the no-interview group (NI).

Table 2.5. Results of regressing each long-term difference variable from the Week 1 and 8 surveys onto the contrast codes.

	Intercept		R vs. others		NR vs. NI	
Difference Variable	b_0	***t* value**	B_1	***t* value**	B_2	***t* value**
1. Owning water saving showerheads	-0.008	-0.22	0.112	1.40	-0.045	-0.48
2. Owning low-flush toilets	0.024	-0.46	0.035	0.33	0.162	1.29
3. Having an energy audit of one's home	0.012	0.66	-0.062	-1.65	0.065	1.45
4. Owning double pane windows	0.081	2.30 *	0.099	1.34	0.032	0.37
5. Weatherizing one's home	0.105	2.28 *	-0.025	-0.26	0.097	0.85
6. Checking tire inflation	-0.011	-0.21	-0.091	-0.87	0.109	0.89
7. Considering efficiency in large household appliance	0.059	1.53	-0.089	-1.04	-0.004	-0.04
8. Considering efficiency in small household appliance	0.066	1.42	0.094	0.95	-0.137	-1.18
9. Owning a front loading washer	0.000	0	-0.033	-0.66	0.069	1.16
10. Owning water saving faucets	0.037	1.65	0.044	0.92	0.045	0.82
11. Eating seasonally	-0.040	-0.81	-0.117	-1.13	-0.131	-1.07
12. Being a member of community supported agriculture	-0.001	-0.06	0.046	1.47	0.032	0.87
13. Buying renewable energy	0.011	1.03	-0.016	-0.74	-0.032	-1.24
14. Owning environmental mutual funds	0.011	0.31	-0.017	-0.23	0.033	0.38
15. Shopping at thrift stores	0.067	1.87	-0.144	-1.94	0.037	0.41
16. Reducing junk mail	0.053	1.20	0.009	0.10	0.034	0.32
17. Having planted a tree	0.051	1.67	0.100	1.57	0.165	2.16 *
18. Being a member of any environmental organization	-0.001	-0.03	0.046	0.65	0.032	0.38
19. Donating money to any environmental organization	0.033	1.18	-0.049	-0.85	0.034	0.49
20. Writing a letter to a political official about environmental issues	0.009	0.36	0.075	1.54	-0.033	-0.57
21. Tuning one's car	0.142	3.36 **	-0.052	-0.58	-0.096	-0.93
22. Number of vehicles	-0.032	-0.71	0.048	0.51	0.161	1.43

owned or leased						
23. Mileage of car	0.495	0.88	-1.319	-1.10	0.440	0.32
24. Number of compact fluorescence light bulbs	0.444	1.77	-0.045	-0.08	-1.275	-2.08
25. Distance from work	0.119	0.36	1.277	1.85	-0.355	-0.43
26. People living in your household	0.058	1.21	0.222	2.21 *	-0.032	-0.27
27. Area of your home	35.024	-0.61	240.0	1.91	-186.594	-1.36

Note: Asterisks denote significance level: * $p < 0.05$; ** $p < 0.05/n = 0.05/27 = 0.002$ (Bonferroni corrected alpha level)

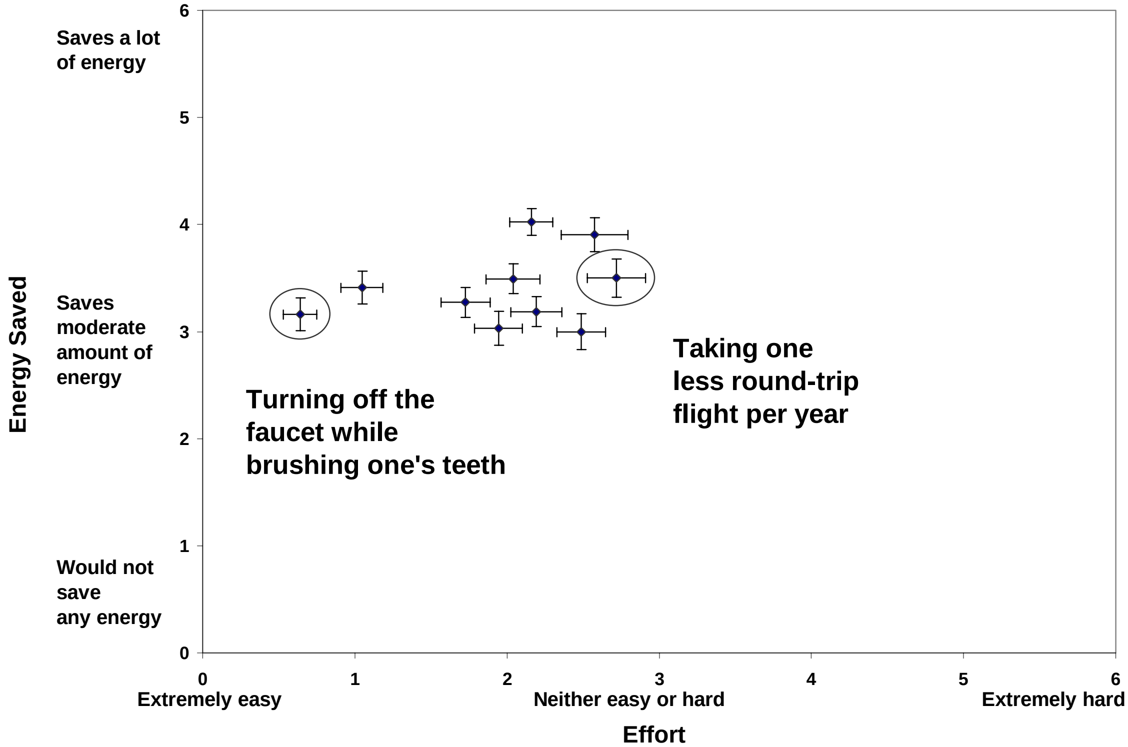
There was, however, one significant b_0 value: *Tuning one's car*. This implies that, on average, more participants reported having tuned their car in the Week 8 survey than in the Week 1 survey, independent of group assignment.

Note that there were no statistically significant changes in opinion responses about attitudes towards climate change and energy conservation in any of the groups, although the coefficients for the difference variables were positive for 11 of the 15 questions.

2.4.3 Perceived Effort and Perceived Energy Saved

The specific effort and energy behavior questions asked in the surveys are listed in Table 2.1. Figure 2.4 shows that there is about a two-unit spread in perceived effort and a one-unit spread in perceived energy savings for these ten behaviors. Note the results for taking one less round-trip flight per year and for turning off the faucet while brushing one's teeth. Although one might expect that these two behaviors would save very different amounts of energy, there was no statistically significant difference in perceived energy savings in either of the Week 1 and Week 8 surveys (e.g., Week 1 survey: $M_{\text{flight}} = 3.50$ vs. $M_{\text{brushing}} = 3.16$, $t = 1.71$, $p = 0.09$, $df = 124$). Participants' responses were more consistent with what one would expect for perceptions of effort, as the perceived effort needed was significantly larger for taking one less round-trip flight per year than for turning off the faucet while brushing in both the week 1 and 8 surveys, (from the week 1 survey: $M_{\text{flight}} = 2.72$ vs. $M_{\text{brushing}} = 0.64$, $t = 9.40$, $p < 0.001$, $df = 125$).

Figure 2.4. Average scores from Week 1 for perceived effort needed and perceived energy saved for ten different behaviors. Error bars indicate standard errors.



2.4.4 Perceived Attitude and Behavior Change

Two separate open-ended questions in the Week 8 survey asked participants whether they believed that being part of the study (a) changed their attitudes and (b) changed their behavior. We found that 57% of the participants perceived that their attitudes changed and 60% perceived that their behavior changed over the course of the study, as seen in Table 2.6. As might be expected, there was a strong positive association between those who perceived an attitude change and those who perceived a behavior change (Fisher's exact test, $p < 0.001$).

Table 2.6. Perceived attitude and behavior change responses to the questions in Week 8.

	Attitude change		
Behavior change	Change	No Change	Row Total
Change	47%	13%	60%
No Change	10%	30%	40%
Column Total	57%	43%	100%

The likelihood that a participant reported these changes was not significantly related to whether they were assigned to the intervention or one of the control groups. This was done by regressing the variables *R vs. others* and *NR vs. NI* into the participants belief in their own attitude and behavior change. None of the variables except for the intercept were significant (attitude and behavior change intercept results: $\alpha = 0.05$, all t's > 11 and all p's < 0.0001 and *R vs. others, NR vs. NI* results: $\alpha = 0.05$, all t's < 0.61 and all p's > 0.54). On predicting *Aggregate behavior* (the difference between the average transportation, household, and food scores pre- and post-intervention) by using the perceived attitude and behavior change variables, no significant relationship was found ($\alpha = 0.05$, all t's < 1.02 and all p's > 0.14). Similar results were found on predicting *Aggregated behavior removing seasonal components* ($\alpha = 0.05$, all t's < 1.34 and all p's > 0.18).

2.5 Discussion

Overall, results show that the intervention developed in this study did not change many behaviors in the three sectors of interest. Compared to the two control groups, participants in the reasons group (R), who were held accountable for their energy-conserving behaviors, effectively changed only one specific behavior after the intervention, *Buying products with less packaging.* One possibility in support of this finding is that the behavior may have been perceived as taking low effort to adopt and thereby implemented. Additionally, medium to large positive effect sizes were found comparing the R group to the other groups for this behavior. There were other difference variables with large effect sizes which did not represent significant behavior change; an explanation for this is that we may not have had enough power to conduct all of the reported analyses.

Independent of group assignment, and after the Bonferroni correction, participants positively changed two behaviors: *Aggregated behavior removing seasonal components* and *Tuning one's car.* This change implies that, on average, participants changed their overall behaviors to those that were energy conserving and tuned their cars. Because these behavior changes occurred in the intervention and both control groups (as the intercept b_0 is significant as opposed to coefficients b_1 or b_2, as shown in Table 2.4 and 2.5), it could be attributed to attention-focusing of the surveys and logs themselves or to external effects. Besides the interview in Week 4, the logs and surveys can also be viewed as an intervention, as they called the participants' attention to their weekly energy consumption. One possibility is that the survey and logs made different behaviors salient to different participants, who adopted conserving behaviors as a result of being part of the study. Additionally, participants could have tuned their cars in preparation for winter.

It is vital that practitioners isolate behaviors that require low effort and also save a lot of energy. The results of perceived effort needed and energy saved as shown in Figure 2.4 suggest that participants distinguish between behaviors more in terms of perceived effort than in terms of perceived energy saved. Although we do not know whether participants' perceptions of effort reflect the actual effort needed, this result suggests that helping people to understand the relative energy impacts of different behaviors might help them reduce their energy use more effectively. With reasonable assumptions (shown in Appendix A.5) we estimate that taking one less round-trip flight saves more energy by a factor of 20 to 100 compared with turning off the faucet while brushing twice a day for a year. This tells us that the participants may not be aware of the relative energy savings for different behaviors. Correcting these misperceptions may help facilitate behavior change, especially for the low-effort behaviors.

From the week 8 survey, 60% of the participants thought they had changed their behavior even though our analysis found no significant relationship to their overall behavior change (Table 2.6). Some possible explanations for this finding are that participants could harbor unrealistic optimism of their own behavior change or that these participants did change their behaviors in a way that the survey could not capture. Unrealistic optimism is referred to as a positive illusion regarding one's behavior (Taylor & Brown, 1994) and may be conjured to reduce cognitive dissonance. In light of these results, simply questioning participants about whether their behavior has changed may not yield accurate results; indirect or observational measures of specific behaviors are most likely needed to confirm these changes did in fact occur.

This study aimed at using a relatively small-scale intervention that was easy to deploy to facilitate energy conservation; however we found that simply focusing participant's attention on conserving behaviors was not enough to significantly incorporate conserving behaviors into their lives. Therefore results of this study have some implications for public policy and practitioners of social change. If we aim to decrease our carbon emissions per capita with minimal government interference and through self-regulation, we need to study stronger interventions that measure behavioral change. There are many organizations that use awareness-raising interventions (via advertising) on lay audiences to facilitate energy conservation; however without testing interventions that simply inform and focus attention on energy saving behaviors, significant changes may be unlikely. Longitudinal studies that use stronger interventions may be needed to as the behaviors we are attempting to change are salient to our current lifestyle. Future studies should have checks in place to determine if conserving behaviors were indeed implemented and retained. As shown in this study, lay-perceptions of energy savings do not match actual energy savings; therefore by first correcting these misperceptions and then targeting high-energy low-effort behaviors we may be able to change lifestyle choices.

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Chapter 3. Preferences for change: Do individuals prefer voluntary actions, soft regulations, or hard regulations to decrease fossil fuel consumption?[3]

3.1 Abstract

Pittsburgh residents (n = 209) reported their preferences for voluntary actions, soft regulations, and hard regulations to (a) limit the number of SUVs and trucks and (b) increase green energy use for household energy consumption. These two goals were presented in one of two motivating frames, as addressing either environmental or national security issues. For the goal of limiting SUVs and trucks, results indicated that participants favored voluntary actions over hard regulations, and soft regulations over voluntary actions. For the goal of increasing green energy, results indicated that participants preferred both voluntary actions and soft regulations over hard regulations, but had no significant preference between voluntary actions and soft regulations. How the problems were framed did not significantly affect participants' willingness to accept voluntary actions or regulations. Participants' environmental attitudes (as assessed using the New Ecological Paradigm scale) had a strong positive relationship with support for regulatory strategies intended to change the behaviors in question. Women were more likely to support voluntary actions than men. The loss of personal freedom was frequently mentioned as a reason for saying no to hard regulations.

Keywords: Preferences for change, Energy conservation, Environmental behavior, Regulations, Personal freedom.

3.2 Introduction

Increasing carbon dioxide levels in the atmosphere (Hansen et al., 1981) is leading to anthropogenic climate change (IPCC, 2007a). Changing consumption habits in the domains of transportation, home energy use, and other resource-intensive activities

[3] This chapter is published in Ecological Economics, Volume 68, Issue 6, Pages 1701-1710

provides one approach to sustainable development (World Commission on Environment and Development, 1987). The effectiveness of alternative policies to promote changing these behaviors is thus of great interest.

Although federal regulation on climate change in the United States is still lacking, a select number of states have been trying to implement policies. In 2007, the United States Supreme Court ruled in favor of the plaintiffs in the landmark case of Massachusetts versus the United States Environmental Protection Agency (EPA), in which twelve states sued the EPA to force the agency to regulate carbon dioxide and other greenhouse gases (GHGs) as air pollutants under the Clean Air Act. Section 202 of that Act states that "the administrator shall by regulation prescribe […] standards applicable to the emission of any air pollutant from any class or classes of new motor vehicles […] which may reasonably be anticipated to endanger public health and welfare" ("Clean Air Act", 1970). The court ruling now requires that the EPA articulate why it should not regulate GHGs. This ruling applies only to mobile sources of GHGs, not to stationary sources such as power plants.

In addition, many states have unilaterally adopted California's emissions standards which require larger emissions reductions and fuel-efficiency improvements than the targets set by the current Corporate Average Fuel Economy (CAFE) standards. However, the EPA has denied California the right to set stronger standards on grounds that national energy legislation should be used instead of statewide initiatives. California has retaliated by suing the EPA (California State, 2007). Although the current state of the law imposes very little restriction on individual consumer behavior, stronger regulations may eventually be adopted.

Governmental bodies may propose *hard* or *soft* regulations (also called *hard-path* or *soft-path* regulations). Hard regulations impose economic costs of non-compliance (Wilms, 1982). Soft regulations make some options more appealing than others in order to change behavior without imposing such economic costs (Thaler & Sunstein, 2003). An example of a successful hard regulation is the mandatory seatbelt law (Viscusi, 1993). An example of a successful soft regulation was demonstrated by Choi *et al.* (2003), where changes in the default savings rates for 401 (k) plans stimulated significant boosts in retirement savings.

In a democracy, such policy changes usually need the support of the majority of citizens. There are a variety of reasons why people may be especially resistant to hard governmental regulations. First, people generally prefer the status quo over a change in their situation (Samuelson & Zeckhauser, 1988), suggesting that they may not support new regulations that require change. Although hard regulations may lead to both losses (in terms of restricting behaviors) and gains (in terms of increased safety, improved environmental quality, reduced costs, or other individual or social outcomes), losses may loom larger than gains in many decisions (Kahneman & Tversky, 1979, 1984). In addition, individuals may not appreciate how well they would adapt to the behavior changes required by hard regulations (as they have adapted to seat belt laws, for example) (Loewenstein et al., 2002).

Moreover, hard regulations may evoke psychological reactance, with individuals seeking ways to re-establish their lost freedom (Brehm et al., 1966; Kornberg et al., 1970). For example, Mazis *et al.* (1973) found that banning phosphate detergents in Miami, Florida led to negative attitudes towards the restrictive laws, with individuals bootlegging phosphate detergents from neighboring counties. However, a softer policy involving a simple educational campaign reduced the market share of high-phosphate detergent by only 12%. Thus, some people who support sustainability may prefer hard regulations because they view such regulations as more effective.

Despite imposing limits on personal freedom, hard regulations may be preferred because they avoid aversive social dilemmas. Without hard policies, an individual's optimal strategy may be to free ride, by continuing to engage in a personally advantageous behavior, such as polluting, at the expense of those who voluntarily limit their own behavior (Hardin, 1968). As a result, people who cooperate are likely to feel "suckered" and tempted to defect as well (Orbell & Dawes, 1993). Hard regulations may be seen as more fair, because they establish similar payoffs for all participants (Hardin, 1968). Moreover, hard regulations may induce social cooperation because “we’re all in this together.”

Research shows that normatively irrelevant changes in how a decision is framed may affect people’s preferences (Kahneman & Tversky, 1984). For example, the same ground beef is evaluated more favorably when it is presented as “75% lean” than when it is presented as “25% fat” (Levin & Gaeth, 1988). Similarly, the framing of the broader context of the decision may also affect choices. Wade-Benzoni *et al.* (2007) showed that manipulating one’s self-perception of being an environmentalist affects whether the participant donates money to environmental causes.

Our exploratory study investigates whether individuals would support voluntary actions, soft regulations, or hard regulations to decrease their fossil fuel consumption in two different ways. As possible mechanisms for behavior change, voluntary actions, soft regulations, and hard regulations can be viewed as different points along a continuum. In our study, *voluntary actions* are characterized by the lack of regulation, with the individual left to decide independently whether or not to engage in a particular behavior. *Soft regulations* are characterized as incentive-based mechanisms or changes in default options, and are intended to guide consumer behavior. *Hard regulations*, on the other hand, are characterized as governmental controls, like bans, and are designed to compel consumer behavior.

We compare individuals’ pro-environmental attitudes and demographic information with their preferences for no action, voluntary action, soft governmental regulation, or hard government regulation. This approach is important in mapping which kinds of actions and regulations to curb carbon emissions will be favored by particular demographic groups. Note that participants’ responses may be only weakly associated with actual reactions to the behavior-change strategies because self-reported preferences may be colored by social desirability (i.e., the inclination to present oneself in a manner that will be viewed favorably by others) (Stone et al., 2000). However, given that we collected no unique identifying information from the study participants, we anticipate that the elicited preferences are as close to actual attitudes as possible.

The guiding questions for this study are:

1) Do participants prefer voluntary actions, soft regulations, or hard regulations?
2) Does the specific goal of the action or regulation, or the way in which that goal is framed, affect participants' willingness to support the action or regulation?
3) Is participants' willingness to support each action or regulation related to participants' environmental attitudes and demographic characteristics?
4) What are participants' reasons for their support or lack of support for each action or regulation?

3.3 Method

3.3.1 Participants

The surveys were distributed in Pittsburgh, Pennsylvania, USA, at the main branch of the Carnegie library, at an outdoor plaza, at a shopping mall, in downtown Pittsburgh, and in residential areas within the city limits, reflecting a sample of convenience (n=209). Power calculation for this sample size is shown in Appendix B.1. The survey was conducted from May through December of 2006.

3.3.2 Procedure

All participants were asked to state their preferences for hypothetical regulatory options intended to (a) limit SUVs and trucks and (b) increase green energy use, in that order. Each participant was randomly assigned to one of four experimental conditions, created by crossing two between-subject variables: they were asked to state preferences for the regulatory options of (a) voluntary actions and soft regulations or (b) voluntary actions and hard regulations, and whether the options were framed as addressing (a) environmental concerns or (b) national security concerns. In each condition, the voluntary action was presented before the (hard or soft) regulation, to provide a systematic reference point. Thus, we used a 2x2x(2) design, with regulatory options (voluntary and soft regulation vs. voluntary and hard regulation) and frame (environmental vs. national security) as between-subject factors, and goals (limiting SUVs and trucks vs. increasing the use of green energy) as a within-subject factor. Table 3.1 shows the number of participants in each of the four between-subject condition. The details of these conditions are described below.

Table 3.1. Number of participants in each of the 2 X 2 between-subjects conditions.

Frame	Regulatory options	
	Voluntary and soft regulation	Voluntary and hard regulation
Environmental	53	56
National security	50	50

Note: Each participant evaluated voluntary actions and regulations for the goals of (a) limiting SUVs and trucks and (b) increasing green energy use (within-subject condition)

3.3.3 Environmental vs. national security frame.

Before making each choice, participants were presented with the environmental or the national security frame. In the environmental frame, the goal of limiting SUVs and trucks was presented as: "Many scientists agree that automobile emissions are changing the composition of the atmosphere. On average, automobile emissions increase the global temperature, which in turn damages ecosystems. Large vehicles like SUVs and trucks typically have low gas mileage, and as a result, release more harmful emissions than compact cars." Similarly, the environmental frame for the goal of increasing green energy use read: "Many scientists agree that electricity generated by coal pollutes the atmosphere with toxic substances and contributes to climate change. Living in Pennsylvania, you can select to have a portion of your energy generated by solar and wind power (green energy). Electricity generated from green energy does not pollute the atmosphere with toxic substances, but is more costly than electricity generated by coal. Selecting green energy, a typical homeowner's monthly bill is likely to increase by about $5.00." The surcharge cost was estimated from a Pennsylvania renewable energy provider (Community Energy, 2006). By contrast, the national security frame presented the goal of limiting SUVs and trucks as: "Many political scientists agree that the low gas mileage of SUVs and trucks is increasing our oil consumption and dependence on foreign oil. This heightened dependence on foreign oil decreases our national energy security – that is our ability to ensure and control our energy supply. The lack of control of our energy supply compromises our national security." Similarly, the national security frame presented the goal of increasing green energy use as: "Many political scientists agree that one way to decrease our nation's dependency on foreign energy supplies is to invest in domestic, renewable energy sources. Living in Pennsylvania, you can select to have a portion of your energy generated by renewable energy. Electricity generated from renewable sources is more costly than non-renewable sources. Selecting renewable energy, a typical homeowner's monthly bill is likely to increase by about $5.00."

3.3.4 Voluntary action and soft regulation vs. voluntary action and hard regulation.

After being presented with the environmental or the national security frame, all participants were asked whether or not they were willing to engage in voluntary action to limit SUVs and trucks. For the environmental frame, the question read, "In order to reduce automobile emissions, I would be willing to pledge that the next car I purchase will not be a high emission vehicle such as a SUV or truck," with response options "yes" and "no." Subsequently, participants were asked whether they would be willing to accept a soft or hard regulation (depending on the survey version). For the environmental frame, the soft regulation option read, "In order to reduce automobile emissions, I would support the government providing tax breaks to individuals who purchase low emission vehicles like compact cars." The hard regulation option read, "In order to reduce automobile emissions, I would support the government restricting the purchase of SUVs and trucks, so that only individuals with approved certification and need can purchase and operate the vehicles." For the national security frame, the phrase "In order to reduce automobile emissions" was replaced by the phrase "In order to reduce dependency on foreign oil."

For the goal of increasing green energy use, the voluntary option under the environmental frame read, "In order to decrease the pollution released into the atmosphere, I would be willing to pledge to buy green energy from my energy supplier," with response options "yes" and "no." Depending on the survey version, participants were then asked whether they would be willing to accept a soft or hard regulation. For the environmental frame, the soft regulation option read: "In order to reduce dependency on foreign oil, I would be in favor of changing the current system ─ so that customers automatically purchase a percentage of renewable energy, unless they explicitly decide not to. This would require a consumer who desires an electricity service plan without green energy to make a telephone call to change their plan." The hard regulation option read, "In order to decrease the pollution released into the atmosphere, I would support a government regulation requiring that home-owners purchase a fraction of their electricity from green energy suppliers." For the national security frame, the phrase "In order to decrease the pollution released into the atmosphere" was replaced by "In order to reduce dependency on foreign oil."

After indicating whether or not they would support a particular voluntary action or regulation, participants were asked to explain their response in writing, by briefly listing the reasons for their preference. Next, they completed the New Ecological Paradigm (NEP) scale, which assesses pro-environmental attitudes (Dunlap et al., 2000). The NEP scale is a well-tested set of 15 statements to assess an individual's beliefs about his or her ability to change the balance of nature, the limits to growth of human societies, and the right of humans to rule over the rest of nature. Each of the 15 statements on the NEP (e.g., "The so-called 'ecological crisis' facing humankind has been greatly exaggerated") was followed by a seven-point scale ranging from 0 (completely disagree) to 6 (completely agree). For each participant, we computed an overall NEP score by the averaging his or her responses to the 15 items.

Finally, participants were asked whether or not they currently owned or leased an SUV, used alternative energy, and purchased green energy. Participants also reported their political party affiliation (Democrat, Republican, Independent, or Not sure) and their political views (with response options on a seven-point scale ranging from extremely liberal to extremely conservative). The survey ended with demographic questions regarding their gender, age, family income before tax, and highest level of education completed. One of the four surveys is shown in Appendix B.2.

3.4 Results

Data from the U.S. Census Bureau indicate that our sample was reasonably representative of the Pittsburgh population (U.S. Census Bureau, 2007b). The Census shows that 82% of Pittsburgh residents who are of age 25 or older have high school diplomas (90% in our sample) and 31% have a bachelor's degree (27% in our sample). Of participants who reported their highest level of education, 4% had completed no high school, 6% had obtained a high school diploma or GED, 31% had completed some college, 27% had finished college, 5% had some graduate training, and 16% had earned a graduate degree.

As reported by the U.S. Census Bureau, Pittsburgh's median family income is $44,027 (our sample median was in the $20,001–$50,000 range), and 47.2% of Pittsburgh's population is male (47% in our sample). The median age in Pittsburgh (38 years) is somewhat greater than that in our sample (28 years, SD=14.5 years). Pittsburgh also has about twice as many registered Democrats than Republicans (Commonwealth of Pennsylvania, 2007), whereas our sample consisted of 52% Democrats, 16% Republicans, and 13% Independents (19% of participants were not sure). Self-reported political views included 46% liberals (scale score = 0–2), 30% moderates (score = 3), and 24% conservatives (score = 4–6). At the time of the survey, 21% of our participants owned or leased an SUV, 5% used alternative energy, and 9.3% bought green energy from their electricity provider.

The average NEP score of 3.6 shows that our sample was slightly pro-environmental relative to the scale mid-point (3), which resembles the results found by Scott and Willits (1994) in their statewide survey of Pennsylvania (n = 3,632), using an earlier 12-item version of the NEP scale. To investigate the correlates of participants' environmental attitudes, we regressed participants' NEP scores (environmental attitudes) onto the following demographic variables: political party (coded using three dummy variables for Democrat, Republican, and Independent; Not Sure was the excluded category), political views, gender, age, income, and education. The results, which appear in Table 3.2, indicate that NEP scores were higher for more liberal participants and older participants, but lower for male participants. Similar to our findings, women have been found to be more pro-environmental than men (Bord & O'Connor, 1997; Davidson & Freudenburg, 1996). Buttel and Flinn (1978) found that liberal political values also imply stronger pro-environmental attitudes and that political party affiliation did not determine environmental concern. The observed relationship between age and pro-environmentalism was somewhat unusual. Many studies have found age to be negatively correlated with environmentalism (Van Liere & Dunlap, 1980), although some have reported a positive relationship. Dietz *et al*. (1998) found that depending on the indicator used, younger participants in a sample may either be the most pro-environmental or the least. Specifically, their study found that younger participants tend to engage in less pro-environmental consumer behavior compared with older participants, and are less likely to sign pro-environmental petitions.

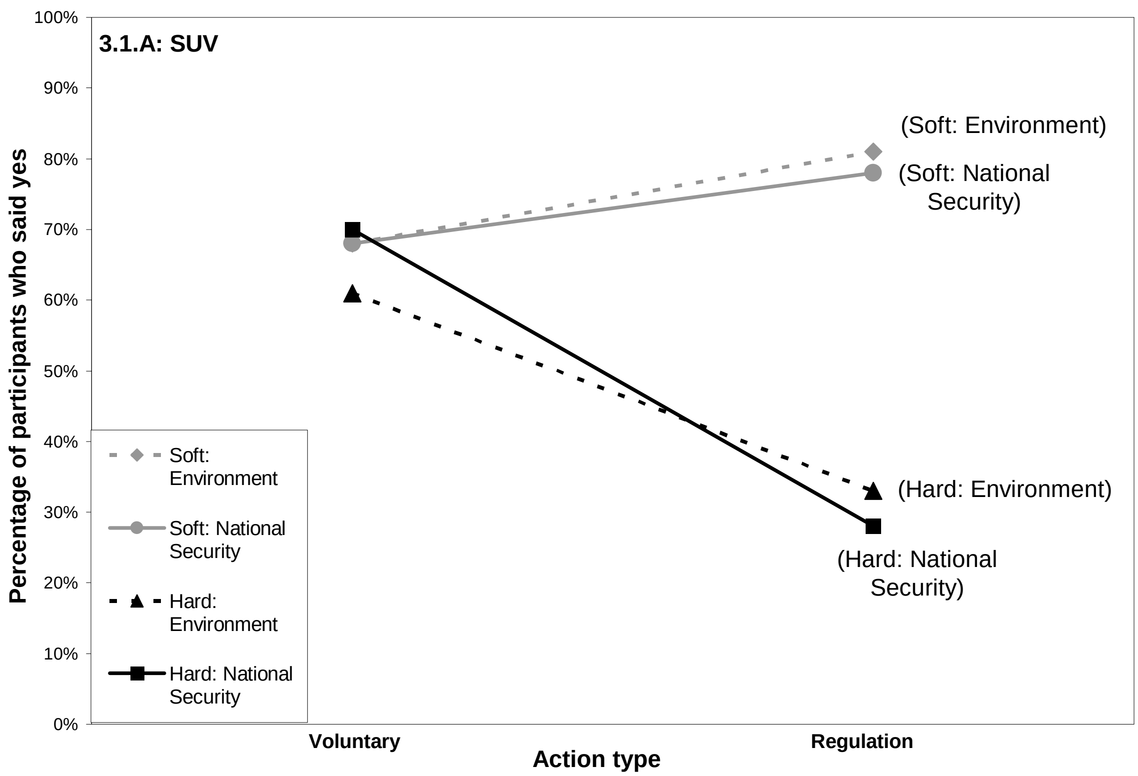
Table 3.2. Results of regressing NEP score onto demographic variables.

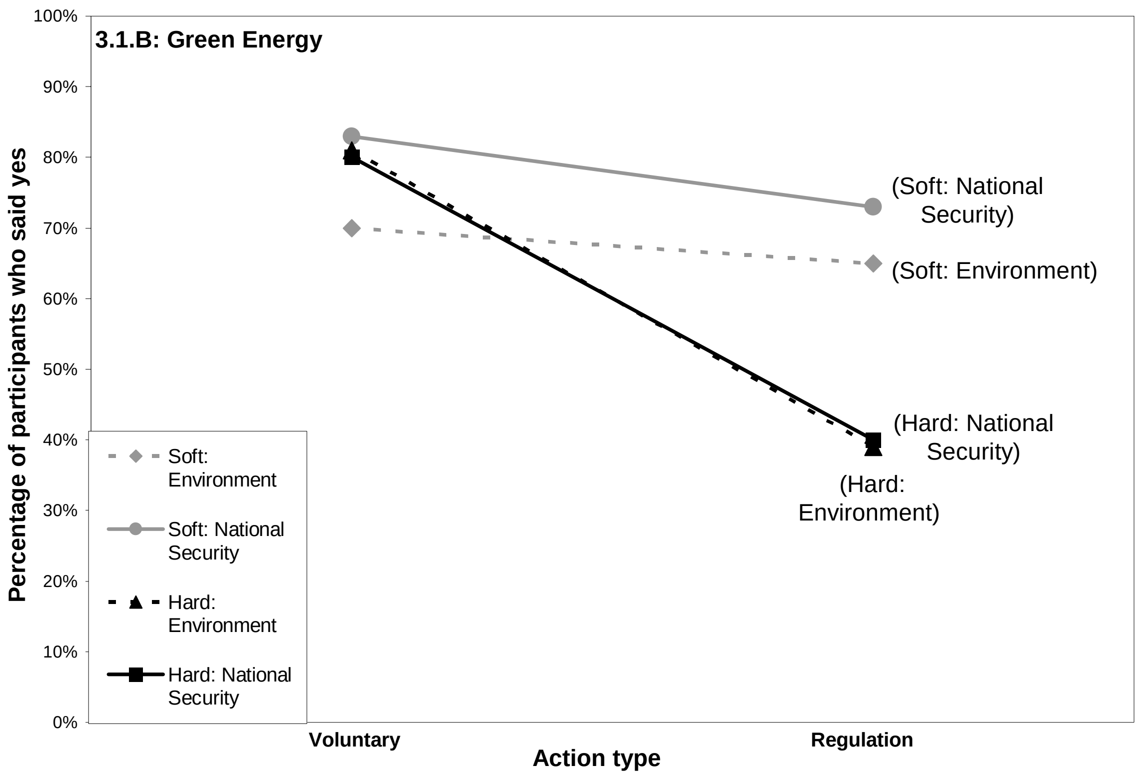
Variable	Estimate	*t* value
Intercept	4.2	15***
Democrat	0.07	0.46
Republican	-0.14	-0.69
Independent	-0.16	-0.79
Political views	-0.18	-3.4***
Gender (male =1)	-0.28	-2.4 *
Age	0.016	3.7***
Income	-0.066	-1.8
Education	-0.039	-0.86
$R^2 = 0.20$		

Note: Asterisks denote significance level: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Figure 3.1 shows the percentage of all participants who reported that they would support voluntary action, soft regulations, or hard regulations, for the goal of limiting trucks and SUVs and for the goal of increasing green energy use. For each goal, the percentage of participants agreeing to support voluntary action was always greater than 50%. There was a significant difference between the percentages of participants supporting voluntary actions and soft regulations for limiting SUVs and trucks (67% vs. 80% respectively, exact p for McNemar's test = 0.029), although there was no significant difference between support for voluntary actions and soft regulations for increasing green energy use (76% vs. 69%, respectively, exact $p = 0.21$). Voluntary actions were significantly preferred to hard regulations for limiting SUVs and trucks (65% vs. 30%, exact $p = 1 \times 10^{-7}$) and for increasing green energy use (81% vs. 39%, exact $p = 8.2 \times 10^{-10}$).

Figure 3.1. Percentage of participants who supported the voluntary and regulation question. Figure 3.1.A shows the results for the goal of limiting SUVs and trucks and Figure 3.1.B shows the results for the goal of increasing green energy. The labels indicate the regulation type and frame.





3.4.1 Support for voluntary actions

To assess the support for voluntary actions to achieve each goal, we conducted two logistic regressions in which support for such actions was modeled as a function of frame, regulatory option (which was always presented *after* the voluntary action question, NEP score, SUV ownership (whether the participant currently owns or leases an SUV), alternative energy (whether the participant currently uses alternative energy, e.g., solar panels on his or her roof), green energy (whether the participant currently buys green energy from his or her provider), political party (using three dummy variables for Democrat, Republican, and Independent), political views, gender, age, income, and education. One logistic regression predicted support for limiting SUVs and trucks and the other predicted support for increasing green energy use. Results appear in Figure 3.3.

The left side of the table indicates that voluntary action to limit SUVs and trucks was not significantly related to whether the survey version also included questions regarding soft regulation or questions regarding hard regulation. This is as it should be, because the type of regulation was not mentioned until after support for voluntary action had been assessed. Whether the voluntary action was framed as addressing environmental concerns or national security concerns did not significantly affect participants' support. Participants' NEP scores significantly affected whether or not they would engage in voluntary actions, with pro-environmental participants being more likely to do so (the odds of supporting the action were 2 times higher for each one-unit increase in NEP score). In addition, SUV owners and men were less likely to pledge not to buy an SUV or truck as their next vehicle (the odds of supporting the action were 4.5 times lower for SUV owners than for non-owners and 2.2 times higher for women than for men).

Table 3.3. Results of logistic regressions for predicting whether or not participants support *voluntary action* to limit SUVs and trucks and to increase green energy use.

Predictor	Limiting trucks and SUVs			Increasing green energy use		
	Estimate	Wald χ^2	Odds ratio estimate	Estimate	Wald χ^2	Odds ratio estimate
Intercept	-2.3	2.2		-1.2	0.45	
Frame (environmental = 1)	-0.14	0.14	0.87	-0.19	0.17	0.83
Regulatory option (soft = 1)	-0.090	0.059	0.91	-0.62	2.0	0.54
NEP score	0.69	6.0*	2.0	0.84	6.2*	2.3
SUV ownership	-1.5	11***	0.22	0.74	1.8	2.09
Alternative energy	0.090	0.0095	1.1	12	0.00080	>1000
Green energy	1.3	2.0	3.7	14	0.0024	>1000
Democrat	0.50	1.0	1.6	-0.32	0.31	0.73
Republican	-0.67	1.2	0.51	0.29	0.16	1.3
Independent	0.13	0.039	1.1	-0.051	0.0049	0.95
Political views	0.24	1.9	1.3	0.11	0.30	1.1
Gender (male = 1)	-0.81	4.6*	0.45	-1.0	5.2*	0.37
Age	0.0030	0.044	1.0	0.0079	0.22	1.0
Income	-0.016	0.015	0.98	-0.27	3.2	0.76
Education	0.098	0.45	1.1	0.15	0.78	1.2
Max-rescaled R^2		0.31			0.29	

Note: Asterisks denote significance level: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

The right side of Table 3.3 shows the results for voluntary action to increase green energy use. As was the case for the SUV goal, participants' support for voluntary action was not significantly affected by the subsequent regulation option (hard or soft) or by whether the voluntary action was framed as addressing environmental concerns or national security concerns. Participants with higher NEP scores were again more likely to support voluntary action (the odds of supporting the action were 2.3 times higher for each one-unit increase in NEP score). Finally, men were less likely than women to pledge to buy green energy from their supplier (the odds of supporting the action were 2.7 times higher for women than for men).

3.4.2 Support for regulations

We conducted two similar logistic regressions to predict participants' support for regulations intended to limit SUVs and trucks or increase green energy use. The left side of Table 3.4 shows the results for limiting SUVs and trucks. Participants were significantly more likely to support the regulation if it was soft rather than hard (the odds of support were 9.4 times higher for the soft regulation than for the hard regulation). Whether the regulation was framed as addressing environmental concerns or national security concerns did not significantly affect participants' support. As was the case for voluntary actions, pro-environmental participants were more likely to support regulations to limit SUVs and trucks (the odds of supporting the regulation were 1.9 times higher for each one-unit increase in NEP score). Additionally, Republicans and Independents were less likely to support the regulation than were participants who were not sure of their party affiliation (the odds of rejecting the regulation were 4.5 times higher for Republicans and 4.2 times higher for Independents).

The right panel of Table 3.4 shows the results for increasing green energy use. Similar to the results for limiting SUVs and trucks, participants were more likely to support regulation to increase green energy use if the regulation was soft rather than hard (the odds of support were 3.4 times higher for the soft regulation than for the hard regulation). Whether the regulation was framed as addressing environmental concerns or national security concerns did not significantly affect participants' support. As was the case for voluntary actions, women and participants with higher NEP scores were more likely to support policies to increase green energy use (the odds of supporting the regulation were 2.1 times higher for each one-unit increase in NEP score).

Table 3.4. Results of logistic regressions for predicting whether or not participants support *regulation* to limit SUVs and trucks and to increase green energy use.

Predictor	Limiting trucks and SUVs			Increasing green energy use		
	Estimate	Wald χ^2	Odds ratio estimate	Estimate	Wald χ^2	Odds ratio estimate
Intercept	-2.9	3.6		-2.8	3.7	
Frame (environmental = 1)	-0.088	0.049	0.92	-0.20	0.30	0.82
Regulatory option (soft = 1)	2.2	32***	9.4	1.21	11***	3.4
NEP score	0.62	5.4*	1.9	0.73	7.4**	2.1
SUV ownership	-0.29	0.36	0.75	0.081	0.031	1.1
Alternative energy	0.64	0.44	1.9	0.72	0.49	2.0
Green energy	0.98	1.6	2.7	1.51	3.0	4.5
Democrat	-0.44	0.70	0.64	0.43	0.74	1.5
Republican	-1.5	5.0*	0.22	-0.19	0.092	0.83
Independent	-1.4	4.4*	0.24	-0.61	0.88	0.54
Political views	0.089	0.25	1.09	0.16	0.89	1.2
Gender (male = 1)	-0.28	0.55	0.75	-0.69	3.6	0.50
Age	0.0070	0.22	1.0	0.0032	0.049	1.0
Income	0.064	0.24	1.1	-0.069	0.28	0.93
Education	-0.032	0.045	0.97	-0.14	0.97	0.87
Max-rescaled R^2		0.42			0.31	

Note: Asterisks denote significance level: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Additional logistic regression results (not shown) indicated that the interaction between frame (environment vs. national security) and regulatory option (soft vs. hard) did not significantly affect participants' support for regulations to limit SUVs and trucks or regulations to increase green energy use. In other words, the magnitude of participants' preference for soft regulations over hard regulations was similar in the environmental and national security frames.

3.4.3 Reasons for choices

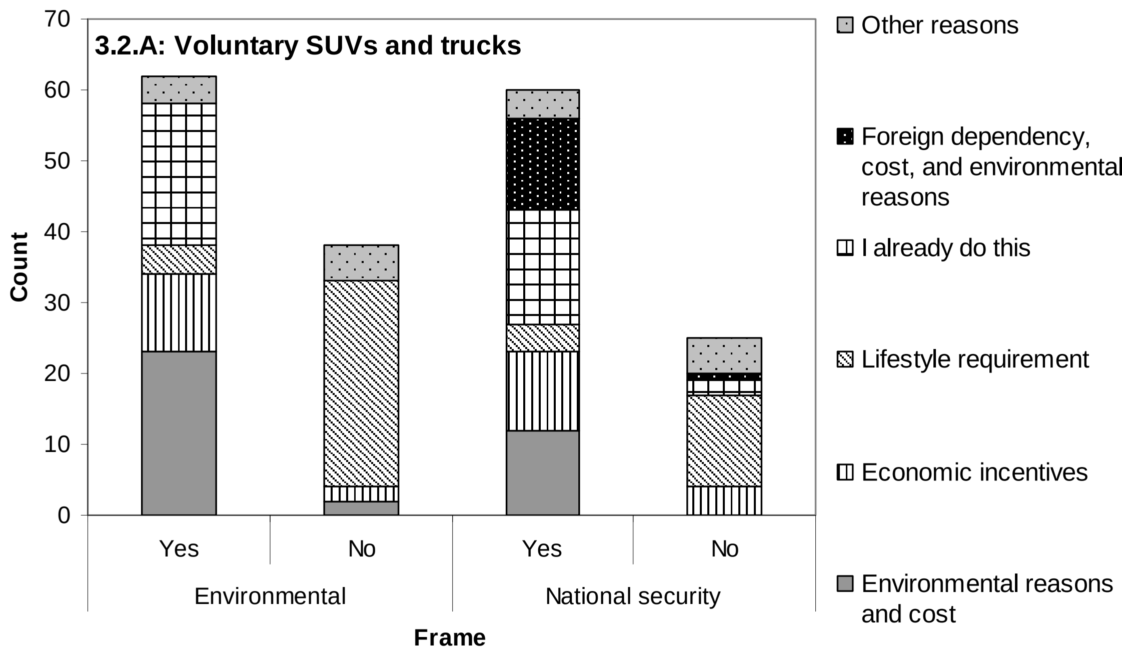
Two judges independently coded the reasons that participants listed for their choices into the 16 categories shown in Table 3.5. The coding showed sufficient reliability, as suggested by a Cohen's kappa of 0.67, where a score of 0.61-0.80 implies substantial agreement (Landis & Koch, 1977). Figures 3.2 and 3.3 show the reasons that had a count greater than five for supporting (or not supporting) voluntary action and for supporting (or not supporting) regulation. The lengths of each of the stacked bars represent the number of times the specific reason was mentioned for the specific goal and frame. Participants supporting voluntary action to limit SUVs and trucks mainly mentioned *environmental reasons*, *economic incentives*, and *I already do this*, while those not supporting it mentioned that their *lifestyle requires an SUV* (Figure 3.2.A). Those supporting voluntary action to increase green energy use mentioned *environmental reasons and costs* and *economic incentives*, whereas those not supporting it mentioned that they need better *economic incentives* (Figure 3.2.B). For both the SUV and green energy goals, participants in the national security frame mentioned *foreign dependency* more often than the participants in the environmental frame.

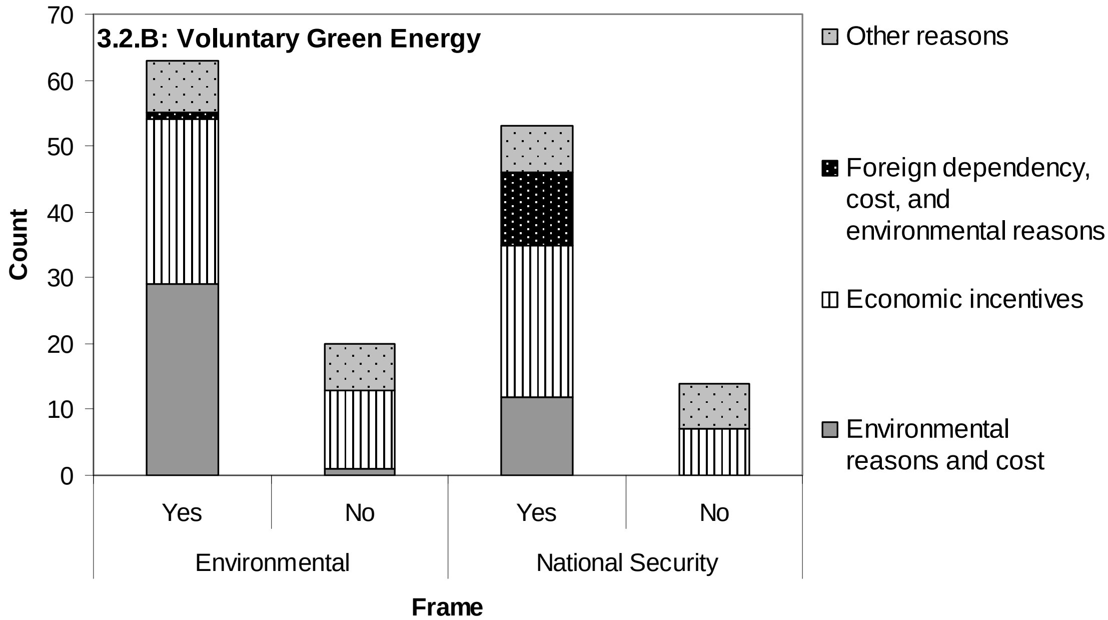
Table 3.5. Reasons provided by participants to explain their support or lack of support for voluntary actions and regulations. The count indicates the number of times a specific reason was mentioned in the whole study, without differentiating between questions or survey versions.

Reason category	Count
Economic incentives	167
Personal freedom and need for choice	129
Environmental reasons and cost	109
Lifestyle requirement	70
I already do this	60
More information is needed	31
Safety and health reasons	31
Better choices needed	24
Other reasons (mentioned only once)	24
Government needed	19
Foreign dependency, cost, and environmental reasons	11
I do not believe in global warming	7
People will accept this	5

This requires too much effort	2
This is a drop in the bucket	2
I do not care	2

Figure 3.2. Reasons most often given by participants for supporting or not supporting voluntary actions. Figure 3.2.A shows the results for voluntarily limiting SUVs and trucks: A pledge that the next vehicle you purchase will not be a high emission vehicle such as an SUV or truck. Figure 3.2.B shows the results for voluntarily increasing green energy use: A pledge to buy green energy from your energy supplier

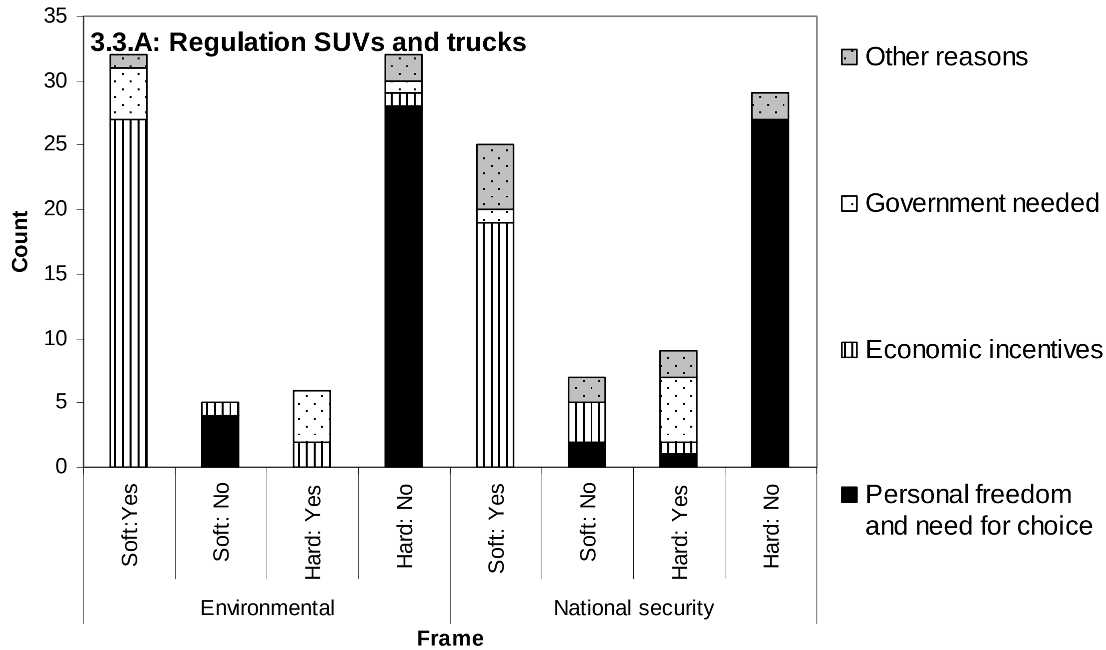


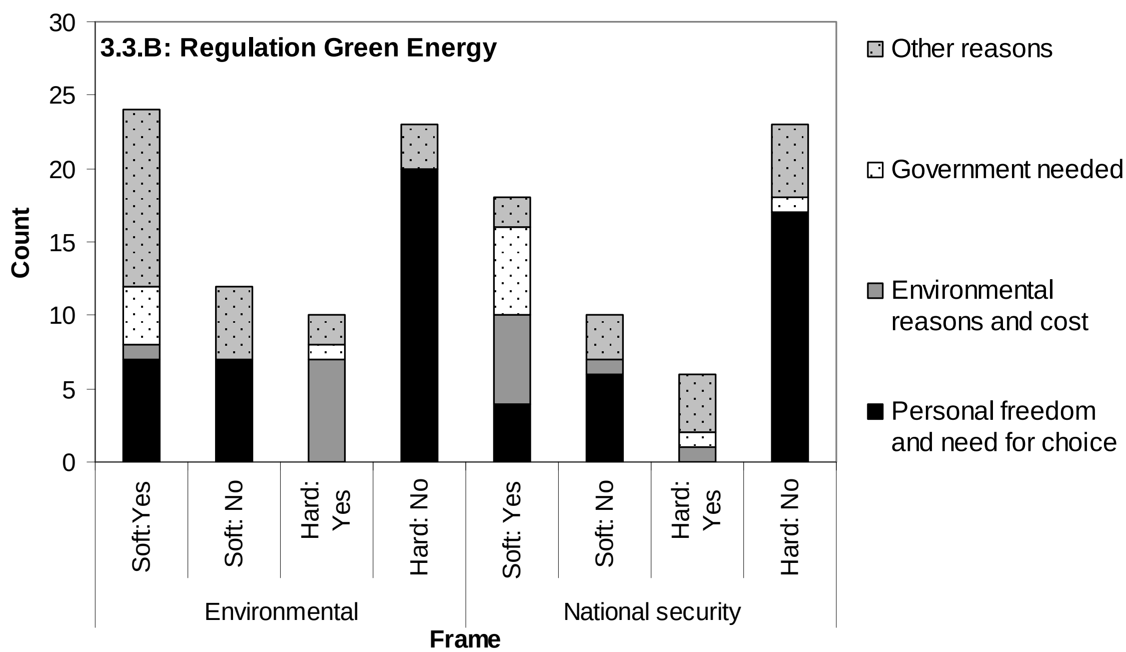


Participants supporting soft regulation intended to limit SUVs and trucks cited *economic savings* as their primary reason; those not supporting soft regulation for this purpose indicated that better *economic incentives* were needed and noted the undesirable infringement on *personal freedom and need for choice*. Those supporting hard regulation mentioned that the *government is needed*, whereas those not supporting hard regulation mentioned *personal freedom and need for choice*. One participant stated "I think whoever wants to buy one should be allowed to." Similarly, for the goal of increasing green energy use (Figure 3.3.B), *government is needed* and *personal freedom and need for choice* were the main reasons for supporting soft regulation, while *environmental reasons and cost* was frequently mentioned as reasons for supporting hard regulation. Finally, *personal freedom and need for choice* was frequently mentioned by those not supporting soft or hard regulation (e.g., "this would be restricting free choice").

Figure 3.3. Reasons most often given by participants for supporting or not supporting soft and hard regulations. Figure 3.3.A shows the results for regulating SUVs and trucks: providing tax breaks for compact cars (soft) or restricting the purchase of SUVs and trucks (hard). Figure 3.3.B shows the results for regulating green energy: changing the system so that customers automatically purchase a percentage of renewable energy unless they specifically decide not to (soft) or

requiring that customers purchase of a fraction of electricity from green energy suppliers (hard).





3.5 Discussion

Participants preferred voluntary actions to hard regulations for both goals of limiting SUVs and trucks and increasing green energy use. Participants favored soft regulations over voluntary actions for the goal of limiting SUVs and trucks, but showed no clear preference between voluntary actions and soft regulations for the goal of increasing green energy use. Thus, our results suggest that there may be more public buy-in for softer regulations, such as market-based mechanisms intended to change behavior. Participants were more resistant to hard regulations when the goal was to limit SUVs and trucks than to increase green energy use. Possibly, participants found the hard regulation more restrictive in the SUV goal, leading to more psychological reactance (Brehm, 1966). Indeed, the need for *personal freedom and choice* was the most frequently mentioned reason by participants who did not want to accept hard regulations. *Economic incentives* (such as monetary savings) were commonly mentioned as reasons for supporting voluntary action and soft regulation to limit SUVs and trucks (see Figures 3.2.A and 3.3.A).

Framing regulations as addressing either environmental or national security concerns did not significantly affect participants' responses to any of the survey questions, in contrast to the results of previous research on framing (Kahneman and Tversky, 1984; Levin & Gaeth, 1988). Possibly, our manipulation was too weak to make a difference. Although our two frames provided different contexts in which to evaluate possible actions, they did not include a clear distinction between gains and losses, as in many previous framing studies. However, framing did play a role in the reasons that individuals gave to justify their preference for voluntary behaviors, mentioning more environmental reasons when an environmental frame was presented and more security reasons when a security frame was presented (Figure 3.2). Of course, it is possible that participants' reasons did not actually drive their choices, but were provided merely as justifications after the fact. An alternative explanation for the lack of a framing effect is that regulations were so salient to the participants that their preferences were not affected by the nuances of changing frames. Finally, environmental and national security frames may have been similarly compelling to the study participants (or compelling to similar numbers of participants).

Even though our study employed a convenience sample, there was enough heterogeneity to detect significant effects of participant differences on support for decreasing fossil fuel consumption in the ways studied. Participants with stronger pro-environmental attitudes were more likely to support voluntary action and government regulation, both for limiting SUVs and trucks and for increasing green energy use. Women were more likely than men to support voluntary actions in both goals, replicating previous research showing that women tend to engage in more pro-environmental behaviors than men (Zelezny et al., 2000). Additionally, participants who were Republican or Independent were less likely to support regulations limiting SUVs.

The voluntary actions and regulations investigated in this study are but snapshots of a range of possible voluntary actions, soft regulations, and hard regulations that can be used to affect behavior change. The specific actions and regulations used here were designed to cover a variety of factors such as degree of inconvenience, type of economic incentive, and extent of governmental control. In order to make more generalized conclusions about preferences for behavior change, we recommend investigating a variety of behavioral domains using specific actions and regulations, as there may be situations in which hard regulations are preferred to soft regulations and voluntary actions. Examples include regulations intended to protect personal health and safety. Repeating portions of this study may also be of interest, to see whether different demographic groups respond differently, or to study whether preferences have changed in response to recent steep increases in energy prices.

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Chapter 4. Lay Perceptions of Energy Consumption[4]

4.1 Abstract

An experiment studied how participants (*n*=505) perceive energy consumption and savings for household, transportation, and recycling behaviors. Participants showed a tendency to overestimate energy consumption and savings for low-energy behaviors and underestimate energy consumption and savings for high-energy behaviors. On average, participants underestimated the amount of energy used or saved by different behaviors. Pro-environmental attitudes and higher numeracy scores were associated with more accurate perceptions of energy consumption. Surprisingly, participants who reported engaging in a greater number of environmental behaviors had less accurate perceptions of energy consumption. On average, participants reported that engaging in energy-conserving behaviors would not be difficult for any of the behaviors considered.

Keywords: Perceptions of energy consumption, Perceptions vs. actual, Energy conservation, Environmental behavior

4.2 Introduction

Past and future anthropogenic carbon dioxide emissions are contributing to global climate change (Hansen et al., 2008), and could negatively impact our way of life if no action is taken in the near future (Stern, 2006). Reducing carbon dioxide emissions is of special importance in the United States because the country produces 22% of the world's total carbon dioxide emissions (EIA, 2006a). Of the total U.S. greenhouse gas emissions, 82% is attributed to carbon dioxide related to energy consumption (EIA, 2006b). The two sectors of greatest CO_2 emissions for individuals in the U.S. are transportation (responsible for 29% of total CO_2 emissions) and household operations (responsible for 21%) (EIA, 2007).

[4] To be submitted to Psychological Science

Chapter 4: Lay perceptions of energy consumption

To decrease energy consumption and carbon dioxide emissions per capita it is imperative that we understand how individuals perceive the amount of energy consumed by their daily activities in transportation and household operations. This study investigates how much energy the lay public believes their specific behaviors use, and also how much energy they perceive can be saved by engaging in conservation practices and using more energy-efficient technologies. It is important to identify lay perceptions of energy consumption to inform policy makers and practitioners which misconceptions need to be corrected. Efficiency is defined as switching to a technology that decreases energy use without sacrificing desired energy services, such as switching to a vehicle with better fuel economy. Curtailment is defined as a cutting back on normal or desired activities, such as driving fewer miles per week (Gardener & Stern, 2008). Pacala and Socolow (2004) indicate that energy efficiency and curtailment may be our cheapest options to stabilize atmospheric carbon dioxide concentrations at 500ppm.

In criticism of the mixed signals offered by the media about what people can do personally to decrease their impacts on climate change, Gardener and Stern (2008) identified a *short list* of the 27 most effective actions United States households could take. In the short list, the authors state that by changing their selection and use of household and motor vehicle technologies, without waiting for new technologies to appear, making major economic sacrifices, or losing a sense of well-being, households can reduce energy consumption by almost 30 % —about 11 % of total U.S. consumption. They also state that there are many misconceptions about how much impact an individuals actions have on the environment. For example, 'turning out lights when leaving rooms' tends to have minimal impact on energy use and corresponding CO_2 emissions. Some examples of their recommended energy-saving behaviors are to buy a more fuel-efficient automobile, to replace incandescent bulbs with compact fluorescent bulbs, and to carpool to work with one other person.

Even if people had correct perceptions about how different behaviors may reduce energy, they may not be willing to change their behavior if they do not believe that climate change will impact them personally. Leiserowitz (2005) found that the majority of the

American public does not currently consider climate change an imminent or high-priority danger. Instead, most Americans believe that the impacts of climate change will have moderate severity and will most likely impact geographically and temporally distant people and places or ecosystem resources. Given that Americans believe global climate change is occurring and they also believe they will not be negatively affected by its impacts, research that investigates how these beliefs relate to perceptions of energy consumption is vital. Measuring perceptions of specific behaviors and effort needed to change these behaviors inform demand-side policy responses, such as switching to more efficient technologies. This is crucial, as public perceptions drive policy as much as scientific assessments (Kellstedt et al., 2008). Additionally, scientists may be failing the lay public by not providing information in a credible and comprehensible manner to facilitate better climate-related decisions (Fischhoff, 2007). Therefore the results of this study have potential to inspire better focused scientific information and risk communication.

To understand public perceptions of energy consumption, it may be useful to draw an analogy with how the public perceives risks, and with the methods that have been used to study such perceptions. There are many studies that show the public misevaluates risks. Lichtenstein *et al.* (1978) asked lay people to estimate the number of annual deaths in the United States from 30 causes (e.g., botulism, heart disease, homicides, tornadoes). The results showed that the perceived risk of death and the actual risk of death differ. Although the participant's perceptions of risk were positively correlated to the actual risk, the estimates of risks were highly regressive, where participants overestimate low risks and underestimate high risks. Additionally, participants exaggerated some risks due to memorability, imaginability and disproportionate exposure. Similarly there are other differences between lay and expert risk perceptions. Slimak and Dietz (2006) showed that when ranking 24 ecological risk items, from global climate change to commercial fishing, the lay public is more concerned about low-probability, high-consequence risks whereas the risk professionals are more concerned about risks that pose chronic ongoing ecosystem-level impacts.

Related to perceptions of energy consumption, Larrick and Soll (2008) showed that many well trained college students misperceive that the amount of gas consumed by an automobile decreases as a linear function of the car's mileage per gallon, while the actual relationship is curvilinear. This relationship is explained by the fact that driving a car that gets 14 miles per gallon versus a car that gets 12 miles per gallon will lead to a 120-gallon reduction in fuel used per 10,000 miles. This saving is larger than the savings of replacing a car that gets 28 miles per gallon with a car that gets 40 miles per gallon (a 107-gallon reduction in fuel used per 10,000 miles). To correct this misperception, the authors recommend that the U.S. adopt the commonly used "liters per 100 kilometers" (equivalent to "gallons per mile") rather than the inverse "miles per gallon".

Related to misconceptions of climate change, Sterman and Sweeney (2007) showed that many well trained college students believe that atmospheric concentrations of greenhouse gases can be stabilized even though emissions of greenhouse gases into the atmosphere continuously exceed their removal. This belief, they explained, is akin to incorrectly arguing that a bathtub filled faster than it drains will never overflow.

To offer an explanation of the discrepancy between perception of risks versus actual risks, Slovic (1987) states that public risk perceptions are influenced not only by scientific and technical descriptions, but also by a variety of psychological and social factors, including personal experience, affect and emotion, imagery, trust, values, and worldviews. However, these issues are not the focus of our study, as we are interested in public perceptions of energy consumption.

4.2.1 Objectives of the current study

This study aims to capture what behaviors lay individuals think of when asked to conserve energy. This study also aims to compare lay perceptions of energy consumed by a variety of behaviors to the actual energy consumed by the behaviors. In addition, the study considers perceptions of how easy or hard it will be for participants to adopt energy conserving behaviors recommended in the short list by Gardener and Stern (2008). This is important, as identifying easy behaviors that save a lot of energy could provide a focus for practitioners and activists.

The guiding questions for this study are:

1) What types of behaviors do participants think of when they are asked to conserve energy?
2) How accurate are participants' perceptions of how much energy is consumed or saved by everyday behaviors?
3) Are perceptions of energy consumption and savings related to environmental attitudes and demographic characteristics?
4) Are there specific behaviors in the short list that are perceived as easy to do and that also save a lot of energy?

We hypothesize that there will be significant differences between actual energy consumed and lay perceptions of the energy consumed by different behaviors. Specifically, similar to the risk of death studies, we hypothesize that lay participants will overestimate energy use of low-energy behaviors and underestimate energy use of high-energy behaviors.

4.3 Method

4.3.1 Participants

The survey was disseminated online via Survey Monkey[5], reflecting a sample of convenience (*n*=505). The participants for this study were elicited via online advertisements on Craigslist, which is a centralized network of online communities, in seven metropolitan areas: Philadelphia, New York, Dallas, Los Angeles, Houston, Denver, and the Washington D.C. area. However many participants in our study were not located in any of the seven cities themselves, as non-residents can still access any other city's Craigslist site. Approximately 34 states were represented, where no more than four participants were from the same zip code. Of the total number of participants that started the survey, 471 completed the survey (attrition rate = 6.7%). The participants were able

[5] http://www.surveymonkey.com/, the survey solicitation is shown in Appendix C.1

to access the survey from 9am to 3pm on Wednesday, February 11, 2009. A $10 Amazon gift certificate was provided to compensate participants within twenty-four hours of completing the survey. Additionally, three methods were used to avoid multiple user submissions (Birnbaum, 2004): repeated Internet protocol (IP) addresses were not allowed, cookies were checked for previous participation, and email addresses were checked for repeats. Demographic information about our sample is presented in the results section below.

4.3.2 Actual energy consumption

For the average household, household operations roughly account for 35% of energy use, transportation accounts for 33% of energy use and food accounts for 12% of energy use (Brower & Leon, 1999; EIA, 2006a). These values were scaled up (to make the total 100%) for data analysis. Data were obtained for actual energy use for other devices and behaviors as shown in Table 4.1-4.3. These behaviors were chosen to represent a wide range of energy consumption.

Table 4.1. Typical energy used in one hour by devices and appliances in the home

Device	Energy used (kWh)	Source
Stereo	0.01-0.03	(altE, 2008; Rosen & Meier, 1999)
Compact fluorescent light (CFL) bulb (with equally brightness to a 100-Watt incandescent light bulb)	0.023	(EIA, 1996; Navigant Consulting Inc., 2002)
Laptop computer	0.02-0.075	(altE, 2008; DOE, 2009b)
100-Watt incandescent light bulb	0.1	
Desktop computer	0.08-0.2	(altE, 2008; DOE, 2009b)
Room air-conditioner	1	(altE, 2008)
Central air conditioner	2-5	(altE, 2008)
An electric clothes dryer	1.8-5	(altE, 2008; DOE, 2009b)
Dish washer	12-24	(altE, 2008; DOE, 2009b)
Portable heater	15	(altE, 2008; DOE, 2009b)

Please note that where energy ranges are present, geometric means were used for data analysis.

Table 4.2. Achieved energy savings by household operations and personal transportation

Activity	Achieved energy savings	Source
Drying one load of laundry on a clothes line instead of using an electric dryer	1.8-5 kWh	(altE, 2008; DOE, 2009b)
Setting the thermostat on your air conditioner 5° F higher for one hour in the summer	0.1 kWh	(Armstrong, 2009)
Setting the thermostat on your heater 5° F lower for one hour in the winter	0.54 kWh	(Northeast Utilities, 2009)
Changing washer temperature settings from “hot wash, warm rinse” to “warm wash, cold rinse” for one load of laundry	4 kWh	(Rocky Mountain Institute, 2009)
Driving a more fuel efficient car (30 vs. 20 miles per gallon) at 60 miles per hour for one hour	1 gallon of gasoline	(Calculated)
Tuning up a car twice per year	24 gallons of gasoline	(DOE, 2009c)
Cutting highway speed from 70 miles per hour to 60 miles per hour, while driving a 20-miles-per-gallon car for 60 miles	0.4 gallons of gasoline	(DOE, 2009a)

Table 4.3. Energy used by different modes of transportation and recycling/manufacturing

	Energy consumption related to transportation and required to make packaging materials				Source
Mode of transportation, to transport one ton of goods per mile	Train	Ship	Truck	Airplane	
Btu per ton-mile	371	411	4360	31600	(DOE, 1992; Imhoff, 2005)
Manufacturing recycled and virgin aluminum and glass	Recycled aluminum can	Virgin aluminum can	Recycled glass bottle	Virgin glass bottle	
Btu per gram of material	10	182	6	8	(Imhoff, 2005)
Btu per can or bottle	120	2180	2370	3160	Calculated based on Imhoff (2005)

4.3.3 Survey Design

One of the studies used by Lichtenstein *et al.* (1978) asked for direct estimated frequencies of annual death in the U.S. for 30 causes. Similarly, our study aimed to elicit direct estimates of energy consumption, where participants were asked to estimate the energy used by the particular device in one hour (usually) and were asked to rank different technologies and behaviors in terms of their energy use.

The survey had a total of 15 pages, each representing a section. Section 1 of the survey asked the participants for the most effective thing they could do to conserve energy in their life, with an open-ended response. This question was placed at the beginning of the survey to ensure that participants' beliefs were captured without affecting them with closed-ended response modes. Next, in Section 2 entitled "Energy Consumed by the Average Household", the participants were asked to provide a percentage of the total energy consumed per year by household operations, transportation, and food production. Section 3 entitled "Energy Used by Devices in One Hour." Pretesting this section found that many lay participants had difficulty understanding units of kilowatt-hours. For this reason, we provided a reference point to help participants compare energy use between devices: we asked participants to assume that "a 100-watt incandescent light bulb uses 100 units of energy in one hour," which is equal to 100 watt-hours. Then the participants were asked to enter how many units of energy each of the following devices typically use in one hour: (1) a compact fluorescent light bulb that is as bright as a 100-watt incandescent light bulb, (2) a desktop computer, (3) a laptop computer, (4) a stereo, (5) an electric clothes dryer, (6) a portable heater, (7) a room air conditioner, (8) a central air conditioner, and (9) a dish washer.

Section 4 entitled "Energy saved in the Household". After explaining that "turning off a 100-watt incandescent light bulb for one hour SAVES 100 units of energy," the participants were asked to fill in a blank for how many units of energy they thought each of the following changes would save: (1) replacing one 100-watt incandescent bulb with an equally bright compact fluorescent bulb that is used for one hour, (2) replacing one 100-watt kitchen bulb with a 75-watt bulb that is used for one hour, (3) drying clothes on a clothes line instead of using an electric dryer for one load of laundry, (4) in the summer: turning up the thermostat on your air conditioner (making your home warmer) by 5° F, (5) in the winter: turning down the thermostat on your heater (making your home cooler) by 5° F, and (6) changing washer temperature settings from "hot wash, warm rinse" to "warm wash, cold rinse" for one load of laundry.

In Section 5, “Energy saved by Transportation”, participants were first asked to assume that a “20-miles-per-gallon car going 60 miles per hour uses 100 units of energy in one hour”. Here, 100 units are equal to 3 gallons of gasoline, which is roughly equal to 100 kWh. Then they were asked to fill in a blank for: (1) how many units of energy they would save in an hour by driving a more fuel efficient car, 30 rather than 20 miles per gallon, at 60 miles per hour, (2) how many units of energy they would save in a year by tuning up the car twice per year (including air filter changes), and (3) how many units of energy they would save in reducing their speed from 70 to 60 miles per hour when driving a 20-miles-per-gallon car for 60 miles.

Section 6 was “Energy Used to Transport Goods” where the participants were asked to rank four modes of transporting one ton of goods over a fixed distance by (1) ship, (2) train, (3) airplane, and (4) truck, with response options (most energy, second most energy, third most energy, and least energy). Section 7 was “Energy Used in Recycling and Manufacturing” where the participants were asked to rank four activities by how much energy they use for (1) making a can out of virgin aluminum, (2) making a can out of recycled aluminum, (3) making a glass bottle out of virgin glass, and (4) making a glass bottle out of recycled glass, with the same response options as the previous section.

Sections 8 and 9 were “Ease or Difficulty of Energy-Saving Behaviors” that asked the participants to indicate how easy or hard it would be for them to make each of several changes. They were asked to consider all aspects of the changes, including the physical or mental effort required, the time or hassle involved, and any relevant monetary costs. These 15 behaviors were taken from the 27 behaviors in the short list (Gardener & Stern, 2008): (1) buying a more fuel efficient automobile (31 vs. 20 miles per gallon), (2) carpooling with one other person to work, (3) replacing poorly insulated windows with highly insulated windows, (4) cutting highway speed from 70 miles per hour to 60 miles per hour, (5) installing a more efficient home heating unit (92% efficient), (6) turning down the thermostat from 72° F to 68° F during the day and to 65° F during the night during the winter, (7) turning up the thermostat on a room air conditioner from 73° F to 78° F during the summer, (8) tuning up the car twice a year (including air filter changes),

(9) replacing 85% of all incandescent bulbs with equally bright compact fluorescent bulbs, (10) turning up the refrigerator thermostat from 33° F to 38° F and the freezer thermostat from –5° F to 0° F, (11) drying clothes on a clothes line instead of using an electric dryer for 5 months of the year, (12) watching 25% fewer hours of TV each day, (13) installing a more efficient washer (replace a 2001 or older non–Energy Star washer with a new Energy Star unit), (14) changing washer temperature settings from "hot wash, warm rinse" to "warm wash, cold rinse," and (15) replacing two 100-watt kitchen bulbs with 75-watt bulbs. Response options were on a seven-point scale ranging from 0 (extremely easy) to 7 (extremely hard), with an added option on the left-hand side of the scale "Do it already," which was coded separately.

Sections 10 and 11 were the "Attitude" portion of the survey, where participants completed the Revised New Ecological Paradigm (NEP) scale which assesses pro-environmental attitudes (Dunlap et al., 2000). The validated NEP scale is a set of 15 statements to assess an individual's beliefs about his or her ability to change the balance of nature, the limits to growth of human societies, and the right of humans to rule over the rest of nature. Each of the 15 statements on the NEP (e.g., "The so-called 'ecological crisis' facing humankind has been greatly exaggerated") was followed by a seven-point scale ranging from 0 (completely disagree) to 6 (completely agree). For each participant, we computed an overall NEP score by the averaging his or her responses to the 15 items.

In Section 12, "Climate Change Attitude", participants were asked four questions relating specifically to personal efficacy and belief in climate change. On a scale ranging from 0 (completely disagree) to 6 (completely agree), they were asked to indicate how much they agreed with the following statements: (1) humans are responsible for global warming and climate change, (2) humans do not need to change their lifestyles to address global warming and climate change, (3) I believe that my actions contribute to global warming and climate change, and (4) I believe that I need to change my lifestyle to address global warming and climate change.

After the attitude questions, Section 13 asked participants to answer three open-ended questions to assess their facility with basic probability and numerical concepts, a construct called “numeracy” (Schwartz et al., 1997). These questions were: (1) Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips? (Answer: 500) (2) In the BIG BUCKS LOTTERY, the chance of winning a $10 prize is 1%. What is your best guess about how many people would win a $10 prize if 1000 people each buy a single ticket to BIG BUCKS? (Answer: 10) (3) In ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percent of tickets to ACME PUBLISHING SWEEPSTAKES wins a car? (Answer: 0.1)

Sections 14 and 15 asked participants about their current behaviors and demographics with response options “yes” and “no.” First, they were asked if they consumed more or less energy than the average household, how much they paid for electricity and gas last month, the number of people in their household, and whether or not they currently owned a vehicle. Then they were asked if they had any compact fluorescent lights in their home, if they thought of energy efficiency when buying large household appliances, if they thought of energy efficiency when buying small household appliances, if they had an energy audit of their home, if they weatherized their home, if they had purchased renewable energy, if they had sent a letter to an official about energy issues, and if they considered themselves environmentalists.

Participants also reported if they rented or owned where they lived, whom they voted for in the last election (Barack Obama, John McCain, an Independent candidate, chose not to vote, could not vote, or did not want to divulge) and their political views (with response options on a 1–7 scale ranging from extremely liberal to extremely conservative). The survey ended with demographic questions regarding their gender, age, family income before tax, and highest level of education completed, along with the participant’s zip code and the participant’s email address for payment. The complete survey is shown in Appendix C.2.

4.4 Results

4.4.1 Demographics

Data from the U.S. Census Bureau (2007a) was used to indicate how representative our sample was. Our sample median was in the $50,000-$79,999 range (where the median family income in the U.S. is $60,374 as reported by the U.S. Census Bureau), 34.8% of our sample was male (49.2% in the U.S. population), and 62.8% own their homes (67.3% own homes in the U.S). The median age in our sample was 31 years (36.4 years in the U.S.). All the participants who were 25 or older held high school diplomas (84% in the U.S.) and 41% have a bachelor's degree (27% in the U.S.).

Of the popular votes cast in the 2008 elections, Barack Obama won 52.9% and John McCain won 45.7% (Office of the Clerks, 2009), whereas 53% of our participants voted for Barack Obama, 20% voted for John McCain, 11% chose not to divulge, 10% chose not to vote, and 5.9% could not vote. Self-reported political views included 47% liberals (scale score = 1–3), 31% moderates (score = 4), and 22% conservatives (score = 5–7). The average NEP score of 3.6, relative to the scale mid-point (3), indicates that our sample is slightly pro-environmental. Our sample's average NEP score resembles the results found by Scott and Willits (1994) in their statewide survey of Pennsylvania (n = 3,632), using an earlier 12-item version of the NEP scale. Average climate change attitude score of 3.6 shows that our sample was more aware of climate change relative to the scale mid-point (3).

Of all participants in the study, 37% considered themselves environmentalists, 20% had sent a letter to their representative about energy issues, 19% bought renewable energy, 63% had double pane windows, 59% had weatherized their homes, 18% had done a home energy audit, 65% thought of energy efficiency while buying small appliances, and 92% thought of energy efficiency while buying large appliances. The high percentages of participants that currently engage in pro-environmental behaviors may indicate some selection bias.

4.4.2 Perceptions of energy saving behaviors

4.4.2.1 Open-ended responses

Two judges independently coded participants' responses for the open-ended question asking for the most effective thing that they could do to conserve energy in their lives. Responses were divided into 17 categories as shown in Table 4.4. The coding showed high reliability, as suggested by a Cohen's kappa of 0.82, where a score of 0.81-1.00 implies 'almost perfect agreement' (Landis & Koch, 1977).

Table 4.4. Behaviors provided by participants when asked for the most effective thing they could do to conserve energy in their lives.

Behaviors	Percentage of participants
Turning off the lights	19.6
Conserving energy	15.0
Drive less / Bike / Use public transportation	12.9
Change the setting on the thermostat	6.3
Change my lifestyle / Not have children	5.9
Unplug appliances	5.7
Shut off appliances / Use appliances less	4.9
Recycle	4.2
Other (for behaviors only mentioned once)	4.0
Education / Thinking about my actions	3.8
Use energy efficient bulbs	3.6
Use energy efficient appliances	3.2
Use efficient cars/ Hybrids	2.8
Sleep more / Relax more	2.8
Buy green energy / Solar energy / Alternative energy	2.6
Insulate my home	2.1
There is no way / I don't know	0.8

The behavior mentioned by most participants was turning off the lights, second was conserving energy in general, third was driving less, biking more or using public transportation. Note that energy efficiency (i.e., using energy efficient light bulbs, appliances and cars) only accounts for about 10% of the participant's responses, however curtailment (i.e., turning off appliances and lights, changing thermostat settings, driving less, changing lifestyles, unplugging appliances) accounts for 73% of the participant's responses.

4.4.2.2 Perceptions of energy used and saved

Perceptions of energy used and saved from three sections (Energy Used by Devices in One Hour, Energy Saved in the Household, and Energy Saved by Transportation) were first transformed by a logarithm base 10 function, because the data encompassed many orders of magnitude leading to a skewed distribution. The logged perceptions were then averaged and compared to logged averages of the actual energy used or saved by the behaviors, as shown in Figure 4.1. The 45° line indicates perfect perceptions, i.e., where perceptions are equal to the actual values. The behaviors from the first section "Energy Used by Devices in One hour" are referred to as "Energy Used" and the behaviors from "Energy Saved in the Household" and "Energy Saved by Transportation" are referred to as "Energy Saved".

The best fitting quadratic curved line has a trajectory that increases as actual energy use increases, indicating that participants have a rough idea about which behaviors use more energy than others. However, the estimates of energy consumption are highly regressive, particularly for high-energy behaviors, where the curved line almost flattens. This implies that participants do not make any specific distinctions between any of the appliances despite the 10-fold difference in actual energy use. The primary bias is an overestimate of how much energy is used or saved by low-energy behaviors, and an underestimate of how much energy is used or saved by high-energy behaviors. The crossover range for the average participant lies between 80 and120 Watt-hours; on average, all behaviors with energy use below this range were overestimated and all behaviors with energy use above this range were underestimated. In specific, people know that laptop computers consume less energy than desktop computers, but they are unable to judge by how much. They correctly estimate how much energy changing the thermostat setting in the summer would save, however they incorrectly assume that the savings are the same for changing the thermostat setting in the winter, a difference that arises because the U.S. expends more energy on heating than cooling (DOE, 2008). However many of our participants are from the south, where the temperature difference is not as great.

Figure 4.1 also shows that people believe driving a more efficient car for one hour saves the same amount of energy as tuning up the car once a year; where in reality tuning the car actually saves more than an order of magnitude of energy. They believe that changing the washer's setting saves less energy than line-drying clothes, however changing the washer's setting saves more energy than line-drying. People assume that a room air conditioner and a central air conditioner use the same amount of energy, when in fact the central air conditioner uses a lot more energy. On average, people underestimate energy consumption, a finding we explore in further detail later.

The regression curves were very similar for the "Energy Used" group and the "Energy Saved" group; however people underestimate energy saved much more than energy used. One such example is that an electric dryer uses the same amount of energy as line-drying clothes would save; however people estimate that line-drying saves less energy than how much the electric dryer uses.

Figure 4.1. Actual energy used and saved versus perceptions of energy used and saved for different behaviors. Error bars (barely visible around the symbols) indicate 95% confidence intervals. (Curved lines are the best-fitting quadratic: log (Perceptions of Energy Used) = -0.12[log (Actual)]^2 + 0.8 log (Actual) +1; log (Perceptions of Energy Saved) = -0.10[log (Actual)]^2 + 0.7 log (Actual) +0.89).

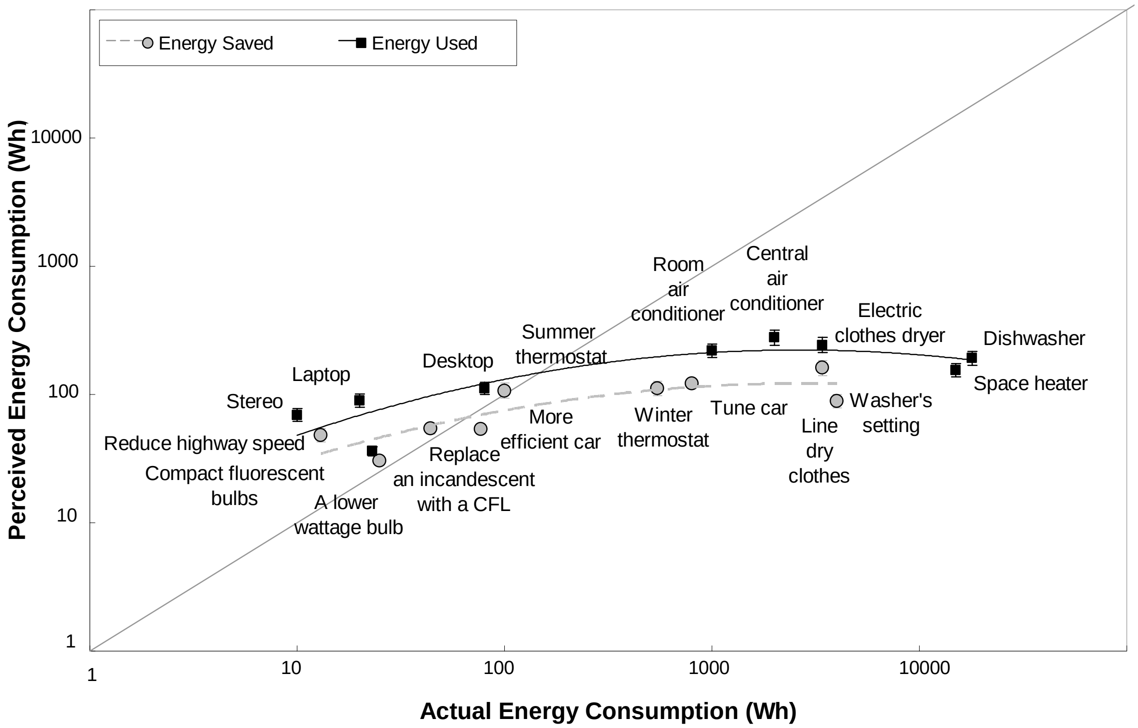
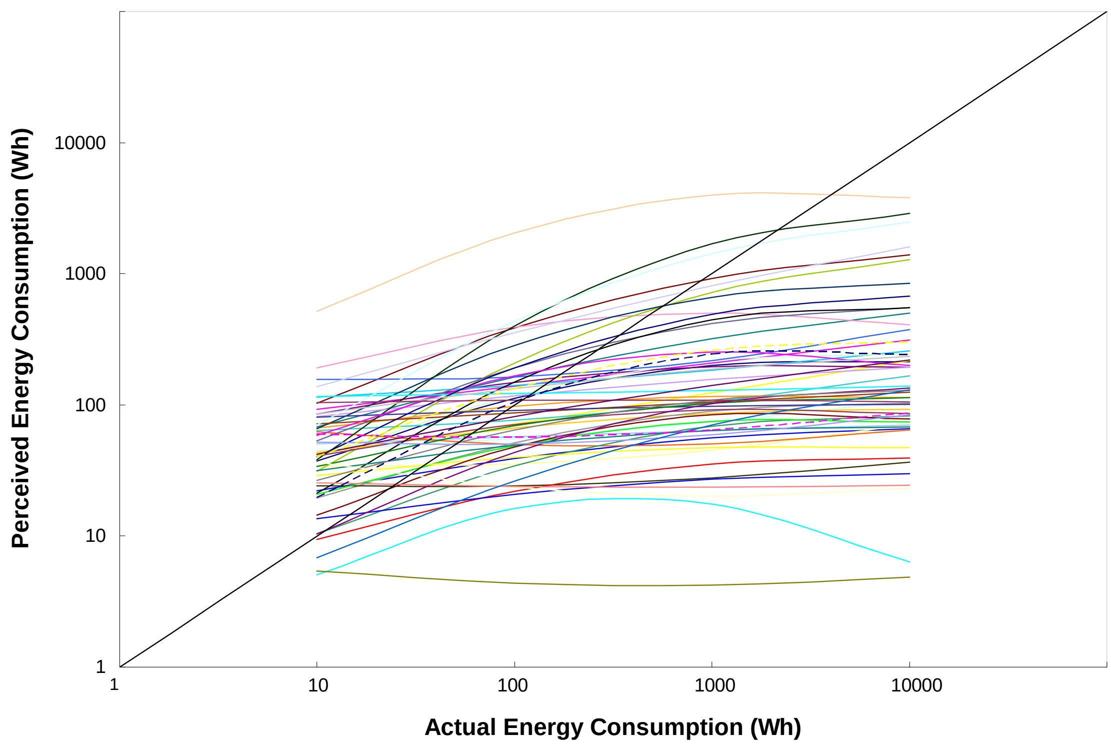


Figure 4.1 indicates how the average perceptions are related to actual energy use and savings, but it glosses over potentially interesting variation among participants. To illustrate individual differences in perceptions of energy consumption, a quadratic regression curve was fit for each of participants. Results for 50 randomly selected participants are shown in Figure 4.2. The results show the model: log(Perception) = A + B×[log(Actual) – mean log(Actual)] + C×[log(Actual) – mean log(Actual)]^2. The results show that there is a large variation in slopes and intercepts for individuals' perceptions of energy consumption compared to actual energy consumed. The mean intercept (A in the above equation) is 2.06 (SD = 0.48), the maximum value of the intercept is 4.67 and the minimum value is 0.07. The mean slope (B in the above equation) is 0.20 (SD = 0.17), the maximum slope for our sample is 0.81 and the minimum slope is -0.15. Note that there appears to be more variation in participants' intercepts than in participants' slopes. In later analyses, we attempt to explain this variation in elevations and slopes on the basis of participants' characteristics.

Figure 4.2. Individual participant's quadratic trend-lines for a sample of 50 participants for the 18 activities investigated for energy used and saved.



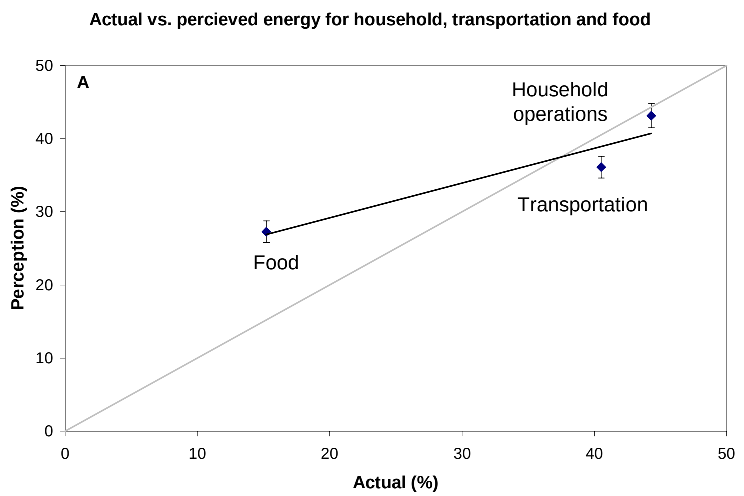
Similarly, participant's perceptions were averaged separately for three other sections: Energy Consumed by the Average Household, Energy Used to Transport Goods, and Energy Used in Recycling and Manufacturing, and compared to the actual percentages and energy consumption data as shown in Figure 4.3.

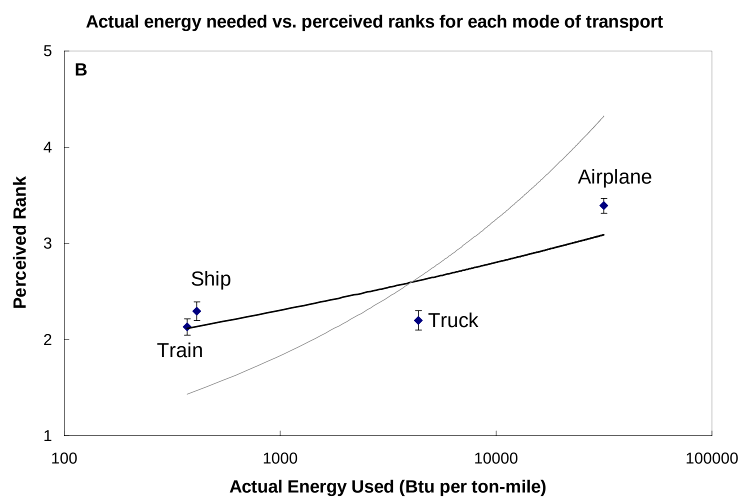
In panel A of Figure 4.3, participants have correct ordering for the percentage of the total energy consumed per year by household operations, transportation, and food production. However, they overestimate energy consumed by food production and underestimate energy used by transportation. Note that people's estimated percentages for the three sectors summed to more than 100% on average (as the survey did not impose this constraint).

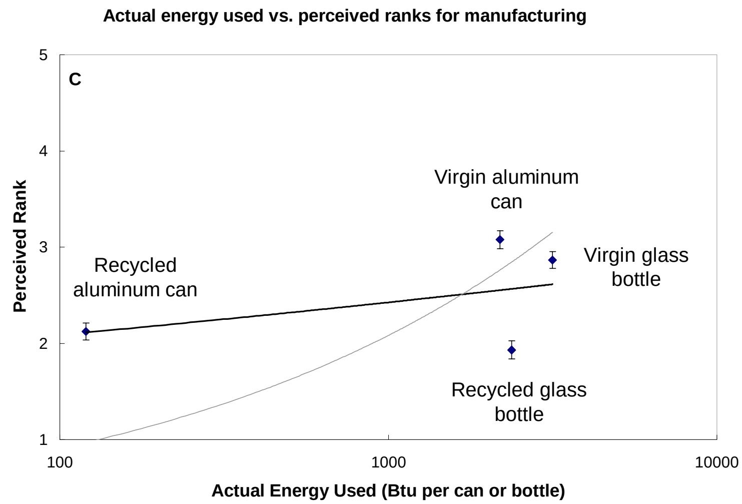
In panel B of Figure 4.3, people correctly perceive that the difference between energy used by trains and ships to transport goods is small. However they incorrectly assume that transporting goods via trucks consumes the same amount of energy as ships and trains, even though in reality trucks consume about 10 times more energy than trains and ships. People also correctly note that transporting goods via airplanes consumes the most energy of all four modes of transportation.

In panel C of Figure 4.3, the data shows that people incorrectly assume that making a recycled aluminum can uses the same amount of energy as making a recycled glass bottle, where in actuality making a recycled glass bottle uses much more energy. Manufacturing a recycled glass bottle uses roughly the same amount of energy as manufacturing a virgin aluminum can; however people assume that manufacturing a virgin aluminum can uses more energy than the recycled bottles. Finally manufacturing a virgin glass bottle uses more energy than manufacturing a virgin aluminum can (primarily because glass bottles weigh much more than metal cans), however people misperceive that manufacturing a glass bottle uses less energy than manufacturing a virgin aluminum can. These results imply that even though many communities encourage recycling efforts, by not knowing what actually consumes more energy to manufacture, people may not know where to direct their limited effort.

Figure 4.3. Mean estimates of perceptions of energy used and saved for: (A) Energy Consumed by the Average Household, (B) Energy Used to Transport Goods, and (C) Energy Used in Recycling and Manufacturing. (Best-fitting lines are: (Perception percentage) = 0.48 (Actual percentage) + 20; (Rank energy use in transportation) = 1.3 log $(\text{Actual})^{0.085}$; and (Rank energy in recycling and manufacturing) = 1.5 log $(\text{Actual})^{0.06}$; Grey lines in panel B and C are actual ranks vs. actual energy consumed: (Rank energy use in transportation) = 0.3 log $(\text{Actual})^{0.25}$; and (Rank energy in recycling and manufacturing) = 0.17 log $(\text{Actual})^{0.36}$).







4.4.2.3 Results of separate regressions

Results of the separate regressions for each participant (the intercepts and slopes) were used as the dependent variable in the regression in an attempt to explain some of the variation seen in Figures 4.1 and 4.2. An example of this method of analysis from risk perception was demonstrated by Willis and DeKay (2007), who predicted slopes (relationships between hazards' scores on psychometric dimensions and the judged riskiness of those hazards) on the basis of participant characteristics like group membership, NEP scores, etc. Similarly, we model the intercepts and slopes as a function of NEP score, Climate change attitudes, Numeracy, More than average (whether participants thought they consumed more energy than average or less energy than average), Owns Car (whether participants currently own a car), Environmental Behavior (whether participants currently engage in environmental behaviors), Owns or rents (whether participants currently own or rent their home), Democrat, Republican, Chose not to vote, Could not vote, political views, gender, age, income, and education. Results appear in Table 4.5.

Note that the predictor parameter "Environmental Behaviors" was constructed by counting nine behaviors which were dichotomous variables (owns compact fluorescent lights, looks at energy efficiency for large appliances, looks at energy efficiency for small appliances, conducted energy audit of home, weatherized home, installed double pane windows, bought renewable energy, wrote a letter about energy, and considers self to be environmentalist). The Kuder-Richardson formula 20 coefficient (KR-20) for these behaviors was 0.65, where a value of 0.7 and higher indicates strong group characteristic.

Analogously, we conducted a separate regression for each participant for each of the question types in Figure 4.3 (percentages of energy consumed by the average household, ranks of energy used to transport goods, and ranks of energy used in recycling and manufacturing) using the same predictor parameters as before, as shown in Table 4.5. The intercepts (elevations) in these regressions were not of interest, because the average percentages and ranks were not completely free to vary across participants (the average percentage should have been 33% and the average rank was constrained to be 2.5). However, differences among participants' slopes reflect differences in the accuracy of perceptions.

The observed intercept in the regression to predict the intercept is less than zero (-0.44), indicating that on average participants underestimate energy use. This underestimation is also seen in Figures 4.1 and 4.2, where the majority of the trend-lines are under the 45° line. Positive coefficients for predictors mean greater accuracy. For the other intercepts in the regressions to predict slopes, significant positive values indicate participant understanding of differences in energy consumption between the behaviors.

Looking at predictors for well informed perceptions, we find that the NEP score is always positive and significant; indicating that people who are pro-environmental are more likely to know how much energy is used or saved by different behaviors. When significant, the environmental behaviors parameter estimate is always negative, which may indicate that people who do some environmental behaviors may have misperceptions abut other behaviors because they simply focus on the behaviors they currently do. Another possibility is that some people just "do everything they can" regardless of whether they know how much energy those behaviors save. Numeracy is always positive and often significant, which indicates that people who have a good understanding of numerical concepts have better perceptions of energy consumption. There is some indication that people who do not vote or could not vote are less accurate, which could be due to being generally less engaged. The adjusted R^2 values are fairly low for all of the models indicating that there is some unexplained variation.

Table 4.5. Results of linear regressions for predicting an individual's perception of energy consumption. Intercept and slope are shown for (1) energy used or saved, and slopes for (2) percentage of household, transportation and food, (3) ranks of energy used in modes of transport, and (4) ranks of energy used in recycling and manufacturing.

Predictor	Estimates for household activities (intercept in Figures 4.1 and 4.2)	Estimates for household activities (slope in Figures 4.1 and 4.2)	Percentages for household, transportation, and food (slope in Figure 4.3A)	Ranks for transportation modes (slope in Figure 4.3B)	Ranks for aluminum and glass (slope in Figure 4.3C)
Intercept	-0.44***	0.20***	0.36***	0.48***	0.25**
Numeracy	0.081**	0.046***	0.045	0.086*	0.02
NEP	0.12**	0.055***	0.10*	0.13*	0.17*
Climate change attitude	0.0073	-0.016	-0.0073	0.093	0.053
Environmental behaviors (count)	-0.021	-0.0076	-0.035*	-0.060**	-0.12***
Uses more energy than average	-0.021	-0.017	-0.093*	-0.039	-0.12
Owns car	-0.11	0.033	-0.090	0.051	0.10
Owns home	0.059	0.014	0.14	0.10	0.24*
Democrat	-0.10	-0.029	0.0045	-0.13	-0.039
Republican	-0.077	-0.016	0.033	-0.17	0.12
Chose not to vote	-0.20*	-0.055	0.0012	-0.33*	0.056
Could not vote	-0.30**	-0.079*	-0.20	0.046	-0.42
Political views	0.0055	0.0031	0.021	0.015	0.017
Male	0.017	0.0070	0.0090	-0.022	-0.026
Age	-0.0020	0.0016	0.0029	0.0065	-0.0039
Income	0.027	0.0036	-0.026	-0.051	-0.024
Education	0.019	0.0095	-0.040	0.054	-0.0046
Adjusted R^2	0.13	0.17	0.07	0.11	0.10

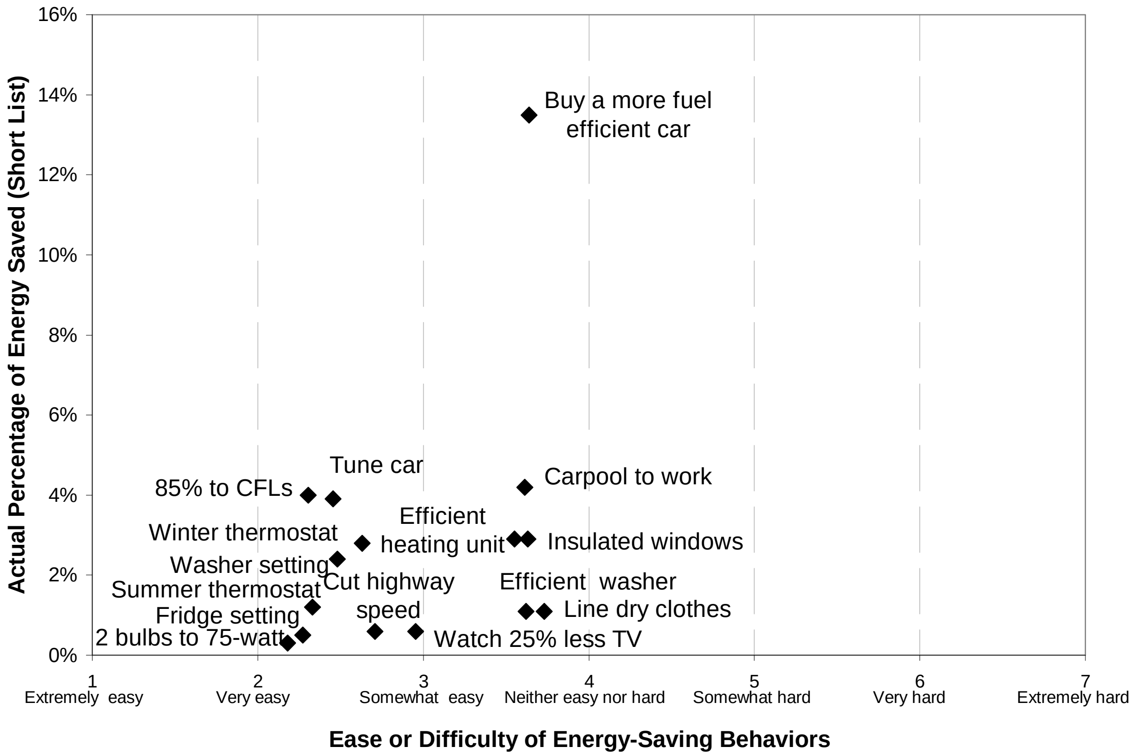
NOTES: All predictor parameters are centered by subtracting the mean value of each parameter. In addition, the intercept gives the elevation at the average value of Log(Actual) (in the middle of the curves), and the slope gives the slope at the average value of Log(Actual). The test for the intercept was conducted versus the mean of Log(Actual) rather than zero to provide a statistical test for over/under estimation. This was done by subtracting the mean of Log(Actual) from each participant's intercept before doing the regression. Also note that 'who the participant voted for' was coded into Democrat, Republican, Chose not to vote and Could not vote. The excluded category is 'Do not want to divulge'. The coefficients for the four categories give the difference between the coded categories (say Democrat) and Do not want to divulge.

Asterisks denote significance level: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

4.4.2.4 Ease or Difficulty of Energy-Saving Behaviors from the Short List

Participants' responses to how easy or hard they found the fifteen behavioral changes from the short-list (Gardener & Stern, 2008) were averaged and plotted against the actual percentage of energy saved by incorporating those behaviors, shown in Figure 4.4. None of the 15 short list behaviors were viewed as difficult to do. Behaviors that would be in the upper left corner of the figure are those that save a lot of energy and would be easier to do. Some behaviors that are close to the upper left are switching two 100-watt bulbs in the kitchen to 75-watt bulbs and tuning one's car. Behaviors farther to the right in the figure are harder to do, both in terms of hassle (carpooling to work with one other person and line drying clothes for five months of the year) or expense (buying a more efficient car and replacing washers and windows). Tuning one's car saves much more energy than cutting highway speeds, and people found tuning their car to be a bit easier. Buying an efficient car saves much more energy than carpooling to work with one other person, but is viewed as equally easy or difficult. Replacing 85% of the incandescent bulbs at home with Compact Fluorescent Lighting (CFLs) is about as easy as replacing two 100-watt kitchen bulbs with 75-watt bulbs. However, the lower wattage bulbs save much more energy than switching to CFLs, due to the amount of time spent in the kitchen.

Figure 4.4. Perceptions of how easy or hard behaviors will be to adopt versus the actual energy saved from the short-list (Gardener & Stern, 2008)



4.5 Discussion

When our participants were asked for the most effective thing that they could do to conserve energy in their lives, only 10% stated efficiency-improving actions and 73% stated curtailment. By contrast, Gardener and Stern (2008) found that efficiency-improving actions generally save more energy and reduce carbon emissions more than curtailing use of inefficient equipment. Thus, participants showed systematic misperceptions of which behaviors may reduce energy. This finding also implies that people may be discouraged from conserving energy as they primarily focus on curtailment rather than energy efficiency, where curtailment may be much harder to implement than efficiency.

Participants' perceptions of energy consumption tend to overestimate energy consumption and savings for low-energy behaviors and underestimate energy consumption and savings for high-energy behaviors (Figure 4.1). This pattern is similar to perceptions of risk of death, where low risk events are perceived as being higher risk, and high risk events are perceived as being lower risk, also known as the overestimation/underestimation bias (Lichtenstein et al., 1978). One possible explanation is that the participants were provided an anchor of 100 watt-hours and adjusted their estimates of energy consumption and savings insufficiently from this anchor (Kahneman & Tversky, 1973). An alternative explanation is that the results reflect a tendency to move towards the mean, or regression to the mean. Because perceptions are imperfectly correlated with actual values, perceptions of low-energy behaviors are expected to be closer to the mean value and therefore too high. Similarly, perceptions of high-energy behaviors are expected to be closer to the mean value and therefore too low. Therefore regression to the mean is occurring to some extent. One characteristic of regression toward the mean is that x and y can be interchanged and the regression effect will still be obtained (Furby, 1973). If the results were due completely to regression to mean, then the slope in this reversed regression should also be less than 1.0. The average participants' slope was 0.20 (see Table 4.5). However, the observed slope in interchanged simple linear regression involving average values was 1.32, which indicates that regression to the mean does not completely explain the shallow slopes in Figures 4.1 and 4.2. Moreover the slope for the higher-energy activities (those on the right of Figure 4.1) is essentially flat, indicating that people have very little knowledge of the relative energy use and possible energy savings associated with these activities. Remarkably, participants in this study were unable to distinguish among various household appliances, even though some of those appliances (e.g., a dishwasher or space heater) use 10 times as much energy as others (e.g., a room air conditioner).

People are able to correctly order the percentage of the total energy consumed per year by household operations, transportation, and food production, as shown in Figure 4.3A. However, they overestimate energy consumed by food production and underestimate energy used by transportation. There are other substantial misperceptions in energy consumption, where average estimates show that people rank the energy consumed by transporting one ton of goods per mile by ship, train and truck as the same, even though trucks use roughly ten times the amount of energy as ships or trains (Figure 4.3B). Additionally, people erroneously believe that manufacturing a recycled aluminum can uses the same amount of energy as manufacturing a recycled glass bottle, where the recycled glass bottle uses roughly twenty times the amount of energy as that needed to manufacture a recycled aluminum can (Figure 4.3C).

On average, participants underestimate how much energy different behaviors consume or save. Those who are numerate and pro-environmental are more likely to have more accurate perceptions of energy consumption (Table 4.5). However participants who currently engage in environmental behaviors have worse perceptions than their counterparts. One possible reason for this finding could be that these individuals focus their attention on the few behaviors they currently engage in, incorrectly assuming that these behaviors save a lot of energy, and ignore other high-energy behaviors, an idea related to the theory of cognitive dissonance (Festinger, 1957). Alternatively, some people may be doing everything they can, regardless of how much energy those behaviors actually save (or are perceived to save). In this do-all-you-can strategy, a person might feel that they do not need to know the relative effectiveness of different behaviors, because every little bit helps. Such a person might have little incentive to pay attention to relative energy consumption.

None of the behaviors in the short list was viewed as being difficult to do (Figure 4.4). This indicates that changing behavior may not be as difficult to individuals as previously believed. It is unlikely that the low difficulty ratings reflect social desirability in responses as we did not observe unrepresentative results for NEP responses, which might be expected to have similar demand characteristics. Additionally, there is enough variation in perceptions of difficulty to isolate behaviors that save the same percentage of energy, and that are perceived easier or harder to do. An example is that “Tune car” (tuning up the car twice a year, including air filter changes), and “Carpool to work” (carpool to work with one other person) roughly save the same amount of energy, but participants find tuning their car significantly easier than carpooling.

One question raised by this study is how to improve lay perceptions of energy consumption to facilitate energy conservation. There have been many campaigns focusing on behaviors that save relatively small amounts of energy, like installing one compact fluorescent bulb in place of an incandescent one; however there are many other behaviors that might save much more energy but which have thus far been neglected. If people do not have accurate information about how much energy they save by changing their behaviors, they may change low-energy behaviors that may be high-effort and feel like they are doing their part, instead of expending their effort on high-energy behaviors. Given that there is no quick fix to climate change, it is vital that risk communications also deal with perceptions of energy consumption, so that scientists provide the public with information in a credible and comprehensible manner to facilitate better climate-related decisions.

4.6 References

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Chapter 5. Conclusions

The three studies in this thesis have considered demand-side issues related to global climate change by investigating (1) an intervention to change energy-intensive behaviors, (2) preferences to change behavior, and (3) perceptions of energy consumption. This work has potential to inform and motivate behavior change that will be a vital force in promoting energy conservation and efficiency. It will also reinforce the need for technological innovation that can lead to mitigation and adaptation under climate change.

5.1 Summary of findings

The first study of this thesis, described in Chapter 2, showed that an accountability intervention did not change many energy-intensive behaviors. Independent of group assignment, participants positively changed *Aggregated behavior removing seasonal components.* This change implies that, on average, participants changed their overall behaviors to those that were energy conserving. Because these behavior changes occurred in the intervention and both control groups, it could be attributed to attention-focusing of the surveys and logs, which made different behaviors salient to some participants, who adopted conserving behaviors as a result of being part of the study.

Kurt Lewin (1951) likened individuals to *tension systems*. When certain interventions face strong opposition, they may not work; weaker interventions, if the system is in balance, can sometimes have greater impact. The study described in Chapter 2 used a relatively small-scale intervention that was easy to implement to facilitate energy conservation. However, the results showed that simply focusing a participant's attention on conserving behaviors was not enough to significantly incorporate conserving behaviors into their lives. If we aim to decrease our carbon emissions per capita with minimal government interference and through self-regulation, we need to study stronger interventions and test their effectiveness by measuring behavioral change over time. There are many organizations that use awareness-raising interventions on lay audiences (via advertising) to facilitate energy conservation, but without testing interventions that simply inform and focus attention on energy saving behaviors, significant changes are unlikely. By researching stronger interventions with longitudinal measures of behavior, we can attempt to change high-energy behaviors that are salient to our current lifestyle.

Additionally the results of surveying perceived effort needed and energy saved in Chapter 2 suggest that participants distinguish between behaviors more in terms of perceived effort than in terms of perceived energy saved, so much so that participants assume taking one less round-trip flight each year saves about the same amount of energy as turning off the faucet while brushing one's teeth. Actually taking one less round-trip flight saves 20-100 times as much energy as turning off the faucet when brushing over one year. This tells us that the participants may not be aware of the relative energy savings for different behaviors, a finding corroborated by results later in the thesis. Correcting these misperceptions may help facilitate behavior change.

The study discussed in Chapter 3 showed that participants preferred voluntary actions to hard regulations for both goals of limiting SUVs and trucks and increasing green energy use. Participants favored soft regulations such as tax incentives over voluntary actions for the goal of limiting SUVs and trucks, but showed no clear preference between voluntary actions and soft regulations for the goal of increasing green energy use. Thus, our results suggest that there may be more public buy-in for softer regulations, such as market-based mechanisms intended to change behavior. Participants were more resistant to hard regulations, possibly resulting from psychological reactance (Brehm, 1966). *Personal freedom and choice* was the most frequently mentioned reason by participants who did not want to accept hard regulations. *Economic incentives* (such as monetary savings) were commonly mentioned as reasons for supporting voluntary action and soft regulation to limit SUVs and trucks.

The voluntary actions and regulations investigated in Chapter 3 are but snapshots of a range of possible voluntary actions, soft regulations, and hard regulations that can be used to effect behavior change. The specific actions and regulations used here were designed to cover a variety of factors such as degree of inconvenience, type of economic incentive, and extent of governmental control. To make more generalized conclusions about preferences for behavior change, we recommend investigating a variety of behavioral domains using specific actions and regulations, as there may be situations in which hard regulations are preferred to soft regulations and voluntary actions. Examples include regulations intended to protect personal health and safety.

The study described in Chapter 4 showed that when people were asked for the most effective thing that they could do to conserve energy in their lives, only 10% stated efficiency-improving actions and 73% stated curtailment. By contrast, Gardener and Stern (2008) found that efficiency-improving actions generally save more energy and reduce carbon emissions to a greater extent than curtailing use of inefficient equipment. This finding implies that people may be discouraged from conserving energy as they primarily focus on curtailment rather than energy efficiency, where curtailment may be much harder to implement than efficiency. Peoples' perceptions of energy consumption tend to overestimate energy consumption and savings for low-energy behaviors and underestimate energy consumption and savings for high-energy behaviors. Additionally, none of the 15 behaviors in the short list of Gardener and Stern (2008) were viewed as being difficult to do.

5.2 Future work

This thesis has attempted to add to the scarce literature on climate change and human behavior. There are many questions raised by this thesis:

1) How can we improve lay perceptions of energy consumption to facilitate energy conservation?
2) What policy tools and interventions can we use that will successfully decrease an individual's energy consumption?
3) What decisions do individuals make today that can be better informed to decrease environmental stresses?
4) In what ways are individuals willing to curtail behaviors now to benefit future generations?

5) What do individuals understand about the risks of anthropogenic climate change, both to themselves and future generations?

To answer these questions, we must understand how people aim to solve a problem (a) which is a social dilemma, where private interests are at odds with collective interests, (b) whose consequences they themselves may not bear, (c) whose environmental, economic, and social consequences have a high degree of uncertainty associated with them, and (d) where personal efficacy may be too insignificant to make a difference.

Answers to these questions may then provide insight into how decision makers can guide our society to reduce carbon emissions and global climate change.

5.3 References

Brehm, J. W. (1966). *A Theory of Psychological Reactance*. New York: Academic Press.

Gardener, G., & Stern, P. (2008). The short list: The most effective actions U.S. households can take to curb climate change. *Environment Magazine, 50*(5), 12-24.

Lewin, K. (1951). *Field theory in social science*. New York: Harper & Brothers New York

Appendix A: Decreasing Demand

A.1 PRE and POST SURVEY

IRB protocol
1) Do you agree? _ } *<Only in Pre-Survey>*

Thank you for taking part in this research. This survey is intended to capture your long-term actions and behaviors. To the extent possible, please base your responses on your memory of actual events in the given time frame. To get started, please enter your subject code.

2) What is your subject code number? _

Transportation Questions

3) How many vehicles (cars, trucks, or vans) are owned or leased by people in your household (including yourself)?
   _0 vehicles
   _1 vehicle
   _2 vehicles
   _3 vehicles
   _4 vehicles
   _more than 4 vehicles

4) For the vehicle you use most, approximately what is the vehicle's gas mileage? (Assume your normal mix of city and highway driving.)
   _ less than 10 miles per gallon
   _11-20 miles per gallon
   _21-30 miles per gallon
   _31-40 miles per gallon

_41-50 miles per gallon

_more than 50 miles per gallon

_I do not own or lease a vehicle.

5) For the vehicle you use most, do you get your engine tuned up at least once a year?

_Yes

_No

_I do not own or lease a vehicle.

6) For the vehicle you use most, do you check that the tires are properly inflated at least four times a year?

_Yes

_No

_I do not own or lease a vehicle.

Household Questions

7) How many people live in your household (including yourself)?

_1 person

_2 people

_3 people

_4 people

_5 people

_more than 5 people

8) How far do you live from work?

_less than 2 miles

_2-5 miles

_6-10 miles

_11-20 miles

_21-30 miles

_more than 30 miles

9) Approximately, how many compact fluorescent light bulbs or fluorescent linear bulbs (tube lights) do you have installed in your home?
_none
_1-3 bulbs
_4-6 bulbs
_7-10 bulbs
_11 bulbs or more
_I do not know.

10) What is the approximate floor area of your home?
_1-500 square feet
_501-1000 square feet
_1001-2000 square feet
_2001-3000 square feet
_more than 3000 square feet
_I do not know.

11) When buying large household appliances (like refrigerators, dishwashers, etc.), do you consider their energy efficiency in your purchasing decisions?
_Yes
_No
_I have not bought any large appliances.

12) When buying small household appliances (like coffee makers, blenders, etc.), do you consider their energy efficiency in your purchasing decisions?
_Yes
_No
_I have not bought any small appliances.

13) Which of the following water-saving devices do you have in your home? (Check all that apply.)

_Front-loading washing machine

_Water-saving faucets

_Water-saving showerheads

_Low-flush toilets

_None

_I do not know.

_Other_________

14) Have you ever had an energy audit of your home? (A home energy audit is done to evaluate measures you can take to make your home more energy efficient. You can audit your own home by going to the US Department of Energy website: http://www.eere.energy.gov/consumer/your_home/energy_audits/ .)

_Yes

_No

15) This past year, did you do anything to weatherize your home? (Examples include caulking and weather stripping to seal air leaks around windows and doors, etc.)

_Yes

_No

_No, I rent an apartment.

_No, my home is already weatherized.

16) Does your home have any double-paned windows (two glass panels set in a frame, separated by a small space) or storm windows (installed on the interior or exterior of the primary window)?

_Yes

_No

17) Have you ever bought renewable energy? (One option for Pittsburgh residents is purchasing energy from Community Energy Inc. One can buy electricity generated from renewable sources at a rate of 2.5 cents per kilowatt hour from this website: http://www.communityenergy.biz/ .)
_Yes
_No

Lifestyle Questions

18) Do you hold any socially or environmentally conscious mutual funds?
_Yes
_No

19) This past year, did you consciously avoid eating foods that were out of season? (Examples include avoiding strawberries and leafy vegetables in the winter.)
_Yes
_No

20) Are you a member of community-supported agriculture? (In community-supported agriculture programs, a member receives a basket of local produce from a farmer every week during the growing season.)
_Yes
_No

21) This past year, did you shop at any thrift stores? (Examples include Goodwill, The Salvation Army, etc.)
_Yes
_No

22) Have you ever signed up to reduce junk mail? (This can be done at http://opt-out.cdt.org/ .)

_Yes

_No

23) This past year, did you plant any trees?

_Yes

_No

24) Are you currently a member of any environmental organization?

_Yes

_No

25) This past year, did you donate money to any environmental organization?

_Yes

_No

26) This past year, did you send a letter to any political official about environmental or energy issues?

_Yes

_No

Opinion Questions

In your opinion, how easy or hard would it be for you to adopt each of the following actions?

	Extremely Somewhat hard	*Somewhat Extremely hard*	*Slightly easy hard*	*Not hard or easy*	*Slightly easy*		*easy*
27) Taking one less automobile trip per week.	0	1	2	3	4	5	6
28) Taking one less round-trip flight per year.	0	1	2	3	4	5	6
29) Never idling your vehicle for more than 2 minutes.	0	1	2	3	4	5	6
30) Reducing the time spent in the shower by 2 minutes.	0	1	2	3	4	5	6

31) Buying at least half of your fresh fruits and vegetables from Pennsylvania growers.	0	1	2	3	4	5	6
32) Bringing your own bags to the grocery store.	0	1	2	3	4	5	6
33) Always recycling your aluminum cans.	0	1	2	3	4	5	6
34) Reducing your electricity use at home by 10%.	0	1	2	3	4	5	6
35) Walking, bicycling, or taking public transportation (or a combination) rather than driving, once a week.	0	1	2	3	4	5	6
36) Turning off the faucet when you brush your teeth.	0	1	2	3	4	5	6

In your opinion, how much energy do you think each of the following actions would save?

	Would not Saves a lot save energy of energy			*Moderately*			*saves energy*
37) Taking one less automobile trip per week.	0	1	2	3	4	5	6
38) Taking one less round-trip flight per year.	0	1	2	3	4	5	6
39) Never idling your vehicle for more than 2 minutes.	0	1	2	3	4	5	6
40) Reducing the time spent in the shower by 2 minutes.	0	1	2	3	4	5	6
41) Buying at least half of your fresh fruits and vegetables from Pennsylvania growers.	0	1	2	3	4	5	6
42) Bringing your own bags to the grocery store.	0	1	2	3	4	5	6
43) Always recycling your aluminum cans.	0	1	2	3	4	5	6
44) Reducing your electricity use at home by 10%.	0	1	2	3	4	5	6

45) Walking, bicycling, or taking public transportation (or a combination) rather than driving, once a week.	0	1	2	3	4	5	6
46) Turning off the faucet when you brush your teeth.	0	1	2	3	4	5	6

Opinion Questions

Please indicate how strongly you agree or disagree with each of the following statements:

	Completely Completely agree	*Somewhat disagree agree*	*Slightly disagree*	*Neither agree disagree*	*Slightly nor disagree*	*Somewhat agree*	
47) Climate change (also referred to as global warming) is a real phenomenon.	0	1	2	3	4	5	6
48) Unless everyone else conserves energy, I will not conserve energy.	0	1	2	3	4	5	6
49) It important for individuals to reduce how much energy they use.	0	1	2	3	4	5	6
50) Humans have the right to consume as much energy as they like.	0	1	2	3	4	5	6
51) I would like to give up some of my possessions voluntarily in order to live a simpler life.	0	1	2	3	4	5	6
52) The current American lifestyle can be sustained with the natural resources we have.	0	1	2	3	4	5	6

Please indicate how strongly you agree or disagree with each of the following statements:

	Completely Completely agree	*Somewhat disagree agree*	*Slightly disagree*	*Neither agree disagree*	*Slightly nor disagree*	*Somewhat agree*	
53) I would like to exercise self-discipline in trying to reduce my consumption.	0	1	2	3	4	5	6
54) One person's actions to conserve energy will not make much of a difference.	0	1	2	3	4	5	6

55) Current climate change (also referred to as global warming) is caused by human activities.	0	1	2	3	4	5	6
56) Conserving energy takes too much effort.	0	1	2	3	4	5	6
57) The government has an important role to play in promoting energy conservation.	0	1	2	3	4	5	6
58) There is nothing I can change in my lifestyle that will decrease the amount of energy I use.	0	1	2	3	4	5	6
59) Regardless of what other people do, I want to conserve energy.	0	1	2	3	4	5	6

Demographic questions

60) What is your sex?

_Female

_Male

61) What is your age?

_20 years or less

_21-30 years

_31-40 years

_41-50 years

_51-60 years

_61 years or more

62) With which political party do you most closely identify?

_Democratic

_Republican

_Not sure

_None

_Independent (please specify): ___________________

63) Check the box that best represents your political views.

_Extremely liberal

_Slightly liberal

_Moderate

_Slightly conservative

_Extremely conservative

64) What is the highest level of education that you have completed?

_Some grade school or middle school

_Some high school

_High school diploma

_Some college

_College degree

_Some graduate school

_Graduate degree

_Some post-graduate school

_Post-graduate degree

65) What is your household's yearly income before tax?

_Do not have an income.

_$20,000 or less

_$20,001 - $50,000

_$50,001 - $80,000

_$80,001 - $110,000

_$110,001 - $140,000

_$140,001 - $170,000

_$170,001 or more

66) In your opinion, has being part of this study changed your attitudes in any way? (Please fill in below.)

<Only in Post-Survey>

67) In your opinion, has being part of this study changed your behavior in any way? (Please fill in below.)

<Only in Post-Survey>

68) Do you have any additional comments about this survey that you would like to share with us? (Please fill in below.)

<Reworded to read 'comments about this study' for Post-Survey>

Thank you for completing our survey. For any questions or further information please contact Shahzeen Attari at attari@andrew.cmu.edu .

<<<<<< Carnegie Mellon University Homepage >>>>>>

A.2 Log questions

Thank you for taking part in this research. This survey is intended to be a log of your actions and behaviors. To the extent possible, please base your responses on your memory of actual events in the given time frame. We are interested in what you actually did during the day or week in question, not what you usually do. When questions are asked about "this past week," we mean the most recent seven days, including today. To get started, please enter your subject code.

Appendix A: Decreasing demand

1) What is your subject code number? _

Questions about Transportation

2) Today, how did you arrive at work? (Check your primary mode.)

_Walk

_Bicycle

_Bus

_Motorcycle

_Carpool (with others from the community)

_Car, truck, or van (with others in your household)

_Car, truck, or van (alone)

_Did not travel to work

_Other _____________

3) Today, how did you or will you leave work? (Check your primary mode.)

_Walk

_Bicycle

_Bus

_Motorcycle

_Carpool (with others from the community)

_Car, truck, or van (with others in your household)

_Car, truck, or van (alone)

_Did not travel to work

_Other _____________

4) Yesterday, how did you arrive at work? (Check your primary mode.)

_Walk

_Bicycle

_Bus

_Motorcycle

_Carpool (with others from the community)

_Car, truck, or van (with others in your household)

_Car, truck, or van (alone)

_Did not travel to work

_Other _____________

5) Yesterday, how did you leave work? (Check your primary mode.)

_Walk

_Bicycle

_Bus

_Motorcycle

_Carpool (with others from the community)

_Car, truck, or van (with others in your household)

_Car, truck, or van (alone)

_Did not travel to work

_Other _____________

6) This past week, did you walk, bicycle, or take public transportation (or a combination) to any of your destinations rather than drive?

_Yes

_No

7) This past week, did you run several of your errands together so that you could take fewer trips?

_Yes

_No

_I only ran one errand this past week.

_I did not run any errands this past week.

8) This past week, did you carpool anywhere?

_Yes

_No

_I did not travel by car this past week.

9) This past week, can you remember a specific instance in which you kept your car idling for more than 2 minutes?

_Yes

_No

_I do not know.

_I did not drive this past week.

Questions about Household Behaviors

10) This past week, what percentage of the time did you turn off the lights when you were the last person to leave the room for more than ten minutes?

_about 0% of the time (almost never)

_about 25% of the time

_about 50% of the time (half of the time)

_about 75% of the time

_about 100% of the time (almost always)

11) The last time you brushed your teeth, did you turn off the faucet while brushing?

_Yes

_No

12) This past week, about how many baths did you take? _baths

13) This past week, about how many showers did you take? _showers

14) The last time you showered, about how many minutes did you spend in the shower? _minutes

15) Last night, did you or anyone in your household turn down the heat?

_Yes, turned it down manually.

_Yes, the heat is automatically turned down using a programmable thermostat.

_No, do not have control of the heat in my home.

_No, did not turn it down.

16) Last night, what was your thermostat setting?

_Do not know.

_Do not have a thermostat.

_Degrees Fahrenheit: ____________

17) Today, what was your thermostat setting?

_Do not know.

_Do not have a thermostat.

_Degrees Fahrenheit: ____________

18) This past week, did you unplug the following appliances or turn off their connecting power strip for any period of time when they were not being used? (Please provide an answer for each appliance.)

Yes/No/Do not own

TV_ _ _

VCR or DVD player_ _ _

Stereo_ _ _

Microwave_ _ _

Toaster oven_ _ _

Computer_ _ _

Questions about Shopping and Consumption

19) This past week, did you buy any fruits or vegetables from the farmers market?

_Yes

_No

20) This past week, did you consciously buy any locally produced fruits and vegetables at the grocery store?

_Yes

_No

_I did not go to the grocery store this past week.

21) This past week, did you consciously buy a product because it had less packaging than the other choices available?

_Yes

_No

_I did not buy any products this past week.

22) This past week, did you bring your own bags when you went shopping?

_Yes

_No

_I did not go shopping this past week.

Questions about Other Activities

23) This past week, what percentage of the time did you recycle aluminum cans that you used?

_about 0% of the time (almost never)

_about 25% of the time

_about 50% of the time (about half of the time)

_about 75% of the time

_about 100% of the time (almost always)

_I did not use any aluminum cans this past week.

24) This past week, did you have any conversations with friends or colleagues about energy or climate-change issues?

_Yes

_No

25) Yesterday, did you change your actions in any way that would either increase or decrease your energy use? If so, please specify. (This could either be something small like using a ceramic coffee cup instead of a disposable cup, or it could be something large like taking a flight or a road trip.)

26) This past week, did you change your actions in any way that would either increase or decrease your energy use? If so, please specify.

27) Do you have any additional comments about this log that you would like to share with us? (Please fill in below.)

Thank you for completing our log for this week. For any questions or further information please contact Shahzeen Attari at attari@andrew.cmu.edu .

<<<<<<CMU HOMEPAGE>>>>>>>>>

A.3 Interview with Reasons Group (R)

<Times contacted: ____________________>

<Time and date when contact successful: __________>

Hello. Is this <interview states the subject name and notes it here>:_____________________? I am calling regarding the interview you had scheduled for a Carnegie Mellon study on attitudes and behaviors. The interview will take only fifteen minutes. With your consent, I would like to record your responses on cassette tape for my own future reference. Your name will in no way be connected to your responses. Do I have permission to start recording at this time?

<Wait for response>

Okay. I am starting the tape recorder. Can I ask for your permission to start recording one more time so that I have your response on tape?

<Wait for response>

Just so we have it on record, your subject number is <interviewer states subject's code and notes it here>__________

<WHY SECTION>

I would like to ask you a few questions. To start with, what do you currently do or have recently done to conserve energy? This could be anything that you do in any area of your life; regardless of whether you think it's big or small.

<Note down all the actions that the subject's mention below, if the subject asks what you mean by recent: say anything in the past two years>:

(1)________________________________ ☐ <ask why>

(2)________________________________ ☐ <ask why>

(3)________________________________ ☐ <ask why>

(4)________________________________ ☐ <ask why>

(5)________________________________ ☐ <ask why>

(6)________________________________ ☐ <ask why>

(7)________________________________ ☐ <ask why>

(8)________________________________ ☐ <ask why>

(9)_________________________________ ☐ <ask why>

(10)________________________________ ☐ <ask why>

(11) ________________________________ ☐ <ask why>

(12) ________________________________ ☐ <ask why>

(13)_________________________________ ☐ <ask why>

(14)_________________________________ ☐ <ask why>

(15)_________________________________ ☐ <ask why>

Now I'd like to focus on energy conservation in your home. Can you tell me the things you currently do or have recently done to conserve energy in your home, other than the things you have already mentioned?

<Wait for response and note down actions below>:

(1)_________________________________ ☐ <ask why>

(2)_________________________________ ☐ <ask why>

(3)_________________________________ ☐ <ask why>

(4)_________________________________ ☐ <ask why>

(5)_________________________________ ☐ <ask why>

(6)_________________________________ ☐ <ask why>

(7)_________________________________ ☐ <ask why>

(8)_________________________________ ☐ <ask why>

(9)_________________________________ ☐ <ask why>

(10)________________________________ ☐ <ask why>

Now I'd like to focus on energy conservation in your personal transportation. Can you tell me the things you currently do or have recently done to conserve energy in your personal transportation, other than the things you have already mentioned?

<Wait for response and note down actions below>:

(1) _________________________________ ☐ <ask why>

(2)_________________________________ ☐ <ask why>

(3)_________________________________ ☐ <ask why>

(4)_________________________________ ☐ <ask why>

(5) ________________________________ ☐ <ask why>

(6)________________________________ ☐ <ask why>

(7)________________________________ ☐ <ask why>

(8)________________________________ ☐ <ask why>

(9)________________________________ ☐ <ask why>

(10)_______________________________ ☐ <ask why>

Now I'd like to focus on energy conservation in your purchasing decisions at the grocery store. Can you tell me the things you currently do or have recently done to conserve energy when you make decisions at the grocery store, other than the things you have already mentioned?

<Wait for response and note down actions below>

(1)________________________________ ☐ <ask why>

(2)________________________________ ☐ <ask why>

(3)________________________________ ☐ <ask why>

(4)________________________________ ☐ <ask why>

(5)________________________________ ☐ <ask why>

(6)________________________________ ☐ <ask why>

(7)________________________________ ☐ <ask why>

(8)________________________________ ☐ <ask why>

(9)________________________________ ☐ <ask why>

(10)_______________________________ ☐ <ask why>

Are there any other things you do that conserve energy, even if you're not doing them for that reason?

<Wait for response and note down actions below>

(1)________________________________ ☐ <ask why>

(2)________________________________ ☐ <ask why>

(3)________________________________ ☐ <ask why>

(4)________________________________ ☐ <ask why>

(5)________________________________ ☐ <ask why>

Now I'd like to go back and ask you about each of the actions you've mentioned. For each action, I'd like you to tell me why you engage in that action. The first action you mentioned was <Go back to the beginning of the WHY section and repeat each of the actions mentioned by the subject in all categories, one by one and ask>: Why do you carry out that action?

<Check the 'why' box for each action once you have asked the subject why>

<WHY NOT SECTION>

Next, what other things could you do to conserve energy that you are currently not doing?

<Note down the actions that the subject mentions below>

(1)________________________________ ☐ <ask why not>

(2)________________________________ ☐ <ask why not>

(3)________________________________ ☐ <ask why not>

(4)________________________________ ☐ <ask why not>

(5)________________________________ ☐ <ask why not>

(6)________________________________ ☐ <ask why not>

(7)________________________________ ☐ <ask why not>

(8)________________________________ ☐ <ask why not>

(9)________________________________ ☐ <ask why not>

(10)_______________________________ ☐ <ask why not>

(11) _______________________________ ☐ <ask why not>

(12) _______________________________ ☐ <ask why not>

(13)________________________________ ☐ <ask why not>

(14)________________________________ ☐ <ask why not>

(15)________________________________ ☐ <ask why not>

As before, now I'd like to focus on energy conservation in your home. What other things could you do to conserve energy in your home that you currently do not do?

<Wait for response and note down actions below>:

(1)________________________________ ☐ <ask why not>

(2)________________________________ ☐ <ask why not>

(3)________________________________ ☐ <ask why not>

(4)________________________________ ☐ <ask why not>

(5)________________________________ ☐ <ask why not>

(6)________________________________ ☐ <ask why not>

(7)________________________________ ☐ <ask why not>

(8)________________________________ ☐ <ask why not>

(9)________________________________ ☐ <ask why not>

(10)_______________________________ ☐ <ask why not>

Now I'd like to focus on energy conservation in your personal transportation. What other things could you do to conserve energy in your personal transportation that you currently do not do?

<Wait for response and note down actions below>

(1)________________________________ ☐ <ask why not>

(2)________________________________ ☐ <ask why not>

(3)________________________________ ☐ <ask why not>

(4)________________________________ ☐ <ask why not>

(5)________________________________ ☐ <ask why not>

(6)________________________________ ☐ <ask why not>

(7)________________________________ ☐ <ask why not>

(8)________________________________ ☐ <ask why not>

(9)________________________________ ☐ <ask why not>

(10)_______________________________ ☐ <ask why not>

Now I'd like to focus on energy conservation in your purchasing decisions at the grocery store. What other things could you do to conserve energy when making purchasing decisions at the grocery store that you currently do not do?

<Wait for response and note down actions below>

(1)________________________________ ☐ <ask why not>

(2)________________________________ ☐ <ask why not>

(3)________________________________ ☐ <ask why not>

(4)________________________________ ☐ <ask why not>

(5)________________________________ ☐ <ask why not>

(6)________________________________ ☐ <ask why not>

(7)________________________________ ☐ <ask why not>

(8)________________________________ ☐ <ask why not>

(9)________________________________ ☐ <ask why not>

(10)_______________________________ ☐ <ask why not>

Are there any other things you could do to conserve energy that you are currently not doing?

<Wait for response and note down actions below>

(1) ________________________________ ☐ <ask why not>

(2) ________________________________ ☐ <ask why not>

(3) ________________________________ ☐ <ask why not>

(4) ________________________________ ☐ <ask why not>

(5) ________________________________ ☐ <ask why not>

Now I'd like to go back and ask you about each of the actions you've mentioned. For each action, I'd like you to tell me why you don't engage in that action. The first action you mentioned was <Go back to the beginning of the WHY NOT section and repeat each of the actions mentioned by the subject in all categories, one by one and ask >: What prevents you from engaging in this action?

<Check the 'why not' box for each action once you have asked the subject why not>

<If the subject does not understand repeat as: what prevents you from acting out those behaviors?>

That's all I wanted to ask you. Thank you very much for your time and thank you for participating in our study. Good Bye.

A.4 Interview without Reasons Group (NR)

<Times contacted: ____________________>

<Time and date when contact successful: __________>

Hello. Is this <interview states the subject name and notes it here>:_____________________? I am calling regarding the interview you had scheduled for a Carnegie Mellon study on attitudes and behaviors. The interview will take only fifteen minutes. With your consent, I would like to record your responses on cassette tape for my own future reference. Your name will in no way be connected to your responses. Do I have permission to start recording at this time?

<Wait for response>

Okay. I am starting the tape recorder. Can I ask for your permission to start recording one more time so that I have your response on tape?

<Wait for response>

Just so we have it on record, your subject number is <interviewer states subject's code and notes it here>__________

I would like to ask you a few questions. To start with, what do you currently do or have recently done to conserve energy? This could be anything that you do in any area of your life; regardless of whether you think it's big or small.

<Note down all the actions that the subject's mention below, if the subject asks what you mean by recent: say anything in the past two years>:

(1)________________________________

(2)________________________________

(3)________________________________

(4)________________________________

(5)________________________________

(6)________________________________

(7)________________________________

(8)________________________________

(9)___________________________________

(10)__________________________________

(11) __________________________________

(12) __________________________________

(13)___________________________________

(14)___________________________________

(15)___________________________________

Now I'd like to focus on energy conservation in your home. Can you tell me the things you currently do or have recently done to conserve energy in your home, other than the things you have already mentioned?

<Wait for response and note down actions below>:

(1)___________________________________

(2)___________________________________

(3)___________________________________

(4)___________________________________

(5)___________________________________

(6)___________________________________

(7)___________________________________

(8)___________________________________

(9)___________________________________

(10)__________________________________

Now I'd like to focus on energy conservation in your personal transportation. Can you tell me the things you currently do or have recently done to conserve energy in your personal transportation, other than the things you have already mentioned?

<Wait for response and note down actions below>:

(1) ___________________________________

(2)___________________________________

(3)___________________________________

(4)___________________________________

(5) ________________________________

(6)________________________________

(7)________________________________

(8)________________________________

(9)________________________________

(10)_______________________________

Now I'd like to focus on energy conservation in your purchasing decisions at the grocery store. Can you tell me the things you currently do or have recently done to conserve energy when you make purchasing decisions at the grocery store, other than the things you have already mentioned?

<Wait for response and note down actions below>

(1)________________________________

(2)________________________________

(3)________________________________

(4)________________________________

(5)________________________________

(6)________________________________

(7)________________________________

(8)________________________________

(9)________________________________

(10)_______________________________

Are there any other things you do that conserve energy, even if you're not doing them for that reason?

<Wait for response and note down actions below>

(1)________________________________

(2)________________________________

(3)________________________________

(4)________________________________

(5)________________________________

Appendix A: Decreasing demand

Next, what other things could you do to conserve energy that you are currently not doing?
<Note down the actions that the subject mentions below>

(1)____________________________________

(2)____________________________________

(3)____________________________________

(4)____________________________________

(5)____________________________________

(6)____________________________________

(7)____________________________________

(8)____________________________________

(9)____________________________________

(10)___________________________________

(11) ___________________________________

(12) ___________________________________

(13)____________________________________

(14)____________________________________

(15)____________________________________

As before, now I'd like to focus on energy conservation in your home. What other things could you do to conserve energy in your home that you currently do not do?
<Wait for response and note down actions below>:

(1)____________________________________

(2)____________________________________

(3)____________________________________

(4)____________________________________

(5)____________________________________

(6)____________________________________

(7)____________________________________

(8)____________________________________

(9)____________________________________

(10)___________________________________

Appendix A: Decreasing demand

Now I'd like to focus on energy conservation in your personal transportation. What other things could you do to conserve energy in your personal transportation that you currently do not do?

<Wait for response and note down actions below>

(1)________________________________

(2)________________________________

(3)________________________________

(4)________________________________

(5)________________________________

(6)________________________________

(7)________________________________

(8)________________________________

(9)________________________________

(10)_______________________________

Now I'd like to focus on energy conservation in your purchasing decisions at the grocery store. What other things could you do to conserve energy when making purchasing decisions at the grocery store that you currently do not do?

<Wait for response and note down actions below>

(1)________________________________

(2)________________________________

(3)________________________________

(4)________________________________

(5)________________________________

(6)________________________________

(7)________________________________

(8)________________________________

(9)________________________________

(10)_______________________________

Are there any other things you could do to conserve energy that you are currently not doing?

<Wait for response and note down actions below>

(1) ____________________________________

(2) ____________________________________

(3) ____________________________________

(4) ____________________________________

(5) ____________________________________

That's all I wanted to ask you. Thank you very much for your time and thank you for participating in our study. Good Bye.

A.5 Calculating Actual Energy Savings

Calculating energy saved by taking one less round-trip flight per year

Table A.1. Data sources used in calculating energy saved by avoiding one round-trip flight per year.

Definition	Value	Units	Source
Average international flight	2,100	Miles	(Bureau of Transportation Statistics, 2001)
Average domestic flight	700	Miles	(Bureau of Transportation Statistics, 2002)
2006 airplane efficiency	50.5	Revenue Passenger miles/gallon	(Air Transport Association, 2006)
Energy in jet fuel	120,000	Btu/gallon jet fuel	(North American Transportation Statistic, 2006)

Using the data from Table A.1, we first calculate the gallons of jet fuel needed per passenger:

$$\text{Gallons of jet fuel needed per passenger} = \frac{\text{Average length of flight [Miles]}}{\text{Airplane efficiency [Revenue Passenger Miles/Gallon]}}$$

$$\text{High estimate} = \frac{\text{Average international flight}}{\text{2006 airplane efficiency}} = \frac{\text{2,100 miles}}{\text{50.5 revenue passenger miles/gallon}} = \text{42 gallons/passenger}$$

$$\text{Low estimate} = \frac{\text{Average domestic flight}}{\text{2006 airplane efficiency}} = \frac{\text{700 miles}}{\text{50.5 revenue passenger miles/gallon}} = \text{14 gallons/passenger}$$

The total kilojoules saved:

$$\text{kJ saved} = \text{120,000 Btu/gallon of jet fuel} \times \text{1.055 kJ/Btu} \times \text{gallons of jet fuel saved} \qquad \textbf{(A1)}$$

$$\text{High estimate} = \text{120,000 Btu/gallon} \times \text{1.055 kJ/Btu} \times \text{42 gallons/passenger} = \text{5,300,000 kJ/year}$$
$$\text{Low estimate} = \text{120,000 Btu/gallon} \times \text{1.055 kJ/Btu} \times \text{14 gallons/passenger} = \text{1,800,000 kJ/year}$$

Calculating energy saved by turning off the faucet while brushing

Table A.2. Data sources used in calculating energy saved by turning off the faucet while brushing one's teeth.

Definition	Value	Units	Source
Flow rate of water	2.5	gallons/minute	(EPA, 2006)
Total water delivered by Pittsburgh Water and Sewer Authority (PWSA)	70,000,000	gallons/day	(States, 2006)
High estimate electricity bill for PWSA (attributed to pumping water to homes)	16,400	$/day	(States, 2006)
Low estimate electricity bill for PWSA (attributed to pumping water to homes)	11,000	$/day	(States, 2006)
Industrial rate of energy costs for Pennsylvania	0.06	$/kWh	(Energy Information Administration, 2006a)
End use electrical power delivery averaged (for USA)	13.0	Quadrillion Btu	(Energy Information Administration, 2006b)
Energy Consumed to generate electricity (for USA)	41.6	Quadrillion Btu	(Energy Information Administration, 2006b)

Using the data from Table A.2 and the assumption that water is left running for 2 minutes/day while brushing one's teeth, we first calculate the total water saved per person if they turned off the faucet:

Appendix A: Decreasing demand

$$\text{Water saved per year} = \text{Flow rate} \times \text{Time faucet turned off} \times 365 \text{ days/year} \quad \textbf{(A2)}$$

$$= 2.5 \text{ gallons/minute} \times 2 \text{ minutes/day} \times 365 \text{ days/year}$$

$$= 1825 \text{ gallons of water saved/year}$$

Next, we need to calculate how much energy PWSA expends to pump water to residents homes:

$$\text{Electricity cost to PWSA per gallon} = \frac{\text{Electricity costs to PWSA}}{\text{Water pumped per day}} \quad \textbf{(A3)}$$

$$\text{High estimate} = \frac{16{,}400 \text{ \$/day}}{70{,}000{,}000 \text{ gallons/day}} = 0.000235 \text{ \$/gallon}$$

$$\text{Low estimate} = \frac{11{,}000 \text{ \$/day}}{70{,}000{,}000 \text{ gallons/day}} = 0.000157 \text{ \$/gallon}$$

Therefore the cost of electricity for the total water saved:

$$\text{High estimate} = 0.000235 \text{ \$/gallon} \times 1825 \text{ gallons of water saved/year} = 0.43 \text{ \$/year}$$

$$\text{Low estimate} = 0.000157 \text{ \$/gallon} \times 1825 \text{ gallons of water saved/year} = 0.29 \text{ \$/year}$$

Next we calculate the total kWh saved by turning off the faucet:

$$\text{kWh saved} = \frac{\text{Cost of electricity saved}}{\text{Industrial rate of electricity cost}} \quad \textbf{(A4)}$$

$$\text{High estimate} = \frac{0.43 \text{ \$/year}}{0.06 \text{ \$/kWh}} = 7.17 \text{ kWh/year}$$

$$\text{Low estimate} = \frac{0.29 \text{ \$/year}}{0.06\text{\$/kWh}} = 4.83 \text{ kWh/year}$$

(Note: this is equivalent to leaving a 100-watt bulb on for 50–70 hours.)

Next we need to calculate the efficiency of electrical power delivery system for the United States:

$$\text{Efficiency} = \frac{\text{End use}}{\text{Energy consumed to generate electricity}} = \frac{13.0 \text{ Quadrillion Btu}}{41.6 \text{ Quadrillion Btu}} = 0.313 \quad \textbf{(A5)}$$

Therefore the efficiency of the electrical power delivery is 31%.

The total kWh saved would be:

$$\text{kWh saved} = \frac{\text{Total kWh used}}{\text{Efficiency of electrical power delivery}} \quad \textbf{(A6)}$$

$$\text{High estimate} = \frac{7.17 \text{ kWh/year}}{0.313} = 22.9 \text{ kWh/year}$$

$$\text{Low estimate} = \frac{4.83 \text{ kWh/year}}{0.313} = 15.5 \text{ kWh/year}$$

Therefore the total kilojoules saved by turning off the faucet while brushing:

$$\text{High estimate} = 3{,}600 \text{ kJ/kWh} \times 22.9 \text{ kWh/year} = 82{,}400 \text{ kJ/year}$$

$$\text{Low estimate} = 3{,}600 \text{ kJ/kWh} \times 15.5 \text{ kWh/year} = 55{,}800 \text{ kJ/year}$$

Comparing energy saved

$$\text{Energy saved} = \frac{\text{Energy saved by taking one less flight per year}}{\text{energy saved by turning off the faucet while brushing for a whole year}}$$

$$\text{High estimate}_{\text{international}} = \frac{\text{International estimate for flight}}{\text{Low estimate for water saved}} = \frac{5{,}300{,}000 \text{ kJ/year}}{55{,}800 \text{ kJ/year}} = 95 \text{ times}$$

$$\text{Low estimate}_{\text{international}} = \frac{\text{International estimate for flight}}{\text{High estimate for water saved}} = \frac{5{,}300{,}000 \text{ kJ/year}}{82{,}400 \text{ kJ/year}} = 64 \text{ times}$$

$$\text{High estimate}_{\text{domestic}} = \frac{\text{Domestic estimate for flight}}{\text{Low estimate for water saved}} = \frac{1{,}800{,}000 \text{ kJ/year}}{55{,}800 \text{ kJ/year}} = 32 \text{ times}$$

$$\text{Low estimate}_{\text{domestic}} = \frac{\text{Domestic estimate for flight}}{\text{High estimate for water saved}} = \frac{1{,}800{,}000 \text{ kJ/year}}{82{,}400 \text{ kJ/year}} = 22 \text{ times}$$

Therefore, the energy saved by taking one less round-trip is 22 to 95 times (or roughly 20 to 100 times) as much as the energy saved by turning off the faucet while brushing.

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Air Transport Association. (2006). Revenue Passenger Miles per Gallon. Retrieved December 23rd, 2006, from http://www.airlines.org/economics/energy/fuel+efficiency.htm

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Appendix B: Preferences for change

B.1 Power calculation for the main logistic analysis

'The power of a statistical test of a null hypothesis is the probability that it will lead to the rejection of the null hypothesis' (Cohen, 1969). A large power with statistical significance may permit the experimenter to say that not only is there a significant result, but also that there is a high probability of replicating the result.

In order to calculate the power statistic for the four logistic regressions in the main analysis (that of predicting characteristic of participants that said *yes* to each of the four questions) we used a SAS macro[6] model that calculates the sample size required to achieve given power values for a logistic regression model with one or more quantitative predictors.

The model is for the power/sample size needed for the effect of *one* predictor (at a time), but allows other predictors to be taken into account through the squared multiple correlation of the tested predictor with all of the other predictors. In this calculation we have used the squared value of the Pearson's correlation coefficient of the NEP score with all of the other 11 variables (that of context, regulation type, SUV, Alternative energy, green energy, political party, political views, gender, age, income and education.) and then computed the sample size requirement for a power score from 0.5-0.9 (where Cohen (1992) suggests that a power of 0.8 is large).

The effect size is calculated internally by the model and is used to derive the sample size curve vs. the power statistic by comparing the probability of saying *yes* in the case of the mean value of the NEP score predictor parameter (P1) to the probability of saying yes

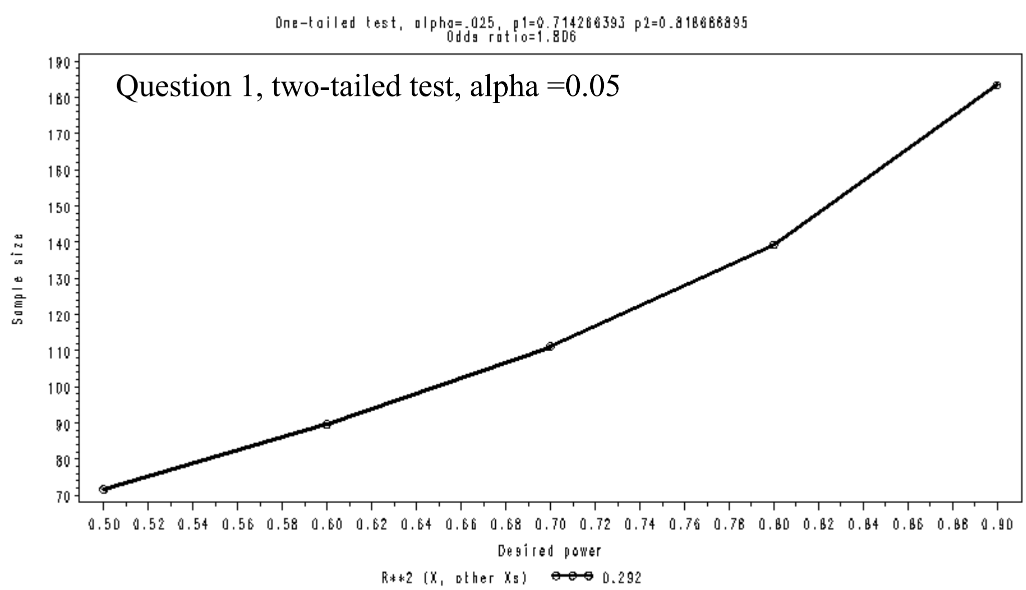
[6] Authored by Dr. Michael Friendly, found here: http://www.math.yorku.ca/SCS/vcd/powerlog.html as well as in discussion with Dr. Friendly

when the NEP score predictor parameter is at a value of the mean plus one standard deviation (P2).

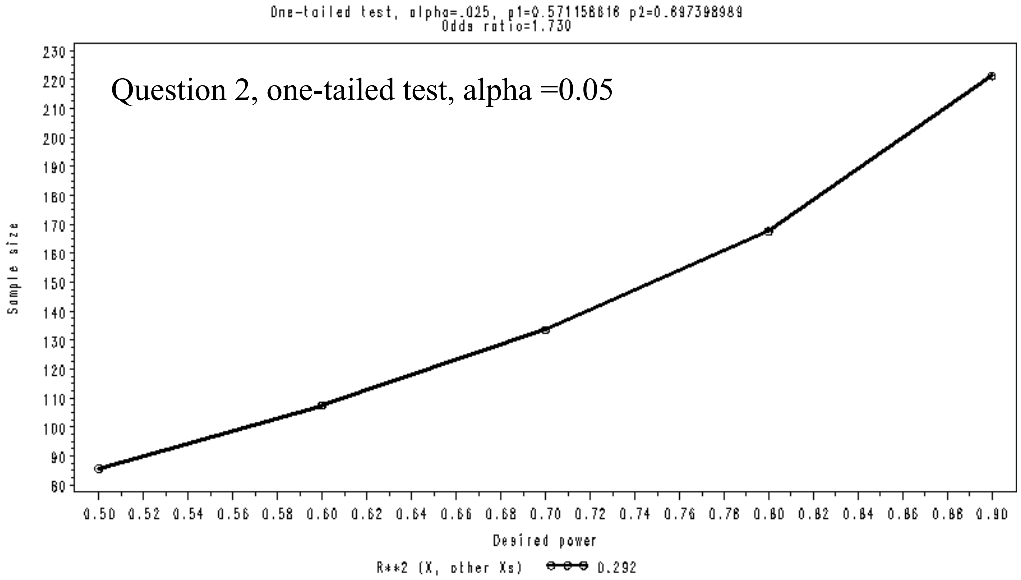
The graphical results from the model are shown in Figure A.1. The curve shown is the output of the model incorporating squared multiple correlation coefficients (RSQ) into the runs (RSQ = is the squared multiple correlation of the predictor with all other 11 predictors). Additionally, the model assumes one-tailed tests. Due to this, we used an alpha value of 0.025, which would correspond to a two-tailed test at alpha = 0.05. This would increase the required sample sizes when compared to a one-tailed test.

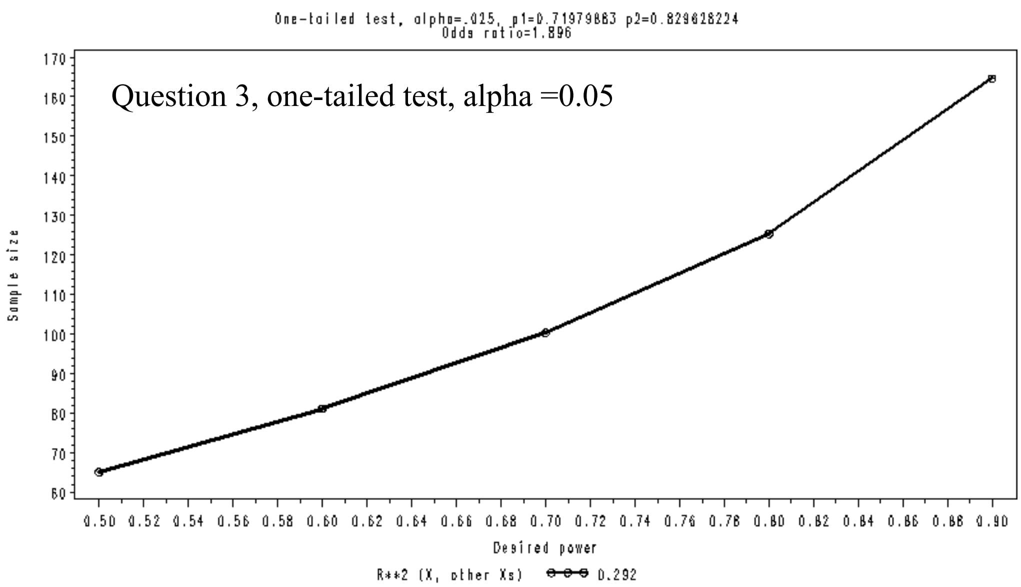
The results suggest that for our particular logistic regressions, we would at most need 180 participants for a power of 0.8. This sample size is below our actual sample size of 209.

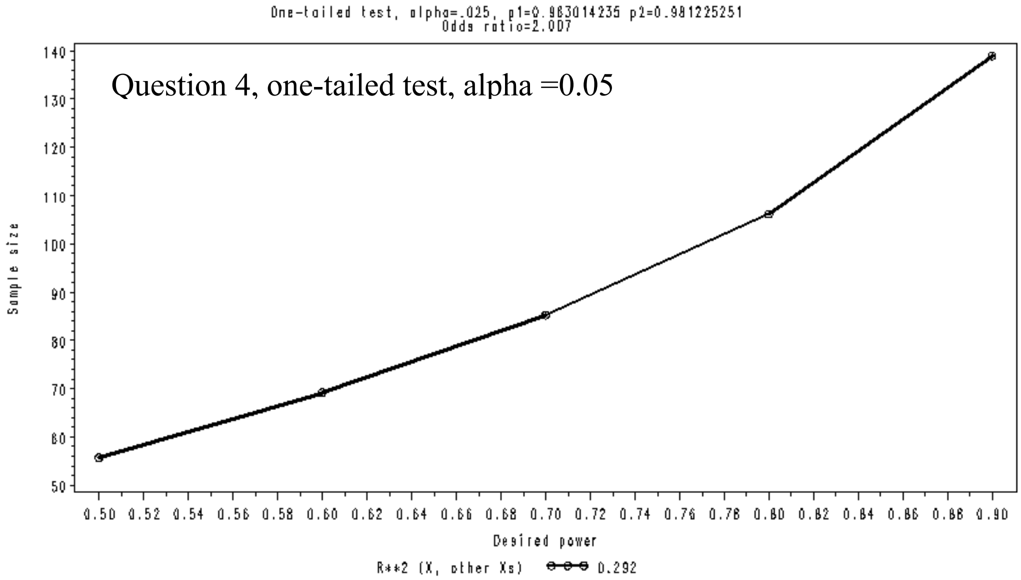
Figure B.1. The power curve for each of the four questions showing the sample size needed for a desired power.



Appendix B: Preferences for change







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Cohen, J. (1969). Statistical power analysis for the behavioral sciences: New York: Academic Press.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159.

Dunlap, R., Van Liere, K., Mertig, A., & Jones, R. (2000). New trends in measuring environmental attitudes: measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues, 56*(3), 425-442.

B.2 One of the four surveys for the 'preferences for change' study

Carnegie Mellon
UNIVERSITY

A survey about preferences and attitudes

Part I.

Below is information summarized from a scientific source:

Many scientists agree that automobile emissions are changing the composition of the atmosphere. On average, automobile emissions increase the global temperature, which in turn damages ecosystems. Large vehicles like SUVs and trucks typically have low gas mileage, and as a result, release more harmful emissions than compact cars.

1. In order to reduce automobile emissions, I would be willing to pledge that the next car I purchase will not be a high emission vehicle such as a SUV or truck.

Yes No

Why? Please explain your response.

____

____

____

2. In order to reduce automobile emissions, I would support the government providing tax breaks to individuals who purchase low emission vehicles like compact cars.

Yes No

Why? Please explain your response.

____

____

____

Below is information summarized from a scientific source:

Many scientists agree that electricity generated by coal pollutes the atmosphere with toxic substances and contributes to climate change. Living in Pennsylvania, you can select to have a portion of your energy generated by solar and wind power (green energy). Electricity generated from green energy does not pollute the atmosphere with toxic substances, but is more costly than electricity generated by coal. Selecting green energy, a typical homeowner's monthly bill is likely to increase by about $5.00.

3. In order to decrease the pollution released into the atmosphere, I would be willing to pledge to buy green energy from my energy supplier.

Yes No

Why? Please explain your response.

____

____

____

4. In order to decrease the pollution released into the atmosphere, I would be in favor of changing the current system - so that customers automatically purchase a percentage of green energy, unless they explicitly decide not to. This would require a consumer who desires an electricity service plan without green energy to make a telephone call to change their plan.

Yes No

Why? Please explain your response.

____

____

____

Part II.

For each statement listed below, please indicate (by circling) how strongly you agree or disagree with the statement:

	Completely Disagree			*Neither agree nor disagree*			*Completely Agree*
5. We are approaching the limit of the number of people the earth can support.	0	1	2	3	4	5	6
6. Humans have the right to modify the natural environment to suit their needs	0	1	2	3	4	5	6
7. When humans interfere with nature it often produces disastrous consequences	0	1	2	3	4	5	6
8. Human ingenuity will insure that we do NOT make the earth unlivable.	0	1	2	3	4	5	6
9. Humans are severely abusing the environment.	0	1	2	3	4	5	6
10. The earth has plenty of natural resources if we can just learn how to develop them.	0	1	2	3	4	5	6
11. Plants and animals have as much right as humans to exist.	0	1	2	3	4	5	6
12. The balance of nature is strong enough to cope with the impacts of modern industrial nations.	0	1	2	3	4	5	6

13. Despite our special abilities, humans are still subject to the laws of nature.	0	1	2	3	4	5	6
14. The so-called "ecological crisis" facing humankind has been greatly exaggerated.	0	1	2	3	4	5	6
15. The earth is like a spaceship with very limited room and resources	0	1	2	3	4	5	6
16. Humans were meant to rule over the rest of nature.	0	1	2	3	4	5	6
17. The balance of nature is very delicate and easily upset.	0	1	2	3	4	5	6
18. Humans will eventually learn enough about how nature works to be able to control it.	0	1	2	3	4	5	6
19. If things continue on their present course, we will soon experience a major ecological catastrophe.	0	1	2	3	4	5	6

Part III

Please answer the following demographic questions.

20. Do you currently own or lease an SUV?

Y N

21. Do you use other alternative energy (example: solar panels on your roof, micro-wind turbines etc.)?

Y N

22. Do you currently purchase green energy for your home?

Y N

23. **Which political party do you most closely identify with?** *(Write an X in one box)*

☐ Democratic
☐ Republican
☐ Independent (please specify): ___________________

☐ Not sure

24. Below, the political views that people might hold are arranged from extremely liberal to extremely conservative. Please choose the number that best represents where you fall.

1	2	3	4	5	6	7
extremely liberal	liberal	slightly liberal	moderate	slightly conservative	conservative	extremely conservative

25. Your sex? F M

26. Your age? _____

27. Your yearly family income before tax? *(Write an X in one box)*

☐ Do not have an income
☐ < $20,000
☐ $20,000 - $49,999
☐ $50,000 - $79,999
☐ $80,000 - $109,999
☐ $110,000 - $139,999
☐ $140,000 - $169,999
☐ >$170,000

28. Highest level of education completed? *(Write an X in one box)*

☐ No Degree
☐ High School Diploma or GED
☐ Some College
☐ College Degree
☐ Some Graduate School
☐ Graduate degree

29. **Do you have any additional thoughts or comments you would like to share with us?** *(Fill in below)*

____

____

____

____

____

Thank you for completing this questionnaire!

Shahzeen Attari and Mary Schoen
Carnegie Mellon University
5000 Forbes Ave.
Pittsburgh, PA 15213

Appendix C: Lay perceptions of energy consumption

C.1 Survey Solicitation published on Craigslist

Receive $10 Amazon gift certificate by filling out a survey

Please participate in an online study on energy consumption. The survey is anonymous, and no one will know what answers you give. This brief survey should take no more than 20 minutes to complete.

You will be receive a $10 Amazon gift certificate shortly afterwards. There is a limit of one gift certificate per person.
Click on the following link:
SURVEY
http://www.surveymonkey.com/s.aspx?sm=gQWLJkO6qt0XATYqOo3lkg_3d_3d
Thank you
Shahzeen Attari

Ph.D. Candidate
Civil and Environmental Engineering
Engineering and Public Policy
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, PA 15213

C.2 A Survey on Energy

Dear Participant:
Your involvement in this study will help us understand some of the main issues relating to energy consumption. Thank you for your time and help with this effort.

Appendix C: Lay perceptions of energy consumption

Please note that participation is voluntary and you can choose to stop participating at any point during the study. The survey is anonymous, and no one will know what answers you give. For this reason, please do not put your name or anyone else's name anywhere in the survey. The survey is relatively brief and should not take any more than 20 minutes to complete.

Thank you again for participating in this study. The asterisks denote questions for which you must provide answers for before going to the next screen. If you feel uncomfortable in answering any question, you can exit the survey. On completing the survey, you will be asked for your email address. You will be emailed a code for a $10 Amazon gift certificate within 72 hours. There is a limit of one gift certificate per person.

If you have any questions, please do not hesitate to send me an email at: sza@andrew.cmu.edu.

Sincerely,
Shahzeen Attari

[A progress bar is shown at the bottom of every page.]

1. Energy-Saving Behaviors

In your opinion, what is the most effective thing that you could do to conserve energy in your life?

____

2. Energy Consumed by the Average Household

Think about an average household in the United States.

Now think about the total amount of energy that is used directly by that household in one year.

Appendix C: Lay perceptions of energy consumption

Consider that the energy used by a household can be divided into household operations, transportation and food production.

Household operations include electricity, natural gas, and heating oil that is used for the house.

Transportation includes air travel, motor travel, and public transportation used by people in the household.

Food production includes growing and shipping food that people in the household eat.

Please enter whole numbers with no other text (not decimals, ranges, or percent signs).
What percentage of the total energy consumed per year by an average household in the United States is attributed to energy used by household operations?___

What percentage of the total energy consumed per year by an average household in the United States is attributed to energy used by transportation?___

What percentage of the total energy consumed per year by an average household in the United States is attributed to energy used by food production?___

3. Energy Used by Devices in One Hour

A 100-Watt incandescent light bulb uses 100 units of energy in one hour.
How many units of energy do you think each of the following devices typically uses in one hour?

Enter a number less than 100 if you think the device uses less energy than a 100-Watt bulb. Enter a number greater than 100 if you think the device uses more energy than a 100-Watt bulb. Your best estimates are fine. Please enter whole numbers with no other text (not decimals, ranges, or percent signs).

[Error message "Please enter whole numbers with no other text (not decimals, ranges, or percent signs)."]

A compact fluorescent light bulb that is as bright as a 100-Watt incandescent light bulb	
A desktop computer	
A laptop computer	
A stereo	
An electric clothes dryer	
A portable heater	
A room air-conditioner	
A central air conditioner	
A dish washer	

4. Energy Saved in the Household

Turning off a 100-Watt incandescent light bulb for one hour SAVES 100 units of energy. How many units of energy do you think each of the following changes will save?
Enter a number less than 100 if you think the change saves less energy than turning off a 100-Watt bulb for one hour. Enter a number greater than 100 if you think the change saves more energy than turning off a 100-Watt bulb for one hour. Your best estimates are fine. Please enter whole numbers with no other text (not decimals, ranges, or percent signs). Remember to enter a number of the amount of energy SAVED, not the amount of energy USED.

[Text entered is validated for a whole number between 0 and 1000000. Error message: "Please enter whole numbers with no other text (not decimals, ranges, or percent signs)."]

Replacing one 100-watt incandescent bulb with equally bright compact fluorescent bulb that is used for one hour would reduce energy use by how many units?____

Replacing one 100-watt kitchen bulb with a 75-watt bulb that is used for one hour would reduce energy use by how many units?___

Drying clothes on a clothes line (not using the dryer) for one load of laundry would reduce energy use by how many units?___

In the summer: turning up the thermostat on your air conditioner (making your home warmer) by 5° F would reduce energy use by how many units?___

In the winter: turning down the thermostat on your heater (making your home cooler) by 5° F would reduce energy use by how many units?___

Changing washer temperature settings from “hot wash, warm rinse” to “warm wash, cold rinse” for one load of laundry would reduce energy use by how many units?___

5. Energy Saved in Transportation

Assume that a 20-miles-per-gallon car going 60 miles per hour uses 100 units of energy in one hour. (Note that this scale in different from that used in previous questions, in that "100 units" now refers to a different amount of energy.)

How many units of energy do you think each of the following changes will save?

Enter a number less than 100 if you think the change saves less energy than is consumed by the 20-miles-per-gallon car going 60 miles per hour. Enter a number greater than 100 if you think the change saves more energy than consumed by the 20-miles-per-gallon car going 60 miles per hour. Your best estimates are fine.

Please enter whole numbers with no other text (not decimals, ranges, or percent signs). Remember to enter a number of the amount of energy SAVED, not the amount of energy USED. [Text entered is validated for a whole number between 0 and 100000000. Error message: “Please enter whole numbers with no other text (not decimals, ranges, or percent signs).”]

Driving a more fuel efficient car (30 miles per gallon instead of 20 miles per gallon) at 60 miles per hour for one hour would reduce energy use by how many units?___

Tuning up the car twice a year (including air filter changes) would reduce energy use by how many units for the whole year? ___

Assume that you are driving a 20-miles-per-gallon car for 60 miles. Reducing your highway speed from 70 miles per hour to 60 miles per hour would reduce energy use by how many units for the trip? ___

6. Energy Used to Transport Goods

In your opinion, which of the following modes of transportation uses the most energy per mile to transport one ton of goods? Please check the mode that uses the most energy, the second most, the third most, and the least energy.

	Most energy	Second most energy	Third most energy	Least energy
Ship				
Train				
Airplane				
Truck				

7. Energy Used in Recycling and Manufacturing

In your opinion, which of the following uses the most energy?

Please check the activity that uses the most energy, the second most, the third most, and the least energy.

	Most energy	**Second most energy**	**Third most energy**	**Least energy**
Making a can out of virgin aluminum				
Making a can out of recycled aluminum				
Making a glass bottle out of virgin glass				

Making a glass bottle out of recycled glass				

8. Ease or Difficulty of Energy-Saving Behaviors

Please indicate how easy or hard it would be for you to make each of the following changes.

Please consider all aspects of the changes, including the physical or mental effort required, the time or hassle involved, and any relevant monetary costs.

If you already engage in the activity please check the option on the far left.

	Do it already	Extremely easy	Very easy	Somewhat easy	Neither easy nor hard	Somewhat hard	Very hard	Extremely hard
Buying a more fuel efficient automobile (31 vs. 20 miles per gallon)	☐	☐	☐	☐	☐	☐	☐	☐
Carpooling with one other person to work	☐	☐	☐	☐	☐	☐	☐	☐
Replacing poorly insulated windows with highly insulated windows	☐	☐	☐	☐	☐	☐	☐	☐
Cutting highway speed from 70 miles per hour to 60 miles per hour	☐	☐	☐	☐	☐	☐	☐	☐
Installing a more efficient heating unit (92% efficient)	☐	☐	☐	☐	☐	☐	☐	☐

In the winter: turning down the thermostat from 72° F to 68° F during the day and to 65° F during the night	☐	☐	☐	☐	☐	☐	☐	☐
In the summer: turning up the thermostat on your air conditioner from 73° F to 78° F	☐	☐	☐	☐	☐	☐	☐	☐

9. Ease or Difficulty of Energy-Saving Behaviors

Please indicate how easy or hard it would be for you to make each of the following changes.

Please consider all aspects of the changes, including the physical or mental effort required, the time or hassle involved, and any relevant monetary costs.

If you already engage in the activity please check the option on the far left.

	Do it already	Extremely easy	Very easy	Somewhat easy	Neither easy nor hard	Somewhat hard	Very hard	Extremely hard
Tuning up the car twice a year (including air filter changes)	☐	☐	☐	☐	☐	☐	☐	☐
Replacing 85% of all incandescent bulbs with equally bright compact fluorescent bulbs	☐	☐	☐	☐	☐	☐	☐	☐

Turning up the refrigerator thermostat from 33° F to 38° F and the freezer thermostat from –5° F to 0° F	☐	☐	☐	☐	☐	☐	☐	☐
Drying clothes on a clothes line (not using the dryer) for 5 months of the year	☐	☐	☐	☐	☐	☐	☐	☐
Watching 25% fewer hours of TV each day	☐	☐	☐	☐	☐	☐	☐	☐
Installing a more efficient washer (replace a 2001 or older non–Energy Star washer with a new Energy Star unit)	☐	☐	☐	☐	☐	☐	☐	☐
Changing washer temperature settings from "hot wash, warm rinse" to "warm wash, cold rinse"	☐	☐	☐	☐	☐	☐	☐	☐
Replacing two 100-watt kitchen bulbs with 75-watt bulbs	☐	☐	☐	☐	☐	☐	☐	☐

10. Attitudes

Please indicate how strongly you agree or disagree with each of the following statements.

	Completely agree	*Agree*	*Somewhat agree*	*Neither agree nor disagree*	*Somewhat disagree*	*Disagree*	*Completely disagree*

We are approaching the limit of the number of people the earth can support.	☐	☐	☐	☐	☐	☐	☐
Humans have the right to modify the natural environment to suit their needs.	☐	☐	☐	☐	☐	☐	☐
When humans interfere with nature it often produces disastrous consequences.	☐	☐	☐	☐	☐	☐	☐
Human ingenuity will insure that we do NOT make the earth unlivable.	☐	☐	☐	☐	☐	☐	☐
Humans are severely abusing the environment.	☐	☐	☐	☐	☐	☐	☐
The earth has plenty of natural resources if we can just learn how to develop them.	☐	☐	☐	☐	☐	☐	☐
Plants and animals have as much right as humans to exist.	☐	☐	☐	☐	☐	☐	☐

11. Attitudes

Please indicate how strongly you agree or disagree with each of the following statements.

	Completely agree	*Agree*	*Somewhat agree*	*Neither agree nor disagree*	*Somewhat disagree*	*Disagree*	*Completely disagree*
The balance of nature is strong enough to cope with the impacts of modern industrial nations.	☐	☐	☐	☐	☐	☐	☐
Despite our special abilities, humans are still subject to the laws of nature.	☐	☐	☐	☐	☐	☐	☐

The so-called "ecological crisis" facing humankind has been greatly exaggerated.	☐	☐	☐	☐	☐	☐	☐
The earth is like a spaceship with very limited room and resources.	☐	☐	☐	☐	☐	☐	☐
Humans were meant to rule over the rest of nature.	☐	☐	☐	☐	☐	☐	☐
The balance of nature is very delicate and easily upset.	☐	☐	☐	☐	☐	☐	☐
Humans will eventually learn enough about how nature works to be able to control it.	☐	☐	☐	☐	☐	☐	☐
If things continue on their present course, we will soon experience a major ecological catastrophe.	☐	☐	☐	☐	☐	☐	☐

12. Climate Change Attitudes

Please indicate how strongly you agree or disagree with each of the following statements.

	Completely agree	*Agree*	*Somewhat agree*	*Neither agree nor disagree*	*Somewhat disagree*	*Disagree*	*Completely disagree*
Humans are responsible for global warming and climate change.	☐	☐	☐	☐	☐	☐	☐
Humans do not need to change their lifestyles to address global warming and climate change.	☐	☐	☐	☐	☐	☐	☐
I believe that my actions contribute to global warming and climate change.	☐	☐	☐	☐	☐	☐	☐

I believe that I need to change my lifestyle to address global warming and climate change.	☐	☐	☐	☐	☐	☐	☐

13. Math Questions

To answer the following questions, please enter whole numbers or decimals with no other text (not ranges or percent signs).

Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?

In the BIG BUCKS LOTTERY, the chance of winning a $10 prize is 1%. What is your best guess about how many people would win a $10 prize if 1000 people each buy a single ticket to BIG BUCKS?____

In ACME PUBLISHING SWEEPSAKES, the chance of winning a car is 1 in 1,000. What percent of tickets to ACME PUBLISHING SWEEPSAKES win a car?____

14. Demographics

Please answer the following questions about yourself and your situation. Your confidential answers will help us understand the types of people who have completed the survey.

Do you consume more or less energy than the average individual in the United States?

_I consume more energy than average

_I consume less energy than average

About how much was the last monthly electric bill for your household? Please provide a dollar amount (rounded to the nearest dollar) with no other text. Your best estimate is fine. ___

Appendix C: Lay perceptions of energy consumption

About how much did your household pay for gas (for transportation) last month? Please provide a dollar amount (rounded to the nearest dollar) with no other text. Your best estimate is fine.___

How many people are there in your household? ___

For the vehicle you use most, approximately what is the vehicle's gas mileage? (Assume your normal mix of city and highway driving.)

_ I do not own or lease a vehicle

_ less than 10 miles per gallon

_11-20 miles per gallon

_21-30 miles per gallon

_31-40 miles per gallon

_41-50 miles per gallon

_more than 50 miles per gallon

Do you have any compact fluorescent light bulbs or fluorescent linear bulbs (tube lights) installed in your home?

_Yes

_No

When buying large household appliances (like refrigerators, dishwashers, etc.), do you consider their energy efficiency in your purchasing decisions?

_Yes

_No

When buying small household appliances (like coffee makers, blenders, etc.), do you consider their energy efficiency in your purchasing decisions?

_Yes

_No

Have you ever had an energy audit of your home? (A home energy audit is done to evaluate measures you can take to make your home more energy efficient.)

_Yes

_No

This past year, was anything done to weatherize your home? (Examples include caulking and weather stripping to seal air leaks around windows and doors, etc.)

_Yes

_No

Does your home have any double-paned windows (two glass panels set in a frame, separated by a small space) or storm windows (installed on the interior or exterior of the primary window)?

_Yes

_No

Have you ever bought renewable energy from your electricity provider?

_Yes

_No

This past year, did you send a letter to any political official about environmental or energy issues?

_Yes

_No

Do you consider yourself an environmentalist?

☐ Yes

☐ No

15. Demographics

Appendix C: Lay perceptions of energy consumption

Do you rent or own the place where you live?

- ☐ Rent
- ☐ Own

In the last election, for whom did you vote?

- ☐ Barack Obama
- ☐ John McCain
- ☐ An Independent candidate
- ☐ Chose not to vote
- ☐ Could not vote
- ☐ Do not want to divulge

How would you describe your political beliefs?

☐	☐	☐	☐	☐	☐	☐
Extremely liberal	Liberal	Slightly liberal	Moderate	Slightly conservative	Conservative	Extremely conservative

What is you sex?

- ☐ Female
- ☐ Male

What is your age? _____

During 2008, what was your yearly household income before tax? Your best estimate is fine.

- ☐ Did not have an income
- ☐ < $20,000
- ☐ $20,000 - $49,999
- ☐ $50,000 - $79,999
- ☐ $80,000 - $109,999
- ☐ $110,000 - $139,999

- ☐ $140,000 - $169,999
- ☐ >$170,000

What is the highest level of education that you have completed?

- ☐ Some schooling, but no diploma or degree
- ☐ High school diploma or GED
- ☐ Some college
- ☐ College degree
- ☐ Some graduate school
- ☐ Graduate degree

What is your email address? Your email address is required to make sure you receive your $10 Amazon gift certificate. The email address will no way be linked to any of the answers you have provided. ______________________________

Your ZIP code?_______

Do you have any additional thoughts about energy use or energy conservation, or any comments about the survey that you would like to share with us?

____

____

____

____

16. Thank you!

Thank you for completing this questionnaire!
