Household Perceptions on Sustainable Transportation Methods

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1 Introduction

Adopting green transportation habits is critical in the face of escalating climate change impacts. This necessity underscores the importance of collective auditing and monitoring of transportation choices at both individual and household levels. Research in human-computer interaction (HCI) has been pivotal in exploring how technology can influence perceptions of sustainability and transportation decisions. By focusing on families and households, we can gain deeper insights into collaborative sense-making of transportation data and the collective behavioral shifts needed to foster pro-environmental habits.

Households, as fundamental social units, play a crucial role in transportation decisions. The interplay of shared values, collective goals, and coordinated actions within these settings can significantly influence sustainable travel behaviors. Collaborative sense-making of transportation data where individuals who cohabit with others in a household jointly interpret and reflect on their travel patterns can lead to more informed and eco-friendly decisions [1]. This approach not only enhances individual awareness but also fosters a collective responsibility towards reducing carbon footprints.

The general impacts of climate change necessitate that families engage in collective monitoring of their transportation choices. Eco-feedback interfaces (EFI), designed to communicate the environmental impact of different everyday decisions, have emerged as effective tools in this context whether it be food waste [11], dietary choices [4, 7] or monitoring home energy usage [6, 9]. These interfaces range from simple indicators to more detailed information about carbon emissions and their equivalents in everyday activities. Broadly speaking, such feedback can help households understand the environmental implications of their unsustainable behaviors and motivate them to adopt greener alternatives. Although there is a plethora of prior works that have explored EFIs there is a dearth of work to understand

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how such platforms can be used for household members. However, before developing an EFI we first sought to understand group knowledge and attitude towards sustainability.

By examining how environmental knowledge and attitudes influence household transportation decisions, we sought to contribute to the development of more holistic strategies for promoting sustainable collaborative sense making interfaces for transportation. In this paper we make one major contribution:

- **(1)**: This study provides empirical data on how household dynamics, including shared values and collective goals, influence transportation decisions. By analyzing the survey results, the paper contributes new empirical evidence on the factors that shape sustainable transportation behaviors within households.

This study leverages insights from HCI, design and evaluations of eco-feedback interfaces which are discussed more in detail in the following section.

2 Background

Researchers have been trying to understand motivations for green transportation habits from perspectives such as transportation research and human computer interaction (HCI). From a transportation research perspective, Flamm [2] explores the environmental knowledge and attitudes that may affect vehicle ownership in Sacramento, California. He found that households with pro-environmental attitudes tend to own fewer and more fuel efficient vehicles and drive these vehicles less than those without these attitudes. He also found that environmental knowledge was associated with vehicle ownership or driving behaviors. We build on this research by exploring knowledge and attitudes of households as well, in a different locality of Orange County, CA. While we do not seek to compare localities, we do seek to expand our reach past vehicle ownership and explore the impacts of environmental knowledge and attitudes on transportation decisions more broadly, including public transportation for example. Also, we add to the discussion a perspective from 2024, more than a decade later, which is interesting since there are more sustainable transportation options now than in 2009.

In HCI, Mohanty et al. [5] explore people's decisions regarding sustainable ride hailing service trips. The researchers present a series of scenarios and visualizations that depict ride hailing services with varying persuasive mechanisms to choose the sustainable options. For example, some images had details of the proposed trip with a point system attached to certain trips, a social norm (i.e., X number of people took this trip). Using a theoretical perspective from this paper we can understand that people have incentives to choose sustainable transportation methods and such incentives are important to understand motivations for acting in a pro-environmental manner. Researchers have looked at vehicle ownership or ride sharing, and we aim to explore transportation decisions made as a household more broadly.

Froehlich et al. [3] add to this discussion in HCI by detailing the development of an Eco-Feedback Interface (EFI) called UbiGreen, a mobile tool aimed at facilitating and tracking green transportation behaviors in users. The authors argue that sustainable behavior does not come naturally to users, nor do they instinctively know how to optimize their transportation decisions in favor of the environment– rather, research suggests that sustainable transportation habits are cultivated over time through feedback and reflection upon personal behavior data. Thus the authors designed the application to support and reinforce green transportation methods by encouraging users' reflection upon their transportation habits, through sharing visuals of seals and polar bears whenever the user chooses a sustainable transportation option. Froleich et al. highlight the importance of user reflection upon their transportation data in order to encourage more sustainable behaviors, which has yet to be demonstrated in group-settings such as households. Thus, by running our survey study we gain a better understanding of not only variations in knowledge, attitudes, and perspectives regarding sustainability, but also how such matters can influence design decisions in context-dependent eco-friendly tracking platforms for household members.

3 Research Questions and Hypotheses

As a response to our objectives and interest in the space of sustainability and household environmental awareness, our team developed the following research question and hypothesis.

- **RQ1**: How do attitudes and knowledge of sustainability affect a household's transportation decisions?
- **H0**: There is no significant relationship between household attitudes and knowledge of sustainability and their transportation decisions.
- **H1**: There is a significant relationship between household attitudes and knowledge of sustainability and their transportation decisions.

4 Method

4.1 Research Design

Our target population is households with two people or more who cohabit in Southern California. Households encompass a broader spectrum of people who live together outside of the typical American nuclear family dynamic. Our unit of analysis is the household. Since we deployed a survey to measure household attitudes and knowledge, our time dimension is cross-sectional. The duration of the study was short (4 weeks), so we recruited households through both convenience and snowball sampling, specifically through personal social networks by posting on our social media accounts (Twitter, Slack, LinkedIn, Facebook).

To answer our research question, we developed a Qualtrics survey of 14 questions which addressed the separate parts of our research question: household characteristics and demographics, attitudes and knowledge about sustainability, and household transportation decisions. First we asked participants to answer general demographic questions such as educational attainment and household income, followed by characteristics of their household (number of household members, ages of members, and zip code). The next 5 questions covered the household members' knowledge and attitudes towards sustainability, such as how often they recycle and to what degree they think protecting the environment is important. Lastly, participants were asked about their transportation habits such as how often they drive, and the frequency they use various methods of transportation.

4.2 Population, sample, and participants

The target population for this study comprises households residing in Southern California. Southern California's urban landscape and transportation challenges make it an ideal region to examine the intersection of sustainability attitudes and transportation decisions.

For our sample population, we focused on households consisting of two or more members located within Orange County, California. The economic landscape and urban infrastructure of Orange County closely align with those of other Southern California counties. Moreover, the transportation options provided in Orange County, including public transit availability and emerging sustainable transportation initiatives, suggests a similar trend observed in Southern California.

To recruit the survey participants, we used convenience sampling. Convenience sampling is a non-probability sampling method that selects participants based on their accessibility and willingness to participate in the study [10].

Given the constraints of time, resources, and access to participants, convenience sampling proved to be the most practical approach for this study. The survey was distributed from May 16, 2024 to May 23, 2024, and 29 participants answered the survey in total (not all responses were complete).

The average number of household members among our participants was 2.65 (min = 1, max = 5). After collecting demographic data, participants who reported fewer than 2 household members in their household were deemed ineligible to continue with the survey. The participants' ages ranged from as young as 2 years old to as old as 77 years old, indicating that the sample includes a broad spectrum of age groups. The average age of all participants was 26.76 years (min = 2, max = 77). Among these participants, the average number of members legally able to drive was 1.82 (min = 0, max = 4). All participants lived in or near Irvine in Orange County.

4.3 Data collection instruments, variables, and materials

To answer our research question, we developed the following survey items to measure household attitudes, knowledge, and transportation decisions. We also collected household characteristics and demographics for further context. See Table 1 in the appendix for more information on the variables.

4.3.1 Attitudes. We measured household attitudes toward sustainability by rating their degree of environmentalism, confidence in pro-environmental behavioral (PEB) self efficacy, and the personal PEBs carried out by their household within the past 12 months. To measure perspectives on Environmentalism participants were asked to answer "How important is protecting the environment for your household?" by rating the degree of how much their household valued the environment on a Likert scale from "not important" to "very important."To understand self efficacy in carrying out PEBs as a household in a matrix question, we asked participants to rate their confidence that their household could attain the following pro environmental behavior (PEB) goals in the next 10 years: protect habitats, reduce plastic pollution in oceans, reduce use of fossil fuels, and save animals at risk of extinction. Participants rated each goal individually in a Likert scale from 1 to 10, with 1 meaning "cannot do at all," 5 meaning "moderately certain can do," and 10 meaning "highly certain can do." We also asked participants to rate the actual PEBs carried out by their household in the past 12 months on a scale of 1 (never) to 5 (very often). The PEB items we asked participants to rate included: Donated money to an environmental cause; Searched for information about an environmental issue; Volunteered for an environmental cause; Signed a petition to support an environmental cause; Took action to improve your local environment (e.g., picked up trash in a public space, planted trees or flowers), Recycle; Avoid products with ingredients that are bad for the environment; Use your own reusable shopping bags; Choose to walk, ride a bike, or use public transportation instead of drive; Talk to friends or household about an environmental issue; Used social media to share information about an environmental issue.

4.3.2 Knowledge. We assessed each household's knowledge of sustainability by asking participants to report their knowledge of transportation carbon impact and their awareness of sustainable public transportation options locally. We measured household knowledge of the carbon footprint of transportation by having participants rank the following transportation options in order from most sustainable (1) to least sustainable (8): EV, Hybrid Car, Gas Powered Car, Public Bus, Commuter Train, Electric Scooter, Electric Bike, Non Electric Bike. To understand awareness of sustainable public transportation options locally in a matrix question, we asked participants to rank how aware their household was of each transportation option locally (bus routes, train, etc) available to them on a scale from 1 (no awareness) to 5 (very aware).

4.3.3 Transportation Decisions. We evaluated each household's transportation decisions by asking participants to report the transportation types used and what kind of fuel powered their car(s). Participants estimated how frequently their household used a given transportation type in the past month. If the household used a car, participants were asked to select what kind of fuel the car used (full gas, hybrid, electric, plug in hybrid, fuel cell, or other), and to select multiple types if the household used more than one car.

4.3.4 Household Characteristics. We measured household characteristics by asking participants to report their resident zip code to determine transportation options locally available to them, the number of people in their household, the number of drivers in their household, and the ages of all household members.

4.3.5 Demographics. We measured household demographics by collecting participant information on their household income (total annual household income in USD), the educational attainment of adults in the household (highest level of educational degree earned in the household), and the members of their household which had a disability (none, DHH, blind or low vision, mobility, cognitive disability, prefer not to answer, or other).

4.4 Data analysis procedures

We selected 2 variables from the following two questions from our survey to analyze:

- Environmentalism Q4: How important to your household is protecting the environment?
- Transportation types used Q11: Estimate to the best of your ability how frequently (number of days) your household used each transportation type in the past month.

We chose these questions since they directly speak to our research questions about environmental attitudes and transportation decisions. Q4 is one variable, containing responses on a Likert scale, which is ordinal. We will rename this variable attitude_caring. The data from Q11 are ratio. From this question we will analyze the number of days people drove a car in a month. We will name this variable car_per_month.

We first conducted univariate analysis. Then, we conducted a two variable analysis using the Spearman rank-order correlation coefficient test on the variables. Spearman's is appropriate for a variable that is ordinal and a variable that is ratio. We decided against Pearson's coefficient, since Pearson's coefficient works only with two interval or ratio variables, but we have a ratio variable and an ordinal variable. We used scipy.stats [8] in Python to run our test. We set $\alpha = 0.05$.

Null Hypothesis H_0: There is no significant correlation between the two variables attitude_caring and car_per_month.

5 Results

5.1 Univariate Analysis

We conducted univariate analysis on each variable. For car_per_month, the mean $\mu = 21$, and the standard deviation $\sigma = 7.6615$. For attitude_caring (environmental attitudes), the mode is 4 on a Likert scale, indicating that many households regard environmental protection as very important. We also created histograms of each variable (see graphs A and B below). car_per_month appears to be not normally distributed, suggesting a skew in the data where certain values are more common than others. This could imply that a few households make significantly more or fewer trips than the average.

5.2 Bivariate Analyses

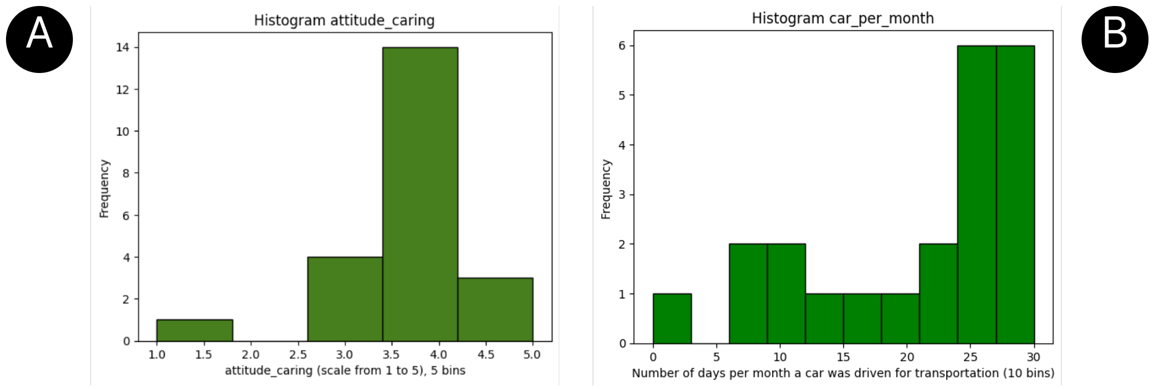

Fig. 1. A. Histogram of Household Environmental Attitudes (attitude_caring): This histogram illustrates the distribution of household responses regarding the importance of protecting the environment. The mode of the distribution is 4, indicating that a significant number of households consider environmental protection very important. B. Histogram of Monthly Car Usage (car_per_month): This histogram shows the distribution of the number of car trips per month made by households. The data reveals that the variable car_per_month is not normally distributed, with a mean of 21 trips and a standard deviation of 7.6615.

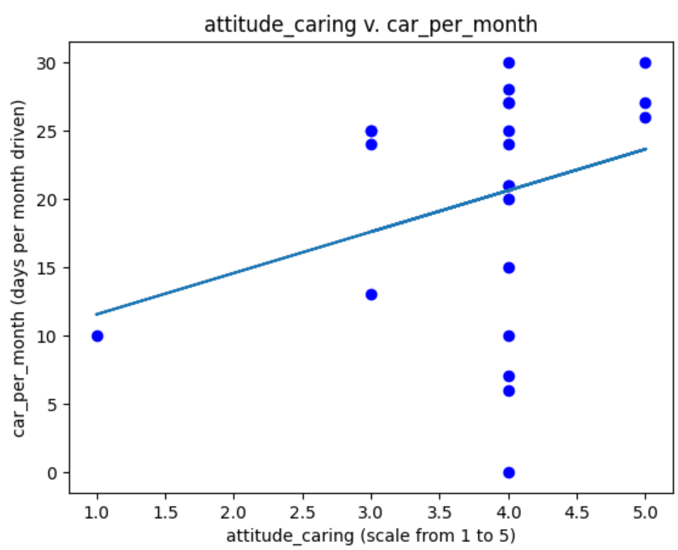

Fig. 2. Scatter Plot of Environmental Attitudes vs. Monthly Car Usage: This scatter plot depicts the relationship between the level of environmental concern (attitude_caring) and the frequency of car use per month (car_per_month). Despite a weak positive correlation (Spearman's = 0.35), the relationship is not statistically significant (p-value = 0.11).

5.2.1 *Attitudes and Car Usage.*

We measured the association of attitudes towards the environment and monthly car usage. Using the Spearman rank-order correlation coefficient. We plotted the data to visualize a potential trend in Figure 2. The data does not follow a line, so Spearman can help us find the relationship between the two variables. The Spearman test produced the following results:

- Spearman correlation coefficient = 0.35

- p-value = 0.11

Since the Spearman correlation coefficient is between 0 and 1, that means that attitude_caring and car_per_month are somewhat positively correlated. Moreover, this suggests that there is a slight tendency for households with higher environmental concern to also have higher car usage, but this tendency is not strong. If it were close to 0, that would indicate no correlation. Our p-value of 0.11 is greater than $\alpha = 0.05$. Thus we do not reject the null hypothesis. The correlation is weak, as it is not statistically significant with a p-value above 0.05. Therefore, we cannot confidently claim that there is a real association between environmental attitudes and car usage based on this data.

5.2.2 PEB Scores and Transportation Method Used. To understand the relationship between pro environmental behaviors performed and transportation types used we performed simple linear regression to understand these associations in greater detail. We took the participant responses from the actual pebs carried out in the survey (see Table 1 in appendix) we summed each of these scores with all scores lying in ranges of 11 and 55. For example we asked partiicpants to rate how often in their household they carried out a specific pro environmental task such as recycling or using a reusable shopping bag at the grocery store. Participants were given 11 out of these quesitons and marked each one on a 5 point scale. We then use these scores to compare relationships between reported transportation types over 30 days. These relationships are depicted in Figure 3

The regression model for car days and PEB score (Constant: 12.62; (p = 0.157), Slope: 0.24 (p = 0.386)) shows that there exists a weak positive relationship however not a statistically significant level. Spearman's correlation further supports this lack of significant relationship (r=0.193, p = 0.389), indicating no meaningful association. The regression model for bike days and PEB score (Constant: -1.13 (p = 0.797); Slope: 0.12 (p = 0.374)) shows that there exists a weak positive relationship however not a statistically significant level. Spearman's correlation further supports this lack of significant relationship (r=0.346, p = 0.115), indicating no meaningful association. The regression model for bus days and PEB score (Constant: 10.15 (p = 0.092); Slope: -0.24 (p = 0.190)) shows that there exists a weak negative relationship but not at a statistically significant level. The intercept does approach significance, suggesting a possible explanation of effect of bus_days when the PEB score is 0 is zero. However Spearman's correlation further supports this lack of significant relationship (r= -0.300, p = 0.175)). The regression results (Constant: 5.75 (p = 0.179); Slope: -0.15 (p = 0.252)) for train days and PEB score indicate non-significant coefficients Additionally, Spearman's correlation (r=-0.075 (p = 0.739)) is weak and non-significant, indicating no meaningful relationship. The regression model for subway days and PEB score (Constant: -0.11 (p = 0.712); Slope: 0.01 (p = 0.490)) shows non-significant coefficients, suggesting no significant linear relationship. The very low R-squared value (R-squared = 0.024) indicates that PEB score explains almost none of the variance in subway days. Spearman's correlation also shows a weak and non-significant relationship. For PEB score and Walking (Constant: 31.42 (p = 0.001); Slope: -0.32 (p = 0.212) the significant constant term suggests a notable baseline level of walking days when PEB score is zero. However, the slope is not significant, indicating no significant linear relationship. The R-squared value is still low, and the negative Spearman's correlation suggests an inverse relationship, though it is not statistically significant (r= -0.291, (p = 0.188)). For Scooter Days and PEB scores The non-significant regression coefficients (Constant: 2.74 (p = 0.531); Slope: -0.05 (p = 0.698)) and the extremely low R-squared value (R-squared: 0.008) indicate no significant linear relationship between PEB score and scooter days. The Spearman's correlation also suggests no significant relationship (r= -0.032, p = 0.888).

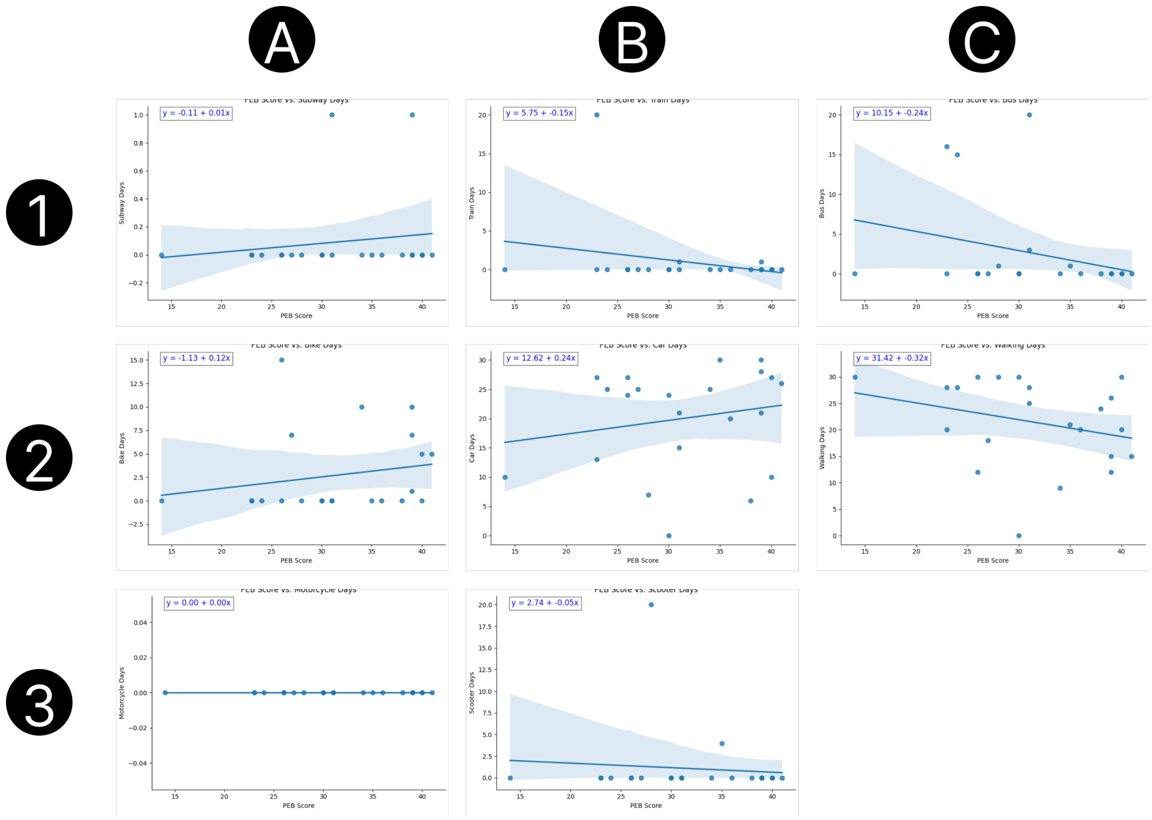

Fig. 3. Scatter plots comparing cumulative Pro Environmental Scores and various methods of transportation types reported. A1. PEB Score vs. Subway Days, A2. PEB Score vs. Bike Days, A3. PEB Score vs. Motorcycle Days, B1. PEB Score VS. Train days, B2. PEB Score VS. Car days, B3. PEB Score vs Scooter Days, C1. PEB Score vs. Bus days, C2. PEB Score vs. Walking days

6 Discussion

Although our analysis was not incredibly thorough it does not seem like identifying with or care for the environment nor carrying out PEB actions (such as sharing about an environmental cause online or avoiding products that are bad for the environment) amongst a household are particularly strong indicators for understanding the transportation types that people use. These findings suggests that other factors, possibly economic, practical considerations, or interpersonal, might play a more dominant role in determining transportation behaviors.

7 Limitations

This study has several limitations that should be acknowledged. First, the cross-sectional nature of the data precludes any claims of causality, limiting our findings to correlations rather than causal relationships. Second, there are limitations in our instrumentation. The survey was designed to capture the collective attitudes and behaviors of households, which presents challenges as participants may not accurately represent their entire household's perspectives. Consequently, the results might reflect individual rather than collective attitudes and behaviors.Third, the scope of environmental behaviors and attitudes included in the survey is not exhaustive. Expanding this list could provide a more comprehensive understanding of household environmentalism. Fourth, while our study focuses on environmental attitudes and transportation decisions, there are potential confounding variables, such as economic factors, that were not accounted for and may influence transportation choices. Finally, our sample population consists predominantly of households in Irvine, CA, within Orange County, introducing potential selection bias. As a result, the findings may not be generalizable to the broader population of Southern California or other regions. Future research should address these limitations by incorporating longitudinal data to assess causality, broadening the range of environmental behaviors surveyed, and including a more diverse sample to enhance the generalizability of the findings.

8 Conclusion and Future Work

In this study, we aimed to understand how household's attitudes about the environment impact their transportation decisions. We surveyed over 20 participants. Through our analysis using Spearman rank-order correlation, we found that environmental attitudes in terms of caring about the environment are positively correlated-although weakly-with the transportation decision of number of days households drove a car in a month. Future work includes recruiting more households in more regions of Orange County, CA as well as conducting further analyses including more variables such as economic factors and social dynamics. Also, conducting a longitudinal study to learn about environmental attitudes and transportation decisions over time may help us to determine a causal relationship between the two. Finally, learning about the association between environmental attitudes and transportation decisions will aid in the design of future eco feedback interfaces for encouraging households and families in making more sustainable transportation decisions collaboratively.

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A Survey Questions and Variables

Table 1. Variables: Attitudinal, Transportation Decisions, and Knowledge

Categories	**Variable Name**	**Variable Definition in plain language**	**Operational definition - how will you measure?**	**Level of Measurement**	**Range of variation in variable**
Attitudinal	Environmentalism (attitude_caring)	Degree of how much people care about the environment	"How important is protecting the environment for your household?"	Ordinal	not important, neutral, somewhat important, very important
Attitudinal	Pro Environmental Behavioral (PEB) Self Efficacy (Confidence in PEBs)	Confidence in ability to carry out PEBs	Please rate how confident you are that your household can attain the following goals in the next 10 years. Protect habitats, Reduce plastic pollution in our oceans, Reduce use of fossil fuels (e.g., petroleum, natural gas, coal), Save animals at risk of extinction: matrix question - each behavior separately	Ratio	A number from 1 to 10 where 1 means "cannot do at all", 5 means "moderately can do" and 10 means "highly certain can do."

Attitudinal	Actual PEBs exhibited in the past 12 months (Personal PEBs)	Actual PEBs carried out	How many, if any, of the following has your household done within the PAST 12 MONTHS?: matrix question - Select all that apply (Donated money to an environmental cause; Searched for information about an environmental issue; Volunteered for an environmental cause; Signed a petition to support an environmental cause; Took action to improve your local environment (e.g., picked up trash in a public space, planted trees or flowers), Recycle; Avoid products with ingredients that are bad for the environment; Use your own reusable shopping bags; Choose to walk, ride a bike, or use public transportation instead of drive; Talk to friends or household about an environmental issue; Used social media to share information about an environmental issue))	Ratio	rate from 1 to 5, never to very often.
Transportation Decision	Transportation types used	what frequency of methods of transportation people in the household have used	Estimate to the best of your ability how frequently your household used each transportation type in the past month: matrix question	Ratio	give numbers for each
Transportation Decision	what kind of fuel car takes	what fuel the cars use	if the household uses a car, what kind of fuel does the car take. select multiple if the household has multiple cars	Nominal	full gas, hybrid, electric, plug in hybrid, fuel cell, other (please specify)

Knowledge	Knowledge of transportation carbon impact	What people know about carbon footprint of transportation	Have people rank carbon footprint for a set distance (20 miles) from most sustainable to least. (EV, Hybrid Car, Gas Powered Car, Public Bus, Commuter Train, Electric Scooter, Electric Bike, Non Electric Bike)	Ordinal	Most Sustainable (1) to Least Sustainable (8) (based on there being 8 option to rank)
Knowledge	Awareness of sustainable or public transportation options locally?	self-assessment of their awareness of transportation options locally	rank how aware your household is of different transportation options available to your household locally?: matrix question: bus routes, train, bike lanes, etc.	Ordinal	no awareness, some awareness, aware, very aware
Household Characteristics	zip code	where the household lives: access to transportation options	Ask the zip code of where their household lives	Nominal	zip codes
Household Characteristics	number of drivers in household	the number of household members who can legally drive	Ask how many number of legally drivable household members are in the household	Ratio	0-infinity
Household Characteristics	ages of all household members	how many years of age is each member of the household	Ask for the ages of all household members	Ratio	0-infinity
Household Characteristics	number of people in household	number of people in the household	Ask for number of people in household	Ratio	2 to infinity
Demographic	Household income	the annual income of the household	What is your total annual household income in USD? [open resonse item constrained to numbers only	Ratio	ranges from $0 to infinity, and prefer not to answer

Demographic	Educational attainment of adults in the household	how educated the household is	What is the highest level of educational degree earned in the household?	Ordinal	Some high school, high school degree, some college, associates degree, university degree, graduate/professional degree, prefer not to answer
Demographic	Members of household having a disability	are there people in the household with a disability	Does anyone in the household have a disability/disabilities? Select from the list (multiple choice)	Nominal	none, DHH, blind or low vision, mobility, cognitive disability, prefer not to answer, Other (please specify)

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