Reducing Carbon Emissions from Student Commuting

March 2024

A Research Report from the Pacific Southwest Region University Transportation Center

Detlof von Winterfeldt, University of Southern California

Richard S. John, University of Southern California

Aleyeh Roknaldin, University of Southern California

Alice Qiao, University of Southern California

Laurel Kruke, University of Southern California

Julie Hopper, University of Southern California

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. PSR-22-01	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle Reducing Carbon Emissions from Student Commuting		**5. Report Date** March 31, 2024 **6. Performing Organization Code** N/A
7. Author(s) Detlof von Winterfeldt, Richard S. John, Aleyeh Roknaldin, Alice Qiao, Laurel Kruke, Julie Hopper, University of Southern California		**8. Performing Organization Report No.** TBD
9. Performing Organization Name and Address METRANS Transportation Center University of Southern California University Park Campus, RGL 216 Los Angeles, CA 90089-0626		**10. Work Unit No.** N/A **11. Contract or Grant No.** USDOT Grant 69A3551747109
12. Sponsoring Agency Name and Address U.S. Department of Transportation Office of the Assistant Secretary for Research and Technology 1200 New Jersey Avenue, SE, Washington, DC 20590		**13. Type of Report and Period Covered** Final report, August 15 2022 to December 31, 2023 **14. Sponsoring Agency Code** USDOT OST-R
15. Supplementary Notes https://metrans.org/research/reducing-carbon-emissions-from-student-commuting https://doi.org/10.25554/7acd-2s78		

16. Abstract

Student commuting is a large contributing factor to the carbon footprint of universities. For example, student commuting at the University of Southern California (USC) alone makes up 7% of USC's emissions from all sources. Many universities have action plans and programs to reduce emissions from student commuting; however, the issues of safety, time, and convenience typically outweigh students' motivation to use alternative modes of transportation. For this reason, it is crucial to understand the behavioral research behind commuting and the environment, as well as the use of nudging or incentives to change behavior. Effective programs need to consider the students' reasons for their mode of transportation and include them in the conversation for solutions. This research provides a survey of student commuting practices and associated carbon emissions at USC, a comprehensive literature review of commuting and nudging behavior, a study on commuting and sustainability plans at several universities, and solutions from focus groups with USC graduate students aimed to encourage environmentally friendly forms of transportation.

17. Key Words Student commuting, behavior change, carbon emissions, environment, nudging	**18. Distribution Statement** No restrictions.		
19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 39	**22. Price** N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Contents

About the Pacific Southwest Region University Transportation Center

The Pacific Southwest Region University Transportation Center (UTC) is the Region 9 University Transportation Center funded under the US Department of Transportation's University Transportation Centers Program. Established in 2016, the Pacific Southwest Region UTC (PSR) is led by the University of Southern California and includes seven partners: Long Beach State University; University of California, Davis; University of California, Irvine; University of California, Los Angeles; University of Hawaii; Northern Arizona University; Pima Community College.

The Pacific Southwest Region UTC conducts an integrated, multidisciplinary program of research, education and technology transfer aimed at *improving the mobility of people and goods throughout the region.* Our program is organized around four themes: 1) technology to address transportation problems and improve mobility; 2) improving mobility for vulnerable populations; 3) Improving resilience and protecting the environment; and 4) managing mobility in high growth areas.

U.S. Department of Transportation (USDOT) Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation's University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.

California Department of Transportation (CALTRANS) Disclaimer

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated under the sponsorship of the United States Department of Transportation's University Transportation Centers program, in the interest of information exchange. The U.S. Government and the State of California assumes no liability for the contents or use thereof. Nor does the content necessarily reflect the official views or policies of the U.S. Government and the State of California. This report does not constitute a standard, specification, or regulation. This report does not constitute an endorsement by the California Department of Transportation (Caltrans) of any product described herein.

Disclosure

Detlof von Winterfeldt, Principal Investigator, Richard S. John, Co-Principal Investigators, and others, conducted this research titled, "Reducing Carbon Emissions from Student Commuting" at the University of Southern California. The research took place from August 15, 2022, to December 31, 2023, and was funded by a grant from the METRANS Center in the amount of $95,075. The research was conducted as part of the Pacific Southwest Region University Transportation Center research program.

Acknowledgments

We gratefully acknowledge Michael “Mick” Dalrymple, Chief Sustainability Officer in the Office of Sustainability at the University of Southern California, for helping us to get this project off the ground and for making survey staff and resources available.

Abstract

Student commuting is a large contributing factor to the carbon footprint of universities. For example, student commuting at the University of Southern California (USC) alone makes up 7% of USC's emissions from all sources. Many universities have action plans and programs to reduce emissions from student commuting; however, the issues of safety, time, and convenience typically outweigh students' motivation to use alternative modes of transportation. For this reason, it is crucial to understand the behavioral research behind commuting and the environment, as well as the use of nudging or incentives to change behavior. Effective programs need to consider the students' reasons for their mode of transportation and include them in the conversation for solutions. This research provides a survey of student commuting practices and associated carbon emissions at USC, a comprehensive literature review of commuting and nudging behavior, a study on commuting and sustainability plans at several universities, and solutions from focus groups with USC graduate students aimed to encourage environmentally friendly forms of transportation.

Keywords: student commuting, behavior change, carbon emissions, environment, nudging

Reducing Carbon Emissions from Student Commuting

Executive Summary

The objectives of this research were to improve the estimates of greenhouse gas (GHG) emissions from university student commuting, to develop a better understanding of the determinants of students' transportation choices, and to explore students' intentions and willingness to change their transportation behavior to reduce carbon emissions.

Universities across the U.S. are making efforts to reduce the carbon emissions from various sources related to their activities. An important source of carbon emissions is student commuting by single occupancy cars. This project analyzed the carbon emissions by students at the University of Southern California and explored ways to reduce these emissions by encouraging students to use modes of transportation that are more environmentally friendly.

The project consisted of three main tasks:

1. Survey of student commuting behavior at USC
2. Literature review of methods to reduce student commuting by car
3. Focus groups to explore students' motivations to use cars or alternative modes of transportation and to identify options for USC to encourage use of public transportation

Survey Results

A survey was sent to all undergraduate students, graduate students, and postdoctoral fellows at USC in the spring of in 2022. It included several general questions about sustainability knowledge and attitudes and specific questions about commuting behavior. Approximately 3,000 students responded to the commuting questions, split roughly between undergraduates and graduates. The most interesting findings were that very few undergraduate students commute by car (7%), while graduate students commute by car more often (32%). In total, student commuting contributes 17,969 metric tons of carbon emissions, or about 7% of all emissions from USC.

Literature Review

We conducted a broad literature review related to student commuting. The most interesting part of the review related to the effectiveness (or lack thereof) of incentives to encourage student commuting by public transportation. Some studies indicate that economic reasons are the main driver of using public transportation, especially for those with a low annual income. This suggests that free travel passes for public transportation may provide a strong incentive to shift from cars to buses or trains. Feedback about pollution and other environmental consequences from single-occupancy vehicles (SOVs) also reduces the frequency of car travel,

as can information and feedback about fuel consumption and associated expenses. Nudging to shift from using an SOV to ridesharing, public transportation, bicycling, or walking has also been tested with mixed success. In a meta-analysis of nine experiments using nudges, we found four studies with a positive effect of nudging, but also five studies with no effect.

Many universities have developed programs to shift students' modes of transportation to environmentally sustainable ones.

Focus Groups

Four focus groups were held in the summer and fall of 2023. Seventeen USC graduate students explored their concerns, values, and criteria when making commuting mode choices. Additionally, we conducted a class exercise in the 2024 spring semester with the same goals.

The most common forms of transportation among graduate students were SOVs, buses, light rail, and biking. When asked to identify important factors that affected decisions on commuting, the top factors were safety, cost, control of timing, and convenience. Environmental benefits mainly were an afterthought or thought of as additional intrinsic benefits.

After discussing with students the factors that influence their commuting preferences, we asked them to share ideas that they believe will encourage graduate students to use alternative transportation. The students suggested that USC invest in safety, affordable graduate housing, convenient routes and times for USC transportation, and incentives for environmentally friendly vehicles.

Introduction

The objectives of this research were to improve the estimates of greenhouse gas (GHG) emissions from university student commuting, to develop a better understanding of the determinants of students' transportation choices, and to explore students' intentions and willingness to change their transportation behavior to reduce carbon emissions.

Universities across the U.S. are making efforts to reduce the carbon emissions from various sources related to their activities. An important source of carbon emissions is student commuting by single occupancy cars. This project analyzed the carbon emissions by students at the University of Southern California and explored ways to reduce these emissions by encouraging students to use modes of transportation that are more environmentally friendly.

The project consisted of three tasks:

1. Surveys of student commuting behavior at USC
2. Literature review of methods to reduce student commuting by car
3. Focus groups to explore students' motivations to use cars or alternative modes of transportation and to identify options for USC to encourage use of public transportation

Survey of Students Commuting

As a first step, we aimed to estimate USC students' carbon emissions from commuting. To do so, we conducted a survey with all USC undergraduate students, graduate students, and postdoctoral fellows in the spring of 2022. Included in the survey were questions about their commuting behavior, as well as their knowledge and attitudes towards sustainability.

Methods

Student sample data was collected by the USC Office of Sustainability in the form of a mass email to all USC students and fellows in April 2022. The final sample size used for analyses was N = 2,889. The survey sent to students included commuting habits (self-reported commute distance to/from school, commute frequency, mode of transportation, car model/make and MPG), school-specific demographic data (year-in-school, major, etc.), and their general attitudes and knowledge towards sustainability.

To calculate the carbon emissions of USC student commuting, we decided to adopt the Well-to-Wheel (W2W) emissions method. W2W emission is the sum of well-to-tank emissions (the amount of CO2 emitted, from oil extraction, to processing, to transporting to gas stations) and the tank-to-wheel emissions (the amount of CO2 emitted from driving). In the state of California, the W2W emission is estimated at 0.012 Metric Ton CO2e/gallon of gas, and 0.013 Metric Ton CO2e/gallon of diesel (https://ww2.arb.ca.gov/sites/default/files/classic/fuels/lcfs/peerreview/050515staffreport_ca-greet.pdf). As for electric, plug-in hybrid, and hydrogen cars in California, corresponding

emissions data was pulled from the fueleconomy.gov website (https://www.fueleconomy.gov/feg/Find.do?action=bt2).

Results

Participants

Of the final sample size of N = 2,889, 3% were post-docs, 54.5% were graduate students, and 42.5% were undergraduate students. Figure 1 shows the status of these respondents at USC in more detail.

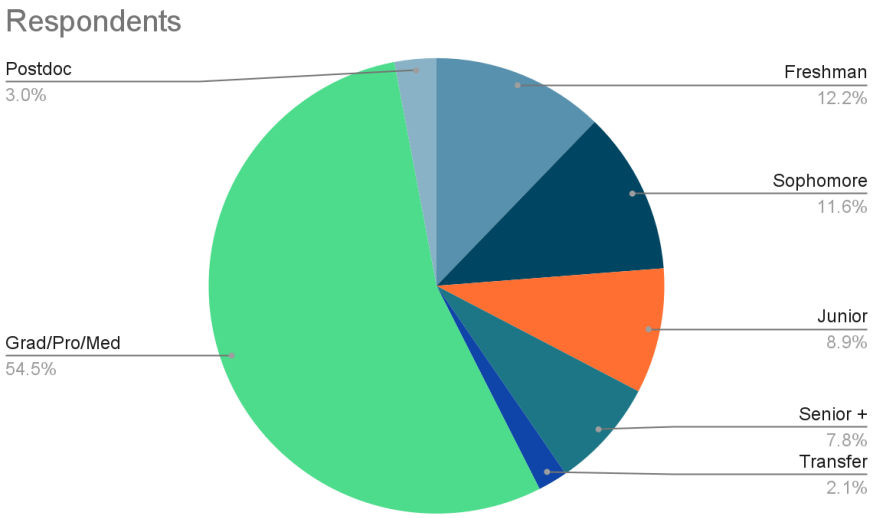

Figure 1. Distribution of survey respondents

Modes of Transportation

Undergraduate students reported driving much less (at approximately 9%, including both Single-Occupancy Vehicles (SOVs) and carpooling) than graduate students (at approximately 37.3%, including both SOVs and carpooling), as shown in Figure 2.

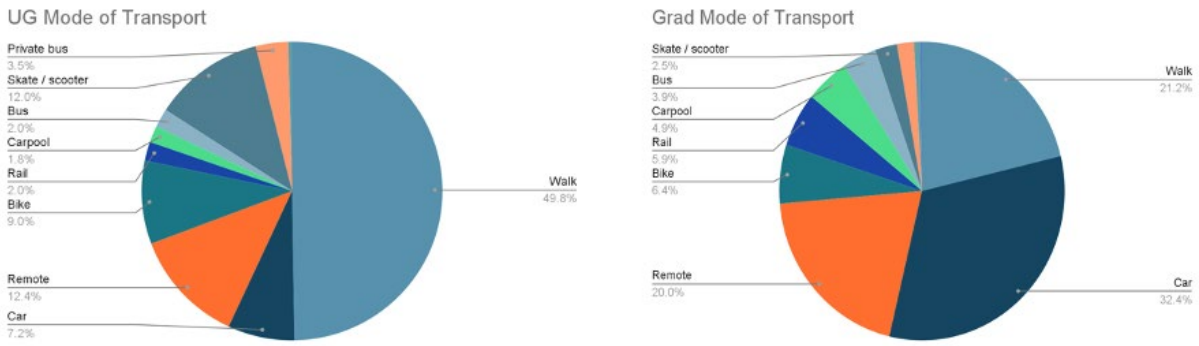

Figure 2. Comparison of undergraduate (UG) and graduate (Grad) modes of transportation

In terms of fuel type, only 17% of driving students drove a lower-emission car (plug-ins, electric, or hybrid), whereas the remaining 82% drove a gas car, as shown in Figure 3.

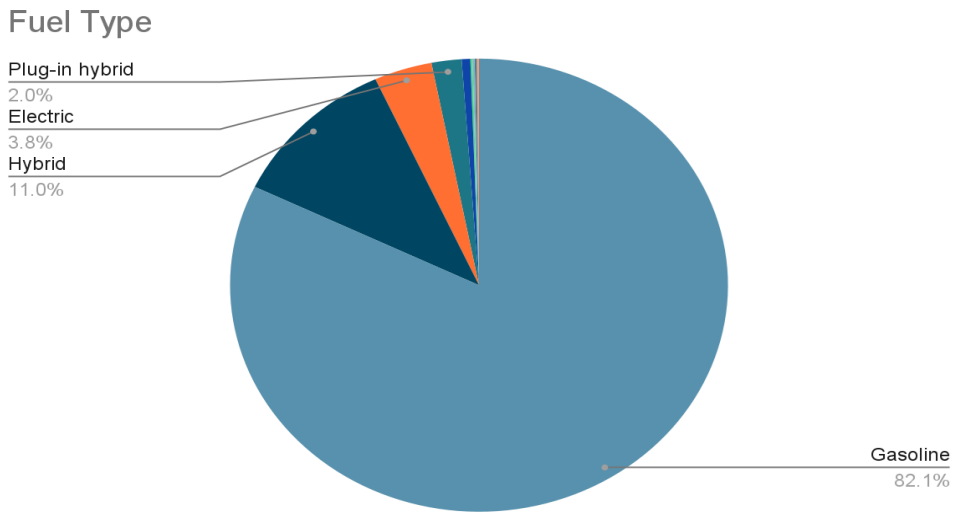

Figure 3. Distribution of car use by fuel types

Emissions Calculation

We compared respondents' self-report MPG data against the official government data. Figure 4 shows the distribution of differences between both estimates. Most respondents' self-reported estimates were within reasonable range (+/- 5MPG), with only a few outliers. 50% of students' mileage estimates were below the government estimates and 50% were above.

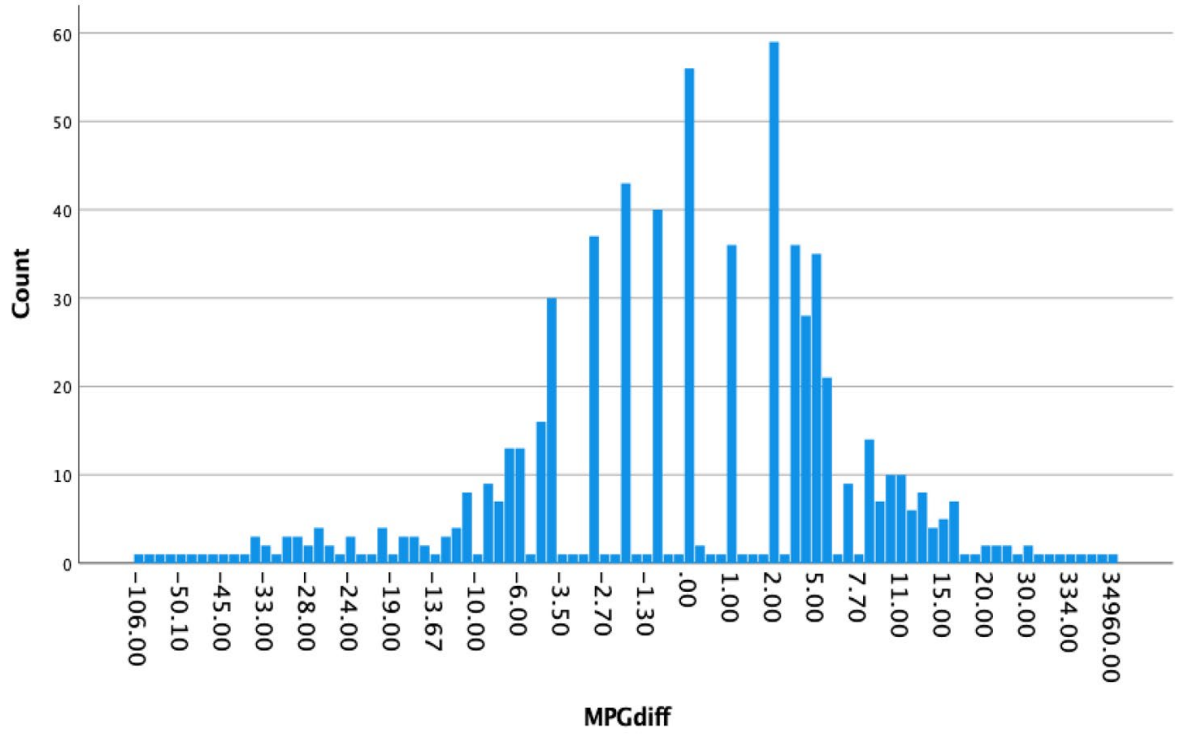

Figure 4. Comparison of self-reported mileage estimates vs. U.S. government mileage estimates

Using U.S. government mileage estimates (https://www.fueleconomy.gov/feg/Find.do?action=bt2) and USC students' self-report mileage data, we estimate that the USC student population emits 440.28 MTCDE/week, or 17,969MTCDE/academic year (35 weeks of fall and spring semesters and 12 weeks of summer semester, the latter adjusted for the number of students enrolled). During the regular school year, undergraduate students are estimated to emit only 56.911 MTCDE/week, whereas graduate students are estimated to emit more than six times the amount that undergraduates do, at 383.373 MTCDE/week.

Comparing USC Student Data with the AQMD Survey Data

During the same year that the USC student commute survey was conducted, the California Air Quality Management District's (AQMD) survey was also administered. The AQMD survey was mandatory for all USC employees, including student workers, research assistants, and teaching assistants. The survey included many of the same questions asked in the student commute survey. Here, we compare the student data from both surveys to benchmark and validate.

In the USC student commute survey, about 9% of undergraduate students and 37% of graduate students indicated that they either drive alone and/or carpool with others when commuting to and from USC. In the AQMD survey, about 12% of undergraduate student and 38% of graduate students indicated that they either drive alone and/or carpool with others. The percentages

from both surveys are not significantly different from one another, though we do observe that the AQMD survey reported 3% higher driving rate among undergraduate students. We hypothesize that because the AQMD survey only captures *working* undergraduate students, those students are more likely to own/drive cars as they need to be on campus more often and for longer periods of time to attend their work shifts.

Comparing USC Students' Modes of Transportation against UCLA's

Even though USC and UCLA are both located in Los Angeles County and are only a short drive away from one another, the students have significantly different commuting habits (*1)*. Most notably, USC students have a higher SOV rate (21.7%) than UCLA students (13%). USC students also walk to school less (33.4%) and take the bus less (5.7%) than UCLA students (52% and 11%, respectively).

Table 1. Comparison between USC and UCLA modes of student commuting

USC Students	Mode of Transport	UCLA Students
33.4%	**Walk**	52%
21.7%	**Solo Drive**	13%
16.7%	**Remote**	12%
5.7%	**Bus**	11%
3.6%	**Carpool**	3%
18.9%	**Other (bike, scoot, ride hail, etc.)**	8%

There are several reasons why USC has a larger share of single occupancy drivers than UCLA. USC offers significantly fewer on-campus living options for their students; only 17% of USC students live on-campus, whereas 37% of UCLA students do so. In addition, there are more housing options near the UCLA campus due to its location in a residential area. USC is located closer to downtown Los Angeles, limiting the space to build affordable new housing tailored for students, particularly graduate students. USC's neighborhood is also less safe than UCLA's motivating USC students to move further away from campus. Another potential reason could be the free rides from campus that both universities offer. While both USC and UCLA partnered with ride share services to give students a safe alternative to travel home, UCLA's service is for 24 hours whereas USC is only certain hours in the evening/early morning (*2, 3*). As for the bus schedule, UCLA and USC have comparable bus times, however due to safety concerns, not all USC students take advantage of the bus system (*4*).

USC has several options to reduce single occupancy driving by students. Starting with the academic year of 2023/24 USC offered free METRO passes to students. This may decrease

commuting by car, but there are no findings yet to support this. Graduate students at USC are the main commuters by car (about 30% vs. 7% for undergraduates). Building affordable graduate housing near USC with safe walkable or bikeable access to campus is another option, albeit expensive. Another lesson from the UCLA comparison is to extend the bus time hours to past midnight to account for graduate students who work late, giving students the time flexibility that they feel when driving. A major concern at USC is safety. Ensuring that USC's public transportation extends to regions that are populated by USC graduate students, especially commuters, is crucial to not only encouraging students to take public transportation but to feel safe while doing so. This includes potentially extending routes to farther parts of Los Angeles, including Pasadena or West Los Angeles

Literature Review

Many universities plan to reduce carbon emissions from various sources directly or indirectly related to their operations. The emissions reduction targets can be categorized into three scopes: direct emissions from on-site sources like buses and waste processing (Scope 1), offsite emissions from electricity and gas generation supplied to the university (Scope 2), and emissions primarily due to transportation, including students, staff, and faculty commuting by car and air (Scope 3). The University of Southern California (USC), for example, had an estimated carbon footprint of 208,916 metric tons of CO_2 equivalent (MTCDE) in 2022, with 120,640 MTCDE coming from Scopes 1 and 2 sources and 88,276 MTCDE from Scope 3 sources. Student commuting alone contributed 17,969 MTCDE, approximately 8.6% of all emissions and 21% of Scope 3 emissions. USC is committed to carbon neutrality for Scopes 1 and 2 by 2025 and Scope 3 by 2035, as well as reducing carbon emissions from Scope 3 by 50% relative to 2014 emissions (*5*). Reducing carbon emissions from student commuting can majorly contribute to these goals.

Before focusing on commuting behavior, discussing the relationships between pro-environmental behavior, beliefs, values, and self-identity is essential. Self-identity is a label that describes oneself by individual motivations, social interactions, and social norms. Pro-environmental self-identities exhibit behaviors where people take action to benefit the environment. Self-identity is a significant indicator of carbon offsetting and a predictor for specific pro-environmental behaviors (*6*). Their perceived status can lead to environmental spillover effects, where engagement in one behavior will cause individuals to adopt a more pro-environmental stance and engage in related pro-environmental behaviors. Spillover effects can occur across behavior, time, and context, typically classified as positive and negative (*7*). According to Truelove et al. (*8*, p. 132), spillover effects can be anticipated when the "performance of an initial behavior changes the perceived resources the individual has at his or her disposal when evaluating the costs and benefits of the subsequent behavior." Concerning commuting, a study investigated how monetary benefits affect spillovers of pro-environmental

behavior among university students in the Netherlands (*9*). The study participants completed an online questionnaire and were randomly assigned to monetary, environmental, and control groups. Students were instructed to imagine the scenario of purchasing an electric vehicle. The situation was presented as an environmentally beneficial behavior, a financially beneficial behavior, or no emphasis on behavior. Spillover effects were measured by asking students to choose between items that were more environmentally friendly but 10% more expensive and items that were cheaper but not environmentally friendly. Emphasizing the monetary benefits instead of the environmental benefits of purchasing an electric car marginally significantly weakened pro-environmental self-identity.

The literature regarding commuting patterns goes back to the 1970s when the concern was less about climate change than energy conservation, especially regarding fuel consumption. For example, Reichel and Geller (*10*) describe the speculative contingencies of the pros and cons of driving cars. The pros include short travel time, high prestige, choice of route, flexibility in departure and arrival time, deferred cost, privacy, and large cargo capacity. The cons include traffic congestion, high gas prices, and maintenance costs. Their work provided a list of transportation management strategies to reduce the impact of car driving that included reducing vehicle miles traveled, encouraging fuel-saving driving practices, and ride-sharing. They provided a list of potential benefits of ride-sharing, adapted from Owens and Sever (*11*), shown in Table 2.

Table 2. Benefits of a ride-sharing program

Benefits to Organization	• Reduced congestion at site • Reduced demand for parking • Reduced capital expenditures for auto-related facilities • More efficient land use
Benefits to User	• Reduced expenses • Reduced risks and tensions of commuting • Greater availability of cars for use by family members • Reduced congestion and parking demand
Benefits to General Public	• Reduced congestion on streets and highways • Reduced land use for auto-related facilities • Less air and noise pollution • Reduced energy consumption

While ride-sharing has numerous benefits, social and psychological factors affect people's willingness to participate. Barkow's 1974 study (as cited in *[11]*, p. 74) stated that "carpooling is a social arrangement and that to understand the contingencies involved in promoting carpooling better, it is necessary to develop an understanding of the psychosocial nature of carpooling." Studies have indicated that the driver's relationship with the rider was an essential factor to consider, and riders were more likely to use ride-sharing if it was with an

acquaintance. Planning and socializing with a stranger seems to deter people when considering carpooling. Yet one of the most common reasons for not carpooling was the perceived lack of freedom.

The literature on commuting behavior and strategies for shifting commuting choices to improve the environment is extensive. For this review, we focused on the effectiveness of pro-environmental messaging, nudges, and incentives to reduce car usage for student commuting.

Van Lange et al. (*12*) define a social dilemma as a situation where

> "behaving in a collectively undesirable manner yields better personal outcomes than behaving in a collectively desirable manner, irrespective of others' choices; yet, if most or all people choose the noncooperative option, the outcomes for all individuals involved are worse than if all or most people choose the cooperative option" (p. 797).

This definition directly applies to the dilemma of driving single-occupancy vehicles (SOVs) instead of other means of transportation like public transportation, ride-sharing, or biking. Van Lange et al. (*12*) examined whether differences in social value orientation affect commuting preferences. Based on a questionnaire, participants were partitioned by their social orientation: "proselfs," who were prone to view situations in terms of their personal well-being, and "prosocials," who were prone to view situations in terms of collective well-being. The study found that when car efficiency, defined as average travel time, was high, proselfs were less inclined to prefer public transportation; however, when car efficiency was low, preferences for public transportation were greater. Similar results were found for proselfs regarding car efficiency and carpooling preferences. The study revealed that perceived car efficiency statistically impacted prosocials' commuting behaviors as well. Prosocial behavior related to environmentally friendly behaviors can also be studied through behavioral paradigms, defined as "systematically arranged model situations that mirror the same critical contingencies as the situations they are supposed to model" (*13*). The review of behavioral paradigms for studying pro-environmental behavior identified 99 ad-hoc paradigms and five validated paradigms across a wide range of disciplines.

Behavioral interventions can be used to decrease the psychosocial barriers associated with carpool driving. One is continued investment in incentives such as carpool lanes, which have been proven effective in promoting ride-sharing. Another is personalized approaches to finding carpool matches. Considering how valuable rider acquaintanceship is, universities could set up events for students to potentially meet other students who live near them to form carpooling schedules. Providing incentives for carpooling, such as reduced parking rates or prizes, could also encourage students to ride-share.

Specifically related to student commuting, Fu et al. (*14*) found just how important proximity to campus and adequate public transportation were to shift the mindset of alternative commuting modes. The study aimed to test the Transtheoretical Model (TTM) on transportation behavior among university students, faculty, and staff at the University of New Hampshire (UNH) and the

University of Rhode Island (URI). TTM predicts that people do not change their minds easily but through habitual behavior. The stages of change are pre-contemplation, contemplation, preparation, action, and maintenance. A high TTM value is maintenance, meaning that the habit has been formed and the chance of relapse to old habits is low, whereas pre-contemplation is a denial of the problem and resistance to change. UNH is known to have an efficient public transportation system, while URI has limited public transportation. Participants were recruited by phone and online for the study. Researchers found that faculty and staff were more likely to drive SOVs than students. An analysis of where participants lived in relation to campus found that a long commute discouraged alternative transportation, leading to a low TTM value. TTM values were also lower at URI, where the public transportation system was ineffective. Living farther from campus and poor public transportation systems are indicators of using SOVs to drive to campus.

The theory of planned behavior (TPB), according to Bamberg et al. (*15*), explains that:

> "Human action is guided by three kinds of considerations: beliefs about likely consequences of behavior (behavioral beliefs), beliefs about normative expectations of others (normative beliefs), and beliefs about the presence of factors that may further or hinder performance of the behavior (control beliefs)" (p. 175).

TPB was used by Bamberg et al. (*15*) in a study conducted at the University of Giessen in Germany to test its validity as a framework for developing and analyzing an intervention plan for student commuting. The study consisted of various experiments that tested the effectiveness of a semester ticket offered to students. Purchasing the ticket would provide free public transportation from the university. The study lasted one year and utilized questionnaires for data collection. After the semester ticket intervention, the results indicated that the proportion of users of public transportation almost doubled, and car use decreased by more than 10%. One analysis closely looked at two subgroups, one in support of the private car-use restriction and one opposed, and found that non-supporters had a 17% increase in public transportation use. Looking specifically at bus usage, students who took the bus more than doubled since the start of the semester ticket intervention. The study also used past behavior to predict future behaviors. Past behavior was determined through a self-report of how often students used alternative transportation modes the previous semester. The study concluded that past behavior could be a valid predictor of future behavior, but only if the circumstances remain constant.

A study conducted at a Canadian university in 2018 revealed economic reasons for using alternative transportation. Daisy et al. (*16*) found that the probability of using alternative travel is higher if the annual income is lower than $15,000. The researchers also found that the number of daily transit trips is positively associated with an annual income of less than $15,000 and no flexibility in their work schedule. The number of daily transit trips is negatively related to the age of the individual, work distance, and annual income. People (including university students) choose different modes of transportation depending on the activity for which the travel is intended. For example, one might drive while running errands due to the number of

location stops for a shopping trip, whereas one might walk or bike to recreational activities with fewer time constraints (*16, 17*). Daisy et al. (*16*) also reported that graduate students travel mainly by walking, SOVs, and transit for paid work. Understanding the requirements of the various tasks and activities people perform during the day and how an incentive or schedule change could impact travel could affect the decision to commute via personal or public transportation.

Graham et al. (*18*) conducted an experiment in which students were asked to reduce their mileage of car driving and to report how many miles they drove every two days. They received feedback about avoiding pollution, avoiding gas expenses, both, or neither. Students responded to a web-based survey of the miles they drove during any two-day interval and received one of the four feedback responses. After two weeks, students responded on a 9-point scale of how much they reduced their driving during two weeks of feedback as follows:

> "'During the past 2 weeks, would you say that you used your car *less often than usual*, *the same*, or *more often than usual*?' Responses were rated on a 9-point scale ranging from 1 (*much less*) to 5 (*the same*) to 9 (*much more*)" (p. 112).

The researchers found significant differences in response to this question. The control group resulted in the least reduction in driving, whereas the dual feedback condition (pollution and cost savings) showed the largest reduction.

Foxx and Hake (*19*) conducted a study using positive reinforcement strategies for fuel conservation. The goal was to develop a method for measuring the driving patterns of college students to reduce nonessential driving. The study was partitioned into a baseline condition with no consequences for driving behavior and reinforcement conditions where students were awarded for lowering their average daily miles driven. The experimental group utilized the reinforcement condition and was given personal fuel conservation guides that stated the mileage-reduction goals and the respective prizes when the student would achieve the reduction. After a month, there was an approximate 20% reduction in miles driven per day in the experimental group that received prizes.

Everett et al. (*20*) set out to develop a sustainable method for a token exchange procedure for students using public transportation. The study was conducted at a large state university with two buses. One bus offered no tokens, whereas the other provided tokens that could be redeemed for prizes. After collecting data for about four weeks, there was a 150% increase in rides when tokens were given out compared to the baseline. Of all the tokens given out, 83% were redeemed for prizes, highlighting that students attached value to the tokens.

Similar to the token exchange study, Deslauriers and Everett (*21*) tested the effects of intermittent token reinforcement, where every *n*th passenger received a token. The field experiment included an experimental bus line and a control bus line. They found that after around seven weeks of intermittent token reinforcement, the number of bus riders in the experimental bus line compared to the control line increased by 30%, and similar to the previous study, 82% of distributed tokens were redeemed.

Interventions such as free or subsidized bus/public transportation passes can be successful, especially if the infrastructure is available and is considered safe and efficient compared to commuting by personal vehicle (*15, 22, 23, 24*). Considerations such as the urbanicity of the campus location, commute distance, and convenience of public transportation routes and schedules played roles in the success of alternative transportation strategies. Recordkeeping interventions encouraging students to reduce their car usage have proven effective in combating other risky driving behaviors, such as intoxicated driving. Recordkeeping makes the behavior change potentially more memorable, increasing the probability that individuals will act on it. Reminding people of the ultimate external environmental consequences strengthens the relationship between their behavior and the resulting consequences, increasing their sense of self-efficacy.

Nudging has been seen as an effective way to encourage people to change their behavior. According to Thaler and Sunstein (*25*), nudging is "any aspect of the choice architecture that alters people's behavior predictably without forbidding any options or significantly changing their economic incentives" (p. 6). In many cases, people fail to change their behavior because their attitudes and values are not aligned with the new behavior. Additionally, even though people may hold attitudes that are aligned with their desired behaviors, their actions may be misaligned with their attitudes. As a result, researchers have investigated the psychological factors that guide behavioral change. Nudging has been used in environmental studies, one example being recycling. Regarding transportation, nudging has been used in various experiments to assess its impact on increasing commuter use of alternative transportation and decreasing the use of SOVs.

Table A-1 in the Appendix summarizes the results of 14 nudging experiments conducted in organizations. An analysis was conducted to assess the homogeneity of effect sizes across experiments and estimate the mean effect size. Nine of the 14 experiments provided sufficient information to calculate effect size (Cohen's d). All nine studies were reported in the papers by Kristal and Whillans (*26*) and Graham et al. (*18*). A forest plot of effect sizes for each experiment is presented in Figure 5. This plot suggests that four of the five experiments reported by Kristal and Whillans (*26*) found no effect for the nudging intervention, and the other showed a modest effect in the predicted direction.

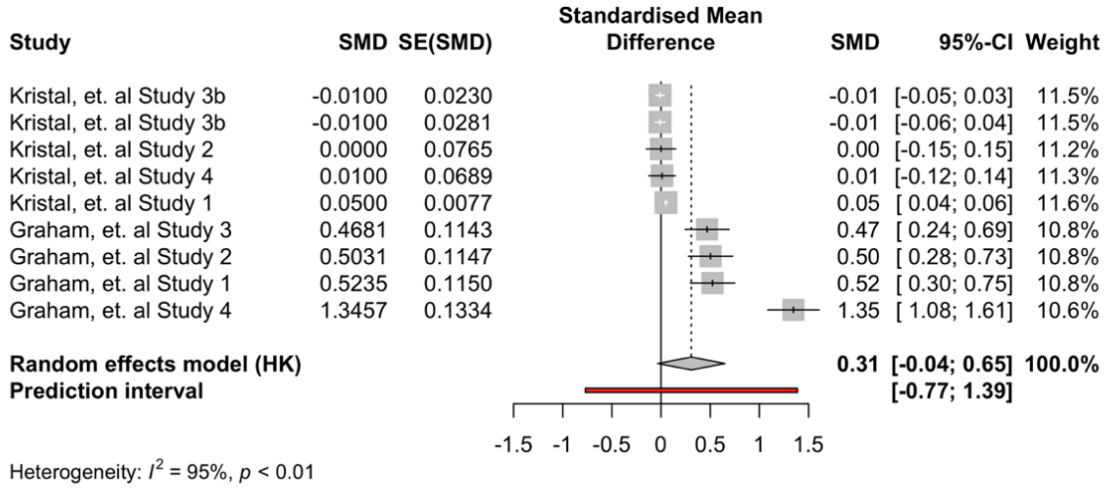

Figure 5. Forest plot of nudging experiments to evaluate commuting behavior

In contrast, in three of four experiments, Graham et al. (*18*) reported moderate effects, and one reported a large effect, all in the predicted direction. The overall effect size estimate is 0.31, suggesting a small effect size resulting from aggregating the null effects reported by Kristal and Whillans (*26*) with the moderate-to-large effects reported by Graham et al. (*18*). The test for heterogeneity of effect sizes is significant, rejecting the assumption that the nine reported effect sizes are random deviations from a true effect size. Heterogeneity suggests that the effect sizes are moderated by one or more features of the nine studies. Many possible moderators exist, including population, commuting context, nature of the nudge, and the dependent variable used. Further research and analysis of a larger sample of nudging experiments is required to estimate the effectiveness of nudging for changing individuals' commuting patterns.

Focus Groups

Student commuting has contributed to approximately 7% of all USC emissions. Graduate students are the main contributors, with 32.4% of them using single occupancy vehicles (SOVs) to commute to campus. 82.1% of the cars driven by students are gasoline cars, while the rest are hybrids or electric vehicles.

This encouraged us to conduct four focus groups during the summer and fall of 2023 where 17 USC graduate students explored their concerns, values, and criteria when making commuting mode choices. Additionally, we conducted a class exercise in the 2024 spring semester with the same goals. We aimed to investigate student preferences for alternative ways in which USC could encourage them to shift to more environmentally friendly modes of transportation. The conversations created a space where USC students could share their reasons for transportation preferences, along with ideas for promoting environmentally friendly transportation choices. Literature has found that to encourage people to participate in energy conservation efforts, the

participants need to feel as if their ideas matter (*27*). Building solutions *with* students, as opposed to *for* students, could increase their effectiveness when implemented.

After reviewing all the information collected from each focus group, the most common forms of transportation among graduate students were SOVs, buses, light rail, and bicycles. When asked to identify important factors that affected decisions on commuting, the top factors were safety, cost, control of timing, and convenience. Environmental benefits mainly were an afterthought or thought of as additional intrinsic benefits. Even those who do not use SOVs stated that the environmental benefits were a coincidental positive outcome instead of a motivating factor. Safety and convenient routes and times were crucial for students who do not have a car and use alternative transportation. Students feel public transportation poses a high safety concern, especially at night. The resources for public transportation are difficult to find, and the routes and times are not convenient for the schedules of graduate students who work late on campus. These concerns are not unique to USC, as literature has found similar concerns amongst students at another university who find inconsistent public transportation routes a deterrent for switching to alternative environmental transportation routes (*28*).

For the students in the focus group who did commute to campus, the MPG for their cars ranged from 26 to 34. None of the cars were fully electric, with the most eco-friendly vehicle being a hybrid. Reasons for not investing in an electric vehicle were cost and accessibility of electric vehicle chargers when traveling. For students who did not have a car, it was mainly due to cost as opposed to environmental reasons. Considering that those who do own cars are unlikely to switch to an electric vehicle, we asked students who do not have a car if they would consider getting an electric car if USC offered incentives. Students without a car said that if USC offered charging stations and a reduced price on the parking permit, that could entice them to choose an electric vehicle if they were to get a car. Students did emphasize that they believe electric car incentives would be more effective for incoming PhD students, as students farther along in the program might not take advantage of the incentives since they are close to graduating.

A majority of the students stated that their housing location impacted their transportation mode. Literature has shown that how close a student lives to campus and the paths of travel available influence their commuting choice to and from campus. Students, who tend to live closer to campus, are more likely than faculty and staff to choose active transportation, which includes walking and biking, or public transportation options for their commute, causing universities to propose policies for providing additional student housing near campus (*16, 22, 29*).

After discussing with students the factors that influence their commuting tendencies, we asked them to share ideas that they believe will encourage graduate students to use alternative transportation. The students suggested that USC invest in safety, affordable graduate housing, convenient routes and times for USC transportation, and incentives for environmentally friendly vehicles. The recommendations can be found in Table 3.

Table 3. USC's potential options based on focus group feedback

Student Concern	Potential Solutions
Free Lyft (Fryft)	Due to the limited Fryft zones, not all graduate students can take full advantage of the program. Extending the Fryft zone to encompass more graduate housing regions could reduce graduate student emissions in the long term.
Housing	Building affordable graduate housing near USC could reduce car usage among graduate students since proximity to campus would allow them to use alternative modes of travel, such as walking or biking, to get to campus.
Reliability	Due to the sprawling nature of Los Angeles, students found it more convenient to have a car for daily transportation needs. A consolidated and updated alternative transportation resource list with consistent, flexible routes and times could alleviate the issue. This way, students can rely on public transportation and use it as opposed to driving.
Cost of Eco-Friendly Cars	For students who do not currently have a car but are considering buying, it was mentioned that if USC had specific incentives for electric vehicles, such as charging stations or reduced parking pass rates, that would motivate them to consider spending more for an electric car.
Facilities	Brighter lights for all USC entrances. This will allow USC students to clearly see their environment when walking at night and contribute to students feeling safer around USC.

Several possible solutions emerged after investigating the student commuting data and conducting focus groups with USC graduate students. An option that USC has already implemented recently is to provide free passes to the LA METRO system (U Pass). As of March 2024, about 10,000 students applied for the U Pass and about half of them used it. It remains to be seen if this option reduced car driving.

Other options relate to facility improvements. A low-cost solution could include items such as better lightening around USC entry points and higher security for metro or bus stops near USC campus. These changes could allow students to be and feel safer when using public transportation, especially in the evening. A more expensive option is to provide affordable and safe graduate housing. This is a longer-term goal as it requires careful planning, but implementing graduate housing that is not only affordable but accessible to campus could reduce the need for commuting. In conjunction with this option, it would be beneficial to have shuttles from USC housing that is farther from campus and runs 24 hours a day, 7 days a week to give graduate students time flexibility. Additionally, mapping out where commuter students primarily reside and extending the USC bus service to those locations could reduce student commuting carbon emissions.

However, there are also potential issues with some of these solutions. It is not clear whether minor facility improvements would reduce student commuting by car. Similarly, creating new graduate student housing is costly and limited by available building space, considering the dense nature of the surrounding USC areas. While investing in new USC graduate housing farther off campus is one solution, the location would still need to be bikeable to campus to disincentivize using cars, or there would need to be shuttles to and from campus on 24 hours a day, 7 days a week schedule.

Investigating the interrelated decisions graduate students make regarding housing and traveling to and from campus is crucial to the success of carbon emission reduction. Easily accessible information about housing locations that have convenient transportation to campus and providing information about the availability and safety of public transportation could help reduce car use. The students that did exhibit pro-environmental behaviors were mainly due to other factors such as cost and convenience, with environmental benefits being an unintentional consequence. The focus groups gave us insight into how the designs of incentives and nudges should consider these student priorities, and how to help students find safe, convenient, and inexpensive modes of public transportation.

References

(1) UCLA Transportation. UCLA State of the Commute 2021. UCLA Transportation, University of California, Los Angeles. https://storymaps.arcgis.com/stories/b5f9d4cc81fe4f15b7bafa75b1f73adf

(2) BruinBus. (2024). Retrieved from https://transportation.ucla.edu/getting-around-campus/bruinbus#evening-loop.

(3) Bus Schedules. (2023). Retrieved from https://transnet.usc.edu/index.php/bus-map-schedules/.

(4) Ride-Hailing at UCLA. (2023). Retrieved from https://transportation.ucla.edu/getting-around-campus/ride-hailing-ucla#:~:text=Ride%2DHailing%20Pick%2DUp%20Zones&text=Pick%2Dup%20zones%20are%20active,day%2C%20seven%20days%20a%20week.

(5) Thrift, S., and D. von Winterfeldt. *Using Carbon Offsets to Reduce Carbon Footprints in USC's Neighborhoods.* USC President's Working Group, University of Southern California, 2021, February 5. Available in PowerPoint form from the Center for Sustainability Solutions, USC (https://sustainabilitysolutions.usc.edu/).

(6) Whitmarsh, L., and S. O'Neill. Green Identity, Green Living? The Role of Pro-environmental Self-identity in Determining Consistency Across Diverse Pro-Environmental Behaviours. *Journal of Environmental Psychology*, Vol. 3, No. 3, 2010, pp. 305–314.

(7) Nilsson, A., M. Bergquist, and W. P. Schultz. Spillover Effects in Environmental Behaviors, Across Time and Context: A Review and Research Agenda. *Environmental Education Research*, Vol. 23, No. 4, 2017, pp. 573–589.

(8) Truelove, H. B., A. R. Carrico, E. U. Weber, K. T. Raimi, and M. P. Vandenbergh. Positive and Negative Spillover of Pro-environmental Behavior: An Integrative Review and Theoretical Framework. *Global Environmental Change*, Vol. 29, 2014, pp. 127–138.

(9) Van Der Werff, E., and L. Steg. Spillover Benefits: Emphasizing Different Benefits of Environmental Behavior and Its Effects on Spillover. *Frontiers in Psychology*, Vol. 9, 2018, p. 414524.

(10) Reichel, D. A., and E. S. Geller. Applications of Behavioral Analysis for Conserving Transportation Energy. In *Advances in Environmental Psychology*, 2014, pp. 53-91.

(11) Owens, R. D., and H. L. Sever. *The 3M Commute-A-Van Program.* Status Report. Federal Highway Administration, U.S. Department of Transportation, 1974.

(12) Van Lange, P. A. M., M. V. Vugt, R. M. Meertens, and R. A. C. Ruiter. A Social Dilemma Analysis of Commuting Preferences: The Roles of Social Value Orientation and Trust. *Journal of Applied Social Psychology*, Vol. *I*, No. 9, 1998, pp. 796–820.

(13) Lange, F. Behavioral Paradigms for Studying Pro-environmental Behavior: A Systematic Review. *Behavior Research Methods*, Vol. 55, No. 2, 2023, pp. 600-622.

(14) Fu, T.S., N. Mundorf, C. Redding, A. Paiva, and J. O. Prochaska. Promoting Behavior Change Among Campus Commuters. Presented at the 53rd Annual Transportation Research Forum, Tampa, Florida, 2012.

(15) Bamberg, S., I. Ajzen, and P. Schmidt. Choice of Travel Mode in the Theory of Planned Behavior: The Roles of Past Behavior, Habit, and Reasoned Action. *Basic and Applied Social Psychology*, Vol. 25, No. 3, 2003, pp. 175–187.

(16) Daisy, N. S., M. H. Hafezi, L. Liu, and H. Millward. Understanding and Modeling the Activity-Travel Behavior of University Commuters at a Large Canadian University. *Journal of Urban Planning and Development,* Vol. 144, No. 2, 2018, p. 04018006.

(17) Cass, N., and J. Faulconbridge. Commuting Practices: New Insights into Modal Shift from Theories of Social Practice. *Transport Policy*, Vol. 45, 2016, pp. 1–14.

(18) Graham, J., M. Koo, and T. D. Wilson. Conserving Energy by Inducing People to Drive Less. *Journal of Applied Social Psychology*, Vol. 41, 2011, pp. 106-118.

(19) Foxx, R. M., and D. F. Hake. Gasoline Conservation: A Procedure for Measuring and Reducing the Driving of College Students. *Journal of Applied Behavior Analysis*, Vol. *10*, No. 1, 1977, pp. 61–74.

(20) Everett, P. B., S. C. Hayward, and A. W. Meyers. The Effects of a Token Reinforcement Procedure on Bus Ridership. *Journal of Applied Behavior Analysis*, Vol. 7, No. 1, 1974, pp. 1-9.

(21) Deslauriers, B. C., and P. B. Everett. Effects of Intermittent and Continuous Token Reinforcement on Bus Ridership. *Journal of Applied Psychology,* Vol. 62, No. 4, 1977, pp. 369-375.

(22) Appleyard, B., A. R. Frost, E. Cordova, and J. McKinstry. Pathways Toward Zero-Carbon Campus Commuting: Innovative Approaches in Measuring, Understanding, and Reducing Greenhouse Gas Emissions. In *Transportation Research Record: Journal of the Transportation Research Board*, Vol. 2672, No. 24, 2018, pp. 87–97.

(23) Klein-Banai, C., T. L. Theis, T. A. Brecheisen, and A. Banai. A Greenhouse Gas Inventory as a Measure of Sustainability for an Urban Public Research University. *Environmental Practice*, Vol. 12, No. 1, 2010, pp. 35–47.

(24) Valls-Val, K., and M. D. Bovea. Carbon Footprint in Higher Education Institutions: A Literature Review and Prospects for Future Research. *Clean Technologies and Environmental Policy*, Vol. 23, No. 9, 2021, pp. 2523–2542.

(25) Thaler, R. H., and C. R. Sunstein. *Nudge: Improving Decisions about Health, Wealth, and Happiness*. Penguin Books, 2009.

(26) Kristal, A. S., and A. V. Whillans. What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour. *Nature Human Behavior,* Vol. 4, 2020, pp. 169–176.

(27) Widman, R., D. Simmons, R. Kaplan, and R. De Young. *Behavioral Approaches to Energy Conservation in Organizations: A Selected Review of the Literature*. CPL Bibliography No. 143. Council of Planning Librarians, Chicago, IL, 1984, pp. i-xv, 1-4.

(28) Delmelle, E. M., and E. C. Delmelle. Exploring Spatio-temporal Commuting Patterns in a University Environment. *Transport Policy*, Vol. 21, 2012, pp. 1-9.

(29) Barron, G., S. Maves, A. Shkembi, G. Sofka, J. Wooldridge, and J. Levine. *Commuting at the University of Michigan: A Report Developed for and Supported by the U-M President's Commission on Carbon Neutrality*. ISBN 978-1-60785-687-0. Michigan Publishing, 2021.

Data Management Plan

Products of Research

The data were collected by a survey, conducted in the spring of 2022, of student commuting at USC. The data were collected and are held by USC's Office of Sustainability.

Data Format and Content

The data are in either CSV or Excel file formats. The data come in multiple fields, with commuting mode, distance of commute, commuting frequency, and miles per gallon (if by car) being the main items used for this study.

Data Access and Sharing

Data access can be provided by USC's Office of Sustainability.

Reuse and Redistribution

Contact the USC Office of Sustainability for restrictions.

Appendix Table A-1. Summary of organizational-level nudging experiments

Purpose	Nudge	Outcome	Reference
Efficacy of sending behaviorally informed letters on carpooling tendencies	Letter with information about carpooling service offered in workplace	0.22% of letter recipients registered for carpooling system 0.05% of non-letter participants signed up Statistically, no significant impact on sending letter	Kristal, A. S., and A. V. Whillans. What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour. *Nature Human Behavior,* Vol. 4, 2020, pp. 169–176.
Encourage employees to be more active in carpooling service that they signed up for	Personalized recommendations and opportunity cost reminders	No statistical significance between matching, matching and opportunity cost, and control email Less than 1% of contacted employees signed up for carpooling service p = 0.746	Kristal, A. S., and A. V. Whillans. What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour. *Nature Human Behavior,* Vol. 4, 2020, pp. 169–176.
Increase use of public transportation	Free bus trial	No statistical significance between letter with bus routes that included how to access discounted transit cards and the same letter but with vouchers for a week free bus trial p = 0.494	Kristal, A. S., and A. V. Whillans. What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour. *Nature Human Behavior,* Vol. 4, 2020, pp. 169–176.

Purpose	Nudge	Outcome	Reference
Encourage employees who did not sign up for free bus pass to become bus users	Email that emphasizes how much money employee missed out on	Loss aversion email had no statistically significant impact on transit card purchases Less than 1.5% of employees shifted their behavior when given a free bus trial/subsidized bus pass p = 0.797	Kristal, A. S., and A. V. Whillans. What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour. *Nature Human Behavior,* Vol. 4, 2020, pp. 169–176.
Test impact of personalized travel plans (PTPs) on reducing SOV behavior	PTPs tailored to each employee that included routes, transit schedules, travel discounts, and carpool matches	No effect on reducing SOV use during the week p = 0.992	Kristal, A. S., and A. V. Whillans. What We Can Learn from Five Naturalistic Field Experiments That Failed to Shift Commuter Behaviour. *Nature Human Behavior,* Vol. 4, 2020, pp. 169–176.
San Francisco Bay Area Rapid Transit (BART) wanted to encourage riders not to ride during peak hours	Rewards program where participants earned points to use as cash or gift cards	9.6% reduction for cash earnings 6-20% alteration in behavior with redeeming points for gift cards	Whillans, A., J. Sherlock, J. Roberts, S. O'Flaherty, L. Gavin, H. Dykstra, and M. Daly. Nudging the Commute: Using Behaviorally Informed Interventions to Promote Sustainable Transportation. *Behavioral Science & Policy*, Vol. 7, No. 2, 2021, pp. 27–49.

Purpose	Nudge	Outcome	Reference
Reduce peak congestion	Congestion and parking relief program provided points and prizes for commuters who avoided peak hours	People enrolled were 21.2% less likely to commute during morning rush hour and 13.1% less likely to commute during evening rush hour	Whillans, A., J. Sherlock, J. Roberts, S. O'Flaherty, L. Gavin, H. Dykstra, and M. Daly. Nudging the Commute: Using Behaviorally Informed Interventions to Promote Sustainable Transportation. *Behavioral Science & Policy*, Vol. 7, No. 2, 2021, pp. 27–49.
Reduce faculty and staff use of campus parking at MIT (Access MIT)	Free transit passes, higher subsidies for costs of commuter rail trips, and subsidizing half the cost of parking at public transit facilities	15% reduction in yearlong parking permits 10% decrease in parking transactions from campus parking lots	Whillans, A., J. Sherlock, J. Roberts, S. O'Flaherty, L. Gavin, H. Dykstra, and M. Daly. Nudging the Commute: Using Behaviorally Informed Interventions to Promote Sustainable Transportation. *Behavioral Science & Policy*, Vol. 7, No. 2, 2021, pp. 27–49.
FlexPass at UC Berkeley gave ability to report whether used campus parking lot or alternative transportation	Receive rebates as rewards to cover cost of campus parking permit	4.2 % decrease in parking demand among group who were offered rebates compared to those who were not	Whillans, A., J. Sherlock, J. Roberts, S. O'Flaherty, L. Gavin, H. Dykstra, and M. Daly. Nudging the Commute: Using Behaviorally Informed Interventions to Promote Sustainable Transportation. *Behavioral Science & Policy*, Vol. 7, No. 2, 2021, pp. 27–49.

Purpose	Nudge	Outcome	Reference
Encourage alternative modes of transportation using personalized route tool and email reminders at mid-sized university in the South	Personalized route tool with follow-up email reminders	Personalized route tool alone did not have statistically significant reduction Personalized route tool with follow-up email led to 7.2% reduction in self-reported driving in 3 months (statistically significant)	Whillans, A., J. Sherlock, J. Roberts, S. O'Flaherty, L. Gavin, H. Dykstra, and M. Daly. Nudging the Commute: Using Behaviorally Informed Interventions to Promote Sustainable Transportation. *Behavioral Science & Policy*, Vol. 7, No. 2, 2021, pp. 27–49.
Test if nudging can increase public transport use in Rotterdam, Netherlands	Give bus passengers free travel card holders with a message on them that stated they were environmentally friendly travelers	0.059% increase in number of rides a day	Franssens, S., E. Botchway, W. De Swart, and S. Dewitte. Nudging Commuters to Increase Public Transport Use: A Field Experiment in Rotterdam. *Frontiers in Psychology*, Vol. 12, 2021, p. 633865.
Test if recordkeeping and online intervention can reduce college students' use of cars	Two control groups were Web and No-Web. Web control group had users input their car (make, model, and mileage), and record-keep car usage. Web group utilized a 2 (Monetary Feedback) x 2 (Pollution Feedback) design, meaning that the groups are divided into no feedback, solely monetary feedback, solely pollution feedback, and both monetary and pollution feedback	Recordkeeping and receiving feedback reduced students' car usage One way ANOVA on Web vs No-Web control group yielded $p = 0.02$ (statistically significant) Receiving both monetary and pollution feedback proved most effective in reducing car usage Suggests that personal and pro-social feedback can have positive effects in changing behaviors	Graham, J., M. Koo, and T. D. Wilson. Conserving Energy by Inducing People to Drive Less. *Journal of Applied Social Psychology*, Vol. 41, 2011, pp. 106-118.

Appendix Table A-2. Top 34 U.S. university plans for interventions to encourage non-SOV commuting

School Name	Interventions	Overview of Plan	Reference
Princeton	Incentive Reimbursement Discount	Revise Your Ride is a commuter plan. It covers 50% transit subsidy and bus pass for faculty and grad students. Started in 2008, Princeton aims to have ~50% commuters use alternative modes of transportation (carpool, rail, walk, telecommute, bus, bike, etc.)	*Increase Commuters Using Alternatives to Single-Occupancy Vehicles | Office of Sustainability. (n.d.). Retrieved from* https://sustain.princeton.edu/sustainability-action-plan/alternative-commuting
MIT	Reimbursement EV Chargers	Fast Forward is a broad sustainability plan. Started in 2021, MIT aims to be net-zero carbon emissions by 2026, eliminating direct emissions by 2050. Commute interventions include increase car-charging stations by 200% (from 120 to 360) by 2026.	Fast Forward: MIT's Climate Action Plan for the Decade. (n.d.). Retrieved from https://climate.mit.edu/climateaction/fastforward
Harvard	Discount Walkability Bikeability	Harvard Sustainability Plan is a broad sustainability plan started in 2014. The plan does not contain much information on commuting.	Harvard's 2021 Sustainability Report. (2022). Retrieved from https://report.green.harvard.edu/
Stanford	Discount Free passes	Stanford has "year-in-review" reports but no clear action plan for sustainability and commuting.	Sustainability at Stanford. (n.d.). Retrieved from https://sustainability-year-in-review.stanford.edu/2022/

School Name	Interventions	Overview of Plan	Reference
Yale	Telecommute EV Chargers Discount	Yale's sustainability plan is broad. It was started in 2016 and has 38 sustainability goals. Yale strives to increase teleworking among faculty and staff and increase its EV infrastructure to 2% of all parking spaces.	Yale Releases 2022 Progress Report on Sustainability Goals. (2022). Retrieved from https://sustainability.yale.edu/news/yale-releases-2022-progress-report-sustainability-goals
U Chicago	Discount	UChicago has a sustainability plan that primarily addresses on-campus building GHG emissions but does not include commuting. Latest reporting states that 90% of students use alt transportation already.	UChicago_GHG_Plan_2022.pdf: Powered by Box. (n.d.). Retrieved from https://uchicago.app.box.com/s/fc57n1iyag489l49jlybbv057e4zeyqi
Johns Hopkins	Free passes	JHU is updating their Climate Action and Sustainability Plan, currently available in draft form and being prepared for final release in Spring 2024. Their most recent Climate Change Implementation Plan was released in 2009.	Johns Hopkins University Office of Sustainability. (n.d.). Climate Action & Sustainability Plan. Retrieved from https://sustainability.jhu.edu/who-we-are/sustainability-plan-2/
U Penn	Discount Reimbursement	Penn has a Carbon Neutrality by 2042 plan but doesn't include clear action items.	Magill, L. (n.d.). Climate & Energy. Retrieved from https://sustainability.upenn.edu/campus-initiatives/climate-energy

School Name	Interventions	Overview of Plan	Reference
Cal Tech	Free passes Reimbursement Discount Incentive	It appears that Cal Tech has no set plan, but the school currently has a lot of commute programs.	Annual Report. (n.d.). Retrieved from https://sustainability.caltech.edu/campus/annual-report
Duke	Discount Free passes	Duke has a 2009 Climate Action Plan, which they updated in 2019. Duke reports 79% SOV use in 2019, and near 40k MTCDE commute emissions in 2018; no clear action items on student commute aside from free passes.	Office of Sustainable Duke. (n.d.). About. Retrieved from https://sustainability.duke.edu/about/
North-western	Walkability Bikeability EV Chargers Discount	Northwestern's commute goals include walk/bike infrastructure and improved EV infrastructure.	(N.d.). Retrieved from https://www.northwestern.edu/sustainability/docs/transportation-survey-report-2016---final.pdf
Dartmouth	Walkability Bikeability	Dartmouth is releasing their sustainability plan in 2023, currently WIP. They currently allow bikers/walkers free access to showers on campus.	OUR GREEN FUTURE UPDATE: Dartmouth Sustainability. (n.d.). Retrieved from https://www.sustainability.dartmouth.edu/ogf-update
Brown	Free passes EV Chargers Walkability Bikeability	Brown's Sustainability Strategic Plan was created in 2021. It does not address student commute action items, but instead points out that student commuting isn't always included in Scope 3 (including it would drastically increase cost of offset). The plan discusses the dilemma and suggests that the college makes a decision about it.	(N.d.). Retrieved from https://sustainability.brown.edu/sites/default/files/281353_FM_Sustainability%20Plan_FNL_11.22.pdf

School Name	Interventions	Overview of Plan	Reference
Vanderbilt	Adjusted parking permits Incentive	MoveVU is a subset of goals related to transportation. 2018 report shows a 76.5% rate SOV, which Vanderbilt aims to reduce to 55% by 2025. 2021 report shows 15k MTCDE for all faculty, staff, and student commute and air travel. Vanderbilt is also moving away from annual parking permits to a daily decision model, in hope of reducing the SOV rate.	Valnosa. (1970). Vision and Goals. Retrieved from https://www.vanderbilt.edu/movevu/summary-and-goals/
Rice	Free passes Discount Walkability Bikeability	In 2022, Rice announced the plan to be carbon neutral by 2030. No clear action plan has been revealed.	(N.d.). Retrieved from https://sustainability.rice.edu/
Washington University in St. Louis	Free passes	The WUSTL 2015-2020 Strategic Plan for Sustainable Operations has expired, and their upcoming sustainability plan is WIP.	Transportation. (2021). Retrieved from https://sustainability.wustl.edu/vision-progress-2/transportation/
Cornell	EV Chargers Telecommute Free passes	Cornell reports that 83% of students utilize sustainable transportation. Their climate action plan aims to achieve carbon neutrality by 2035, which includes a few action items pertaining to alt transportation.	Climate Action Plan: Sustainable Campus. (n.d.). Retrieved from https://sustainablecampus.cornell.edu/our-leadership/cap

School Name	Interventions	Overview of Plan	Reference
Columbia	Telecommute EV Chargers Walkability Bikeability Adjusted parking permits	Columbia's 2030 plan outlines their goal for a SOV rate below 8% for employees and below 0.5% for students by 2030.	Fall 2023 Bicycle Interest Group Newsletter. (2023). Retrieved from https://sustainable.columbia.edu/content/sustainable-transportation
U of Notre Dame		UND aimed to start tracking and report on Scope 3 emissions by 2022; last progress update was 2021, but we don't see Scope 3 on their webpage yet. Transportation-wise, they don't seem to offer any discount/incentives for students or staff.	Marketing Communications: Web | University of Notre Dame. (n.d.). Sustainability Strategy Progress: University of Notre Dame Sustainability Strategy: Mission: Office of Sustainability: University of Notre Dame. Retrieved from https://green.nd.edu/mission/university-of-notre-dame-sustainability-strategy/sustainability-strategy-goals/
UC Berkeley	Free passes Discount Incentive EV Chargers Adjusted parking permits Telecommute	UCB sustainability plan was introduced in November 2020. It includes action items on many aspects, including transportation. By 2025, UCB aims to reduce SOV to less than 30% for students and employees combined, with at least 4.5% commuter vehicles zero-emissions. By 2050, UCB aims to have at least 30% commuter vehicles zero-emissions and achieve carbon neutrality from commuting.	(N.d.). Retrieved from https://sustainability.berkeley.edu/sites/default/files/uc_berkeley_sustainability_plan_2020_1.pdf

School Name	Interventions	Overview of Plan	Reference
UCLA	EV Chargers Telecommute Free passes	UCLA aims to achieve 33% SOV for students and employees by 2030 (44% for employees alone).	(N.d.). Retrieved from https://policy.ucop.edu/doc/3100155/SustainablePractices
Carnegie Mellon	Free passes	Carnegie Mellon seems to offer no set plan on student commute, and very few sustainable transportation programs.	University, C. M. (n.d.). Retrieved from https://www.cmu.edu/leadership/the-provost/provost-priorities/sustainability-initiative/index.html
Emory	Telecommute Incentive Walkability Bikeability Discount	Reported that 52.8% of Emory students use sustainable transportation options, supposedly around 5.2k MTCDE. Emory aims to increase telecommute, extend incentives for sustainable commuting, and build in bike/pedestrian infrastructure. Emory offers lots of incentives for alt transportation.	Transportation. (n.d.). Retrieved from https://sustainability.emory.edu/initiatives/transportation/
Georgetown	Walkability Bikeability	Most recent report was from 2014. Georgetown found that about 12% of commuters would park off-campus on residential streets. No set plan for student commute except for making the campus more bikeable.	Georgetown University Annual Transportation Monitoring Study 2014 Final Report.pdf: Powered by Box. (n.d.). Retrieved from https://georgetown.app.box.com/s/u7ugpnra0ywzptgbzxbkdd40movm20wm

School Name	Interventions	Overview of Plan	Reference
NYU	Walkability Bikeability	NYU's climate action plan, updated in 2021, aims to achieve carbon neutrality by 2050. There is no set plan on transportation, probably because 94% of NYU already uses mass transit.	(N.d.). Retrieved from https://www.nyu.edu/content/dam/nyu/sustainability/documents/Transportation%20Survey%20Results%20and%20Findings.pdf
U Michigan	Walkability Bikeability	U Mich has offered no set plans for transportation per se.	Sustainability Goals. (2023). Retrieved from https://ocs.umich.edu/sustainability-goals/
UVA	Bus route increase	UVA has a 2020-2030 plan, but nothing on transportation.	(N.d.). Retrieved from https://sustainability.virginia.edu/sites/g/files/jsddwu1096/files/2022-11/UVA_Sustainability_Plan_2020-2030.pdf
U Florida	EV Chargers Walkability Bikeability Incentive	UF released their initial draft of their Climate Action Plan 2.0 this past year. Transportation-wise, they aim to minimize the need for gas vehicles.	UF Climate Action Plan 2.0. (2023). Retrieved from https://sustainable.ufl.edu/campus-initiatives/uf-climate-action/uf-cap-2/#minimize-the-need-for-gas-powered

School Name	Interventions	Overview of Plan	Reference
U North Carolina	EV Chargers Adjusted parking permits Discount Free passes Reimbursement	UNC's climate action plan includes commuter interventions, such as increasing EV chargers, potential changes to parking permits, and increasing the alt transport discount services.	Climate Action Plan. (n.d.). Retrieved from https://sustainable.unc.edu/focus-areas/climate-action/climate-action-plan/
Wake Forest		Wake Forest seems to have no plan, no report, and no programs listed on their website regarding transportation.	Climate Action. (2023). Retrieved from https://sustainability.wfu.edu/initiatives/climate-action/
Tufts	Discount Reimbursement	Tufts reports 2020 student commuting emitted 2,027 MTCDE; no set plan regarding transportation.	Sustainability Reporting. (2023). Retrieved from https://sustainability.tufts.edu/sustainability-at-tufts/progress-reports/
UC Santa Barbara	EV Chargers Discount Free passes	In 2022, UCSB reported 19% graduate student SOV and 8% undergrad SOV rate. Faculty and staff remain the highest % SOV rate among all schools.	UC Santa Barbara. (2023). Retrieved from https://sustainabilityreport.ucop.edu/2021/locations/uc-santa-barbara/
UC Irvine	Telecommute EV Chargers Adjusted parking permits	UCI aims to have less than 30% SOV rate among UCI community by 2050. UCI has very detailed 2022 action plan that includes several transportation items.	(N.d.). Retrieved from https://policy.ucop.edu/doc/3100155/SustainablePractices

School Name	Interventions	Overview of Plan	Reference
UC San Diego	EV Chargers	UCSD has a set plan for transportation, mostly in line with all other UCs. UCSD has more of a focus on EV infrastructure.	(N.d.). Retrieved from https://facilityservices.ucsd.edu/sustainability/transportation.html