DAILY TRAVEL FEEDBACK
TO ENCOURAGE ECO-ROUTING

Final Report

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April 2015

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The purpose of this study was to explore how individuals responded to a robust and interactive daily travel feedback program. Fifty individuals from the Moscow, Idaho area participated in a before-and-after study using an android-based device that continuously logged their physical movement. All participants subsequently received an e-mail each day linking them to a website that showed one to five trips, predicted their mode of travel and trip purpose, and asked specific questions related to their daily travel. Based on the cumulative results of this study, participants reacted favorably to the ease of use, visual feedback, and information related to travel time, associated costs, and energy usage. However, the travel feedback program did not influence a dramatic change in travel behavior or mode during this particular two week study. It is anticipated that the lessons learned with regard to methodology and implementation will provide researchers and practitioners with valuable insight for future travel feedback or user nudging studies.</td></tr>
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EXECUTIVE SUMMARY

This study explored how individuals respond to daily travel feedback. People are often unaware of other travel options available to them or don't realize the benefits from choosing differently. For example, some people might not realize that, for a particular trip, walking is actually a fairly feasible option. Likewise, people might not comprehend the personal savings in fuel costs or the benefits to society by choosing to ride the bus. Most people typically don't know even a rough estimate of how much their travel choices contribute to vehicle emissions and fuel consumption.

The goal was to help people make travel decisions that will reduce vehicle emissions and fuel consumption. Fifty individuals from the Moscow, Idaho area participated in the study. Their daily travel was logged using an android-based device. All participants subsequently received an e-mail each day linking them to a website that showed one to five trips from the previous day. The website also showed a prediction of their mode of travel and trip purpose, and asked specific questions related to their daily travel. Figure ES-1 shows a screenshot of the website.

The webpage summarized calculated information about their travel, such as total distance, calories burned, fuel used, parking cost, and vehicle emissions. The participants were asked to verify the inferred mode and trip purpose and make comments about the assumptions related to the calculated information. Furthermore, the participants were shown various travel alternatives (primarily mode and time of day alternatives, but possibly route alternatives as well) for some of the trips and information about potential savings. The goal was to investigate the influence of the feedback through surveys before and after and also through observed changes in travel behavior.

Based on the cumulative results of this study, participants reacted favorably to the ease of use, visual feedback, and information related to travel time, associated costs, and energy usage. However, the travel feedback program did not influence a dramatic change in travel behavior or mode during this particular two week study. It is anticipated that the lessons learned with regard to methodology and implementation will provide researchers and practitioners with valuable insight for future travel feedback or user nudging studies.

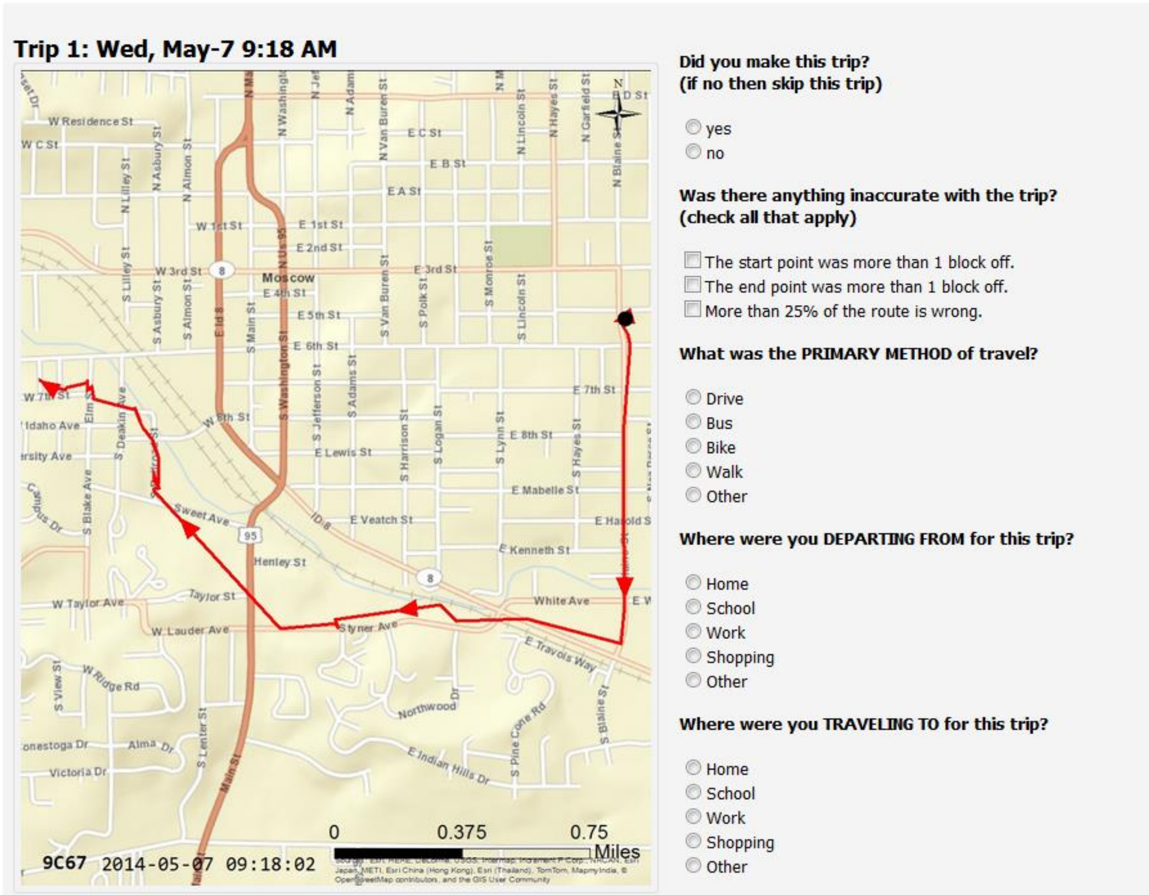

Figure ES-1: Screenshot of travel feedback.

INTRODUCTION

"People are creatures of habit." This cliché is especially true in terms of the four commonly recognized travel choices: when to travel (trip choice), where to travel (destination choice), how to travel (mode choice), and which way to go (route choice). As each decision is made, the individual traveler may neither be aware of other options nor realize the benefits gained from a different choice. For example, walking instead of driving may be both a reasonable and feasible alternative for a particular trip; some people might alternately forget to recognize the potential saving in fuel costs or the sustainability benefits to society when the choice to ride a bus is made. Other drivers may have difficulty comprehending or accurately estimating how their travel choice impacts air quality or the amount of fuel that is being consumed for their daily travel.

The trend of choosing more eco-friendly transportation can be seen not only within broad research efforts but also in American society as a whole. The American Journal of Public Health [1] used the 2001 and 2009 National Household Travel Surveys (NHTS) to analyze the proportion of trips that Americans take by sustainable modes. Cycling increased from 0.9% to 1.0% over the time period, and the share of walking trips rose from 8.6% to 10.5%. The surveys show that the average American took seventeen more walking trips and two more bicycling trips in 2009 than in 2001. The 2009 data also provided insight that three-fourths of walk trips and half of bike trips were taken for utilitarian purposes, and represented reasons other than recreation, exercise, or sport. This trend is significant because household travel accounts for three-quarters of America's carbon dioxide (CO_2) emissions from "on-road" sources [2].

This report describes an interactive and responsive tool that was developed to provide daily feedback to individuals about their travel choices and investigates how this tool influenced personal opinion and behavior over a two-week period.

BACKGROUND

Travel feedback programs (TFPs) have been conducted as early as 1999 when Taniguchi first proposed this type of program as part of a pilot test [3,4]. The goal was to modify travel behavior and reduce automobile use, and participants reported their trips and then received feedback from a program coordinator. The feedback included statistics on their mode choice and the amount of carbon dioxide (CO_2) generated based on their mode, and offered constructive suggestions that were intended to steer the traveler toward a more environmentally-favorable mode.

In 2000, a Taniguchi TFP was conducted in the city of Sapporo, Japan with two target audiences, a Community Program consisting of residents from two neighborhood districts, and an Education Curriculum Program comprised of fifth graders from a city-wide elementary school and their families. Both programs had four major steps that began with an explanatory pamphlet promoting program goals and an initial seven-day travel activity log [5]. After the first week participants received a diagnostic checklist providing graphical data for both themselves and the overall group. The checklist was developed to ensure that activity-travel patterns were captured in terms of CO_2 emissions and also promoted alternatives to car use [4]. A second seven-day travel activity log was subsequently distributed. This log contained a list of family members and their cars, a travel activity diary, and a daily family car use diary. When the activities from the second week were completed, a final diagnostic checklist compared behavioral change between the two weeks. The 599 total participants came from 219 households and the overall results showed that the number of personal car trips dropped by 5%, public bus use increased by 15%, public rail use increased by 4%, and total CO_2 emissions fell by three tons or 16.3% [4,5].

Taniguchi and Fujii subsequently introduced a TFP-dependent system called Mobility Management (MM) [6]. MM was a transportation and traffic system management method that attempted to change travel behavior by using a form of communication. In MM, TFPs provided personalized communication to participants that included information on public transport, travel campaigns, and travel education. To analyze its effectiveness, ten previously published TFPs were classified by location, technique, procedure, and communication media.

The research indicated that individualized information from a TFP did not always result in behavioral modification by participants. In 2005, a new study explicitly evaluated behavior-planning impact and the importance of implementation intention, namely when, where, and how the behavior would be implemented. They found that directly asking participants to create a plan to reduce their car use contributed to improved results [7]. The MM document had previously concluded that all TFPs requiring participants to include a behavioral plan saw significant increases in behavioral change. Programs with a behavior plan netted the largest increase in public transit use, the largest reduction in car use, and the largest reduction in CO_2 [6]. A 2007 study provided more evidence in favor of TFPs as a soft measure of traffic easing. The results included a 19% reduction in car use as well as a 32% increase in public transit use. Taniguchi et al. also foreshadowed the emerging growth of information technology and its ability to provide automatic appropriate feedback for MM [8].

The administration of a TFP can be broken down in terms of contact type with the participant and the number of contacts. For example, the Travel Blending approach involved four contacts similar to Taniguchi's TFP. It provided information to motivate change and then conducted two travel surveys each followed by individualized comments [6,9,10]. In terms of communication the options included face-to-face, telephone, webpage, post mail, and e-mail. The least effective TFP occurred when only an e-mail and a webpage were used, implying that internet communication alone resulted in minimal participant influence [6,11].

Fujii et al. performed a meta-analysis of fifteen Japanese TFPs in 2009 and concluded that the estimated average car use reduction was between 11.4% and 17.2% and differed based on research design strategy [12]. In proving effectiveness of behavioral change they concluded that randomly assigned control groups and increased lag time between pre-test and post-test should be included. Because employing a control group can be inconvenient, they believed that intact groups can be compared with one another if they are large enough; they noted that many previous studies lacked appropriate size. By using devices already possessed by study participants such as a mobile phone, technology also offered a means of increasing both participant size and minimizing the impact of an extended study duration.

Technology-Assisted Feedback

There has been significant research and effort to change travel behavior with a user-friendly application that provides real-time data. One Italian-based program focused on voluntary travel behavior change (VTBC), a subset of travel demand management (TDM) policies that promoted individual values and societal benefits to cause a change in personal travel behavior [13]. The Italian "Cap and Save" program used VTBC methods alongside a GPS-based data collection application system called "Activity Locator". A small group of fourteen participants first completed a week of travel with the application installed on their cellular phones. During the second week they were asked to focus on remaining under a CO_2 cap which was based on a threshold of 20% fewer vehicle kilometers than their first week. Half of the participants reduced emissions, but only 30% successfully stayed below the proposed cap. The preferred methods of reducing emissions included non-motorized travel and/or the use of public transport. The authors themselves criticized the results due to sample size limitations, but felt that the study provided a positive start to promoting the use of similar devices in future mobility management efforts [13].

The United States Department of Transportation (DOT) and the Florida DOT sponsored a three-phase study to improve TDM by developing a GPS-based, non-proprietary location awareness information system. The system, TRAC-IT, contained a "Personal Travel Coach" that had an enhanced rule-based Expert System and a real-time Path Prediction prototype [14]. Their objective was to encourage individuals to choose a mix of travel choices and minimize habitual car behavior. Survey feedback data required minimal inputs such as beginning and ending location descriptions, purpose, and occupancy. The mode of transportation was passively collected through a mode detection algorithm. Fourteen volunteers performed field testing over a period of three months and produced 317 recorded trips. Of the total trips, 160 were provided with feedback advice from the Expert System and the remaining 157 did not require additional guidance. The majority of trips where advice was provided recommended trip chaining (24%), walking (23%), and bicycling (21%). The Path Prediction algorithm would be greatly enhanced with additional real-time data from GPS-enabled mobile phones within the street network and providing push information from real-time advanced traveler information systems [14]. In 2014, Broach et al. [15] performed a study that used a multinomial logit model to predict trip mode and had difficulty gathering ground truth data. However, individuals were not asked about their trips until the end of the study, at which time many had difficulty recalling their travel mode from a previous day.

The University of California Travel Center developed a computational travel feedback system called Quantified Traveler (QT) in 2013 [16]. One hundred thirty-five subjects installed the QT app on their smartphone that served as a travel diary for three weeks. The subjects also conducted an entry and exit survey measuring psychological changes to quantify the impact. In addition to the survey questions, the smartphone tracking allowed the research team to measure any realized behavior shift during the study. Although 118 participants completed the experiment and both surveys, the dataset was cleaned under various criteria to a final observation total of 78 participants. The average participant's driving distance during the third week was 33% lower (39 fewer miles) than their first week of the study. Participants on average walked or biked 0.8 miles more and used transit 0.7 miles less over the two weeks. The exit survey results on future travel decisions showed more insight on mode choice, though average responses were fairly close to neutral. Walking and public transit exhibited slightly higher future intention whereas driving, carpooling, and biking future intention were slightly lower. The survey question results as a whole shifted in the researcher's desired direction, with users choosing more sustainable transportation modes [16].

Although changing individual mode choice and eliminating trips entirely can be viewed as eco-friendly, there has been emission-conscious research emerging to use technology during automobile travel as well. One such 2014 report used a microscopic traffic assignment and simulation software, INTEGRATION, to develop an eco-routing application [17]. Using designed networks of Cleveland, Ohio and Columbus, Ohio, simulations were able to develop outcomes that reduced fuel consumption and emissions network-wide. Though results are sensitive to network configuration and market penetration, the eco-routing was able to achieve network wide fuel savings of 3.3% to 9.3% [17].

METHOD

Study Administration and Participant Survey

For this study, a community and campus-wide solicitation of participants was administered in Moscow, Idaho in the vicinity of the University of Idaho campus. Moscow is a small town with a population of approximately 24,500. Because of the location and demographics, a large portion of our study participants were university students. Fifty total volunteers would ultimately sign up for this study, with fifteen individuals serving as our control group. As a small incentive, a $50 gift card was given to three random participants who participated in the study and completed both the before and after survey.

The thirty-five volunteers representing the experimental group used an app on an android device (installed either on their own phone or on a phone provided to them for the experiment) beginning the week of April 28, 2014. The app continuously recorded the phone's location using Global Positioning System (GPS) information. All of the data were stored on the android phone until the phone was connected to a Wi-Fi signal; at that time the data were uploaded to a central server. Figure 1 shows the phone app. The participants were instructed to simply carry the android device with them and ensure that battery power was sufficient for the duration of the study period.

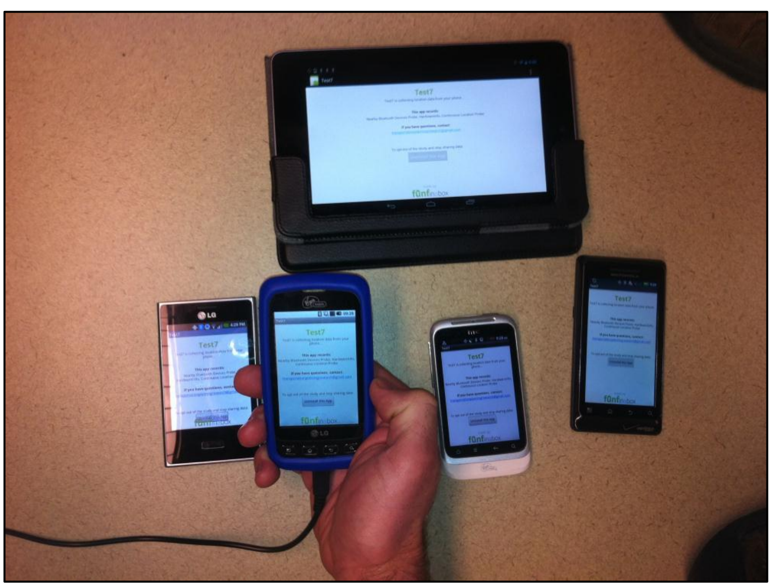

Figure 1: Android devices and Funf travel app.

Each individual was required to physically stop by the offices of the primary researchers to either pick up an android phone loaded with the research app or have the app installed on their personal phone. The individual subsequently was asked to complete an online survey featuring various questions about their daily travel and travel behavior (see Table 1); a survey with similar questions was also administered at the completion of the study.

Table 1: Travel Feedback Survey Questions

Consider your first trip each day from home to work or school. What METHOD OF TRAVEL did you use each day last week? [M, T, W, Th, F]
How many times last week did you take SMART Transit (Moscow's bus)?
On a typical morning, how long would it take you to travel from home to work or school for each of the travel methods listed below? [Car , Bicycle, Walk, Bus]
Consider a trip from the University Bookstore/Student Union Building to Wal-Mart. Predict how long it would take you to travel for each of the travel methods listed below. [Car, Bicycle, Walk, Bus]
Consider your typical week of travel. Do you think your car use could be reduced?
Do you think your daily car use impacts global climate change?
How much do you consider the health benefits of WALKING rather than driving?
How much do you consider the health benefits of BICYCLING rather than driving?
How much money do you think the City of Moscow should allocate to help operate SMART Transit?
How much money do you think the City of Moscow should allocate to infrastructure projects to improve opportunities for WALKING (i.e. new or improved sidewalks, intersection crossings, and other pedestrian amenities like sidewalk benches)?
How much money do you think the City of Moscow should allocate to infrastructure projects to improve opportunities for BICYCLING (i.e. new or improved bike lanes, off-street pathways, and other bicycling amenities like bike racks)?

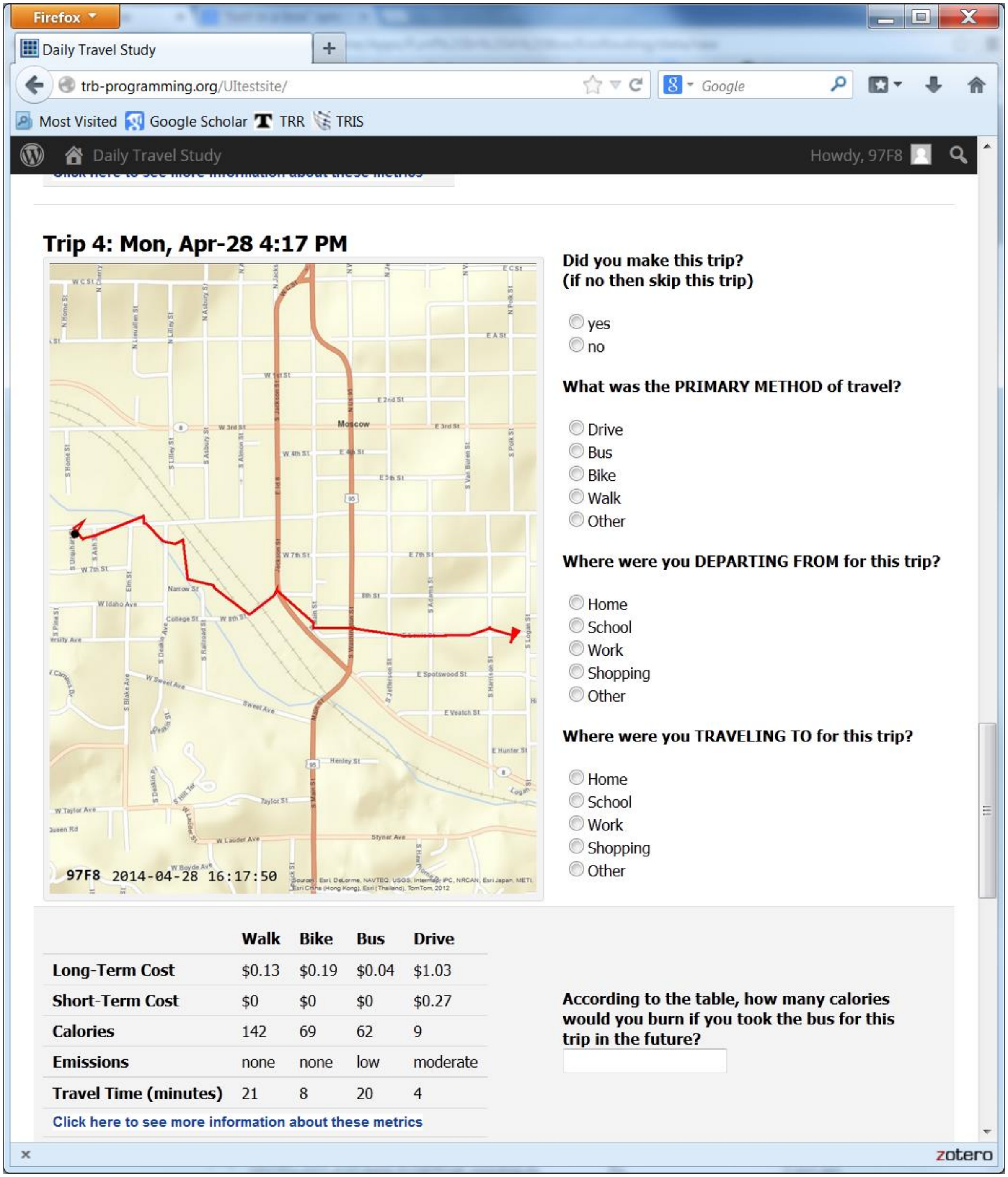

Figure 2: Website used for giving travel feedback.

To address the responsiveness limitations of travel feedback programs, individuals for this study were asked about a trip shortly after the trip occurred as data were uploaded to the study website at the end of each day. Each participant then logged onto the website and answered questions about a particular trip or set of trips. The website also provided a summary of calculated information about each individual's travel including: total distance traveled, calories burned, fuel used, parking costs incurred, and vehicle emissions burned. Figure 2 shows a sampling of the screenshots from the website. Each participant was also asked to verify the inferred trip mode and purpose, make comments about the assumptions related to the calculated information, and identify any inaccuracies.

Trip Isolation and Mode Prediction

Participants were shown no more than five trips per day on the website to avoid overwhelming them with information. An attempt was made to show a diverse set of trips based on time of day, trip length, and mode. Trips were isolated from the continuous stream of GPS data by identifying dwell points where movement did not exceed two hundred feet for a fifteen minute window. Dwell points less than thirty minutes were deemed intermediate stop points, while thirty minutes and greater were deemed trip ends.

Mode was predicted for isolated trips using a multinomial logit model based on data from a pilot study that was collected in Fall 2013. The pilot data was obtained through the same means, i.e., the android app and a webpage for participants to indicate primary mode of travel. Multinomial logit models are an extension of logistic regression which takes the following form:

$$log\left[\frac{P(Y_i = 1)}{P(Y_i = 0)}\right] = \beta_0 + \beta_1 x_{i_1} + \beta_2 x_{i_2} + \cdots + \beta_p x_{i_p}$$

where Y is the response variable which equals either 0 or 1, x represents the explanatory variables, and β is the coefficient predicted by regression analysis. To define multinomial logit models: suppose Y_i=1, 2 … K denotes K categories, and let π_{i1}, π_{i2} … π_{iK} be the probabilities of each category. The multinomial logit model is then defined by the following equations:

$$log\left[\frac{\pi_{i_2}}{\pi_{i_1}}\right] = \beta^{(2)}{}_0 + \beta^{(2)}{}_1 x_{i_1} + \beta^{(2)}{}_2 x_{i_2} + \cdots + \beta^{(2)}{}_p x_{i_p}$$

$$log\left[\frac{\pi_{i_3}}{\pi_{i_1}}\right] = \beta^{(3)}{}_0 + \beta^{(3)}{}_1 x_{i_1} + \beta^{(3)}{}_2 x_{i_2} + \cdots + \beta^{(3)}{}_p x_{i_p}$$

$$\vdots$$

$$log\left[\frac{\pi_{i_K}}{\pi_{i_1}}\right] = \beta^{(K)}{}_0 + \beta^{(K)}{}_1 x_{i_1} + \beta^{(K)}{}_2 x_{i_2} + \cdots + \beta^{(K)}{}_p x_{i_p}$$

This is a series of logistic regression models where each one compares the probability of the first or reference category with the probability of a different category. The probabilities are solved to determine the following:

$$\pi_{i_c} = \frac{e^{\eta_{i_c}}}{1 + \sum_{t=2}^{K} e^{\eta_{i_t}}}$$

where $\eta_{i_c} = \beta^{(c)}{}_0 + \beta^{(c)}{}_1 x_{i_1} + \beta^{(c)}{}_2 x_{i_2} + \cdots + \beta^{(c)}{}_p x_{i_p}$

Numerous variables were considered during model development, including: day of the week, time of day in minutes, time period of day (morning, afternoon, evening, or night), trip duration, average speed, standard deviation of speed, number of stops, start latitude, start longitude, end latitude, end longitude, dwell time (time spent without moving) before trip, dwell time after trip, start land use, end land use, percent of the trip that occurred on the street and path network, percent of the trip that occurred on a bus route (PercBus), percent of trip that occurred on a trail (PercTrail), and distance.

Forward-selection based on the Aikaike information criterion (AIC) selected the following explanatory variables: average speed in miles per hour, standard deviation of speed, PercTrail, PercBus, and distance in miles. The model coefficients are shown in Table 2; note that driving was the reference category. Table 3 shows the number of trips this model correctly predicted as well as the corresponding percentages. To account for model optimization, ten random iterations of 10-fold cross-validation were performed, and the cross-percentage column gives the prediction accuracy after accounting for model optimization. This model correctly predicted mode for the pilot study with a 77% accuracy rate.

Trips were uploaded to the website in a manner that would provide a diverse set for the participants to review. Future research could investigate developing a mode prediction algorithm that continuously updates model coefficients based on daily participant feedback.

Table 2: Mode Prediction Regression Coefficients

Mode	(Intercept)	Speed (Average)	Speed (Stndrd. Dev.)	PercTrail	PercBus	Distance
Bike	1.408	-0.117	-8%	781%	0.361	-0.223
Bus	-4.515	-0.201	19%	447%	3.081	0.121
Other	0.338	-0.23	12%	275%	0.73	-0.199
Walk	4.741	-0.521	21%	657%	0.575	-0.516

Table 3: Mode Prediction Accuracy

Mode	Correctly Predicted	Incorrectly Predicted	Percent Correct	Cross-Percent
Drive	107	11	91%	89%
Bike	14	21	40%	35%
Bus	4	7	36%	29%
Walk	107	9	92%	90%
Other	0	14	0%	0%
Total			79%	77%

RESULTS

Before and after surveys (stated-preference analysis) as well as observed changes in travel patterns (revealed preference analysis) were reviewed to gain an understanding as to how this travel feedback study influenced individual travel behavior.

Demographics

During the two week study period the experimental group was comprised of thirty-five participants who recorded 306 trips through the app and android device. Fifteen participants recorded no trips and represented the control group. The gender split was relatively even at 58% men and 42% women. Age groups were broken down into three categories: 18 to 24 year olds, 25 to 39 year olds, and 40 to 65 year olds. Due to the university setting, a disproportionately high number of people (62%) were in the 18 to 24 year old range, followed by 24% in the 25 to 39 year old range, and 14% in the 40 to 65 year old range. With regard to educational background and income, 56% of the participants had both "some college, yet no degree" and an annual income base of less than $30,000, respectively. Participants were asked to identify their political party and the results reflected a balanced population: ten people identified themselves as liberal, eight as moderately liberal, seven as moderate, ten as moderately conservative, four as conservative, and eleven preferred not to answer.

The distance between home and work was collected and summarized, and both groups had a similar distribution. The experimental group's split was 60% within a mile and 40% separated by a mile or more, whereas the control group had 53% living within a mile and 47% living a mile or more away. Even though nearly half of the participants lived a mile or more from their workplace, upon completion of the survey 82% of all participants claimed that they had walked to work at least once during the program, 38% bicycled to work at least once, and 16% used SMART Transit, the local bus carrier, at least once.

Mode Choice

All participants were asked to identify their mode choice for their first trip of each weekday during the survey. The mode preference order was the same for both groups: walk, car, bicycle, and then bus. For the control group, walking rose 6.5% in the second week to 60.9%

of trips taken, car use reduced 4.4% to 25%, and bicycle use reduced 2.2% to 12.5%. The experimental group's first trip mode choice of walking reduced by 4.8% to 52.1%, car use increased 2.1% to 28.8%, and bicycle use rose 3.6% to 12.9% in the second week. During the second week the experimental group had a slightly higher percentage of bicycle users and 4.5% more bus riders than the control group. These results likely reflect the survey demographics and the proximity of their home to work (or campus).

SMART Transit bus usage was collected not only for the first trip of day, but also for any trip during the study. The control group used SMART Transit a total of only two times during the first week and six trips during the second week. These values equate to 0.13 and 0.40 rides per participant per week. The experimental group had 0.29 rides per participant during week one and 0.46 rides per participant during the second week.

Perception of Trip Distances

In order to examine how our study affected one's perception of trip duration, participants were asked to estimate the time it would take to travel between two locations using each mode choice. The first trip was between a participant's home and their work or school. The second trip to estimate was between the Student Union Building (SUB) and the Moscow Wal-Mart. Though both locations for the second estimation are well-known landmarks this trip would have required more thought as most participants likely had never walked to Wal-Mart due to its perimeter location at the edge of town. When comparing their before-and-after estimates, control group participants remained fairly neutral, with only a slight increase in duration for car, bike, and bus on both trips.

For walking, the control group's net perception of duration dropped for both trips after the second week. Results for the experimental group showed more perception change than the control group. Experimental group participants had a net increase in duration perception for all modes on the home to work trip, with car and bicycle travel showing the most increase. On the SUB to Wal-Mart trip, a large number of participants from the experimental group reduced their predicted bus and walking duration times at the end of the study. Based on the results in these two individual categories, the predictions after the second week tracked more accurately with the actual trip duration than with initial estimates.

Travel Impact Opinions

Four questions were asked to participants at the start and end of the program.

- "Considering your typical week of travel, do you think your car use could be reduced?"
- "Do you think your daily car use impacts global climate change?"
- "How much do you consider the health benefits of walking rather than driving?"
- "How much do you consider the health benefits of bicycling rather than driving?"

Feedback was given on a 1 to 5 scale with 5 representing the highest positive value. The experimental group's average values decreased for all four questions at the end of the study. Health benefits of walking and bicycling reduced less than 1% from the initial survey and remained the highest scores at 3.66 and 3.26 respectively. For the experiment group car use reduction fell by the largest percentage, -5.6%, and received the lowest final average of 2.91. The feeling of their daily car use affecting climate change had a 4.3% reduction to a 3.17 average.

The control group surprisingly finished with a higher average than the experimental group in all four questions. Reducing car use improved 16% to 3.93, climate change grew 11% to 3.33, and the health benefits of bicycling remained at the same average of 4.07 as in the original survey. The health benefits of walking was the only control group question to have a reduction in the average falling 7.5% to 4.13, though still 0.48 higher than the experimental group's final average. One similarity between the control and experimental groups was that both groups perceived the health benefits of walking greater than that of bicycling.

Funding Sustainable Infrastructure

Three questions were asked at the start and end of the study to gauge participants on how much the City of Moscow should fund sustainable transportation improvements. Participants gave feedback on funding SMART Transit, walking infrastructure, and bicycle infrastructure by choosing dollar ranges from $0 to greater than $50 per resident per year. For SMART

Transit funding both the control and experimental group's most popular category was $5 per resident per year. Over the course of the program the experimental group had a net five people reduce their transit allotment whereas the control group had a net one person increase. The experimental group had a net change of four people reducing bicycle infrastructure funding with twenty-two of thirty-five people responding with $10 and $20 per resident per year recommendations.

The feedback with regard to improving walking opportunities in the community varied between the control and experimental groups. The control group had a net seven participant increase, while the experimental group had a four participant decrease over the course of the study. When all of the sustainability questions were reviewed in concert the results suggest that participants in the experimental group, though displaying a slight net reduction over the course of the program, still recommended higher sustainable transportation funding than the control group. The combined data also shows participants recommended the least amount of funding for public transit and a larger amount for walking and bicycling infrastructure. Collectively, the responses to the questions in this subject area yielded limited substantive information, and despite efforts to present the question in a clear and understandable manner, the abstract nature of gauging appropriate funding on an annual basis for each travel purpose arguably contributed to the limited value of the results.

Participant Observations

In order to gauge the effectiveness and interest level of this study, participants were asked to provide qualitative feedback on their experience. Participants generally provided favorable feedback with regard to study design and implementation. When asked if the study influenced their mode choice, participants provided the following range of responses. Some participants enjoyed the study:

- "Yes, I liked the idea of trying new modes of travel and will continue to do so. I also liked the calorie display."
- "It was interesting to see the different routes that I took by bike versus car."

- "Yes, it helped me (to) see the distances (of) my trips and how easy/difficult it would be to walk instead of drive."
- "Definitely. I wanted to record my travel by bicycle. I pouted on the day that it rained."

Other participants expressed an unwillingness to change:

- "No, I'm a creature of habit."
- "No, but it was interesting to see the route maps."
- "I feel like I could walk or bike more places but my car is faster and there is a hill near my house which makes the bike hard to use."

Study participants were asked if they learned anything new from this study. Many of them offered a reflective perspective on their experience:

- "I became more aware of where I go and how I travel, and that was pretty neat to think about."
- "I realized that I use the car more than needed."
- "I walk much less than I should."
- "I should travel and walk to more events because everything is close by and doesn't take very long. I wasn't walking as much as I thought."
- "I do enjoy walking, but due to time constraints I tend to drive more."
- "Walking can be done for small in-town trips more successfully than in cars in most cases."
- "Yes, my walking paths are really inefficient."

- "Yes. Sometimes I drive unnecessarily because I overestimate the distances and the amount of time it would take me to walk."

When participants were asked to identify a specific aspect that they liked about the study, a number of responses focused on either the technology aspect or its interactive nature.

- "I liked the personalized questions about routes I took, as well as seeing maps of those routes."
- "I liked seeing how far I moved, and seeing all of the weird paths that I sometimes walk."
- "I liked thinking about how I travel."
- "I liked answering the daily questions about my trips and trying to remember which trip it was from looking at the arrows (map)."
- "I really liked how easy it was. The app was simple to use and all of the online stuff was easy."
- "My favorite part was seeing the costs associated with each mode. I also liked the ease of filling out the travel diaries."
- "I enjoyed the thought that someone was interested in my particular modes of travel."
- "I enjoyed feeling like I was assisting in a study that could help reduce environmental strain and make people healthier."

Study participants were equally honest when asked which aspect or aspects of the study were not desirable. Many of them complained about how the app drained the phone battery or the limitations of the prediction models.

- "The constant GPS use was a big power user on my cell phone. It was pretty irritating to have to charge it twice a day."
- "I didn't like how some of my trip paths weren't recorded accurately."
- "I didn't like how easy it was to forget to charge or forget to take it with me on a short trip that I didn't think to bring the phone."
- "I did not like that my phone battery died so fast because of the app. I think on the maps it was hard to tell where the start and ending point was in Moscow."
- "The phone died within a day."
- "Sometimes I got confused with the route maps; a magnifier option would have been helpful."
- "The maps were somewhat difficult to see if they were accurate or not."

The participants generally acknowledged that it was a "good study", "very simple", "fun" and "easy to participate". One individual, likely a student, suggested that "maybe next time it should not be held ‘so close to finals’". Several people acknowledged that the survey should have been longer in duration. Lastly, when asked how the study or website could be improved, several participants strongly agreed that providing more community information, such as a bus schedule and noting popular bicycle and walking paths, would have been beneficial.

- "I would give links of the alternate transportation that is available and how to get involved using them."
- "Include information about CO_2 emissions for travel distance. Include more information on how one might access SMART transportation to encourage participants to use it. Have the option for participants to request a bicycle for one day so they could experience that mode of transportation if not available otherwise."

- "Provide participants with a route map for bus and bicycle options. Solicit rewards from bike shops and the transit system for using alternate transit. Little stuff would be fine, like a water bottle, pant clips, or a drawing for a t-shirt."

- "I don't ride a bike - I'm 61 and have a new knee. When asking questions, you might consider possible disabilities of the people being surveyed."

CONCLUSION

Instantaneous day-of travel feedback served to continuously engage each study participant for the duration of this study. The use of an android device along with an on-line website proved to be a relatively easy way of capturing and confirming user trips. However, the ability to force a dramatic change in user behavior appears to have been limited given the survey participant demographic and duration.

Some suggestions for future research efforts would be to extend the time frame for the study, include a more heterogeneous group, and then determine if such a travel feedback or user nudging program would be more impactful. One concern with a longer study period, however, would be the increased likelihood of participant obsolescence and disregard over time.

A significant amount of travel data were generated for very little cost from this study. In this regard, the authors believe that the methodology employed here could be used to complement travel diary activities. A travel diary allows for detailed reports on trips, but is completely reliant on the effort and thoroughness of the volunteer. A common problem occurs when an individual forgets to record short trips, especially those as part of a trip chain, or to put off filling out the journal for a few days, by which time the details of a trip have been forgotten. Because travel diaries are reliant on volunteers providing all of the information, they are considered active feedback. Individuals carrying a Global Positioning System (GPS) enabled device that records their location is a passive form of data collection that is much easier on the participant.

This study was able to demonstrate the potential of predicting trip mode, although the results for predicting trip purpose were somewhat muted. With this passive data collection there are no recall issues, as all the data is stored electronically. Less effort is required of the participant, so researchers can conduct studies for longer time periods without having to be concerned about participant fatigue.

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APPENDIX A

Figures A-1 through A-6 present demographic information for the participants.

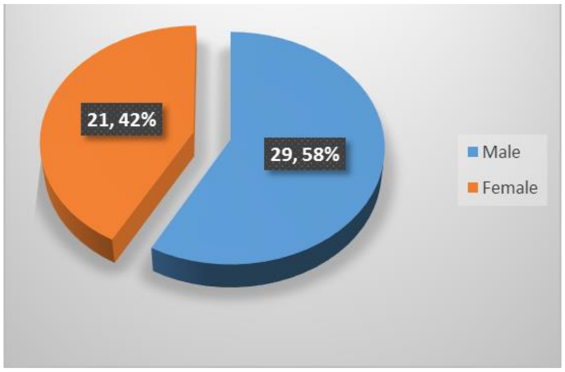

Figure A-1: Participant gender.

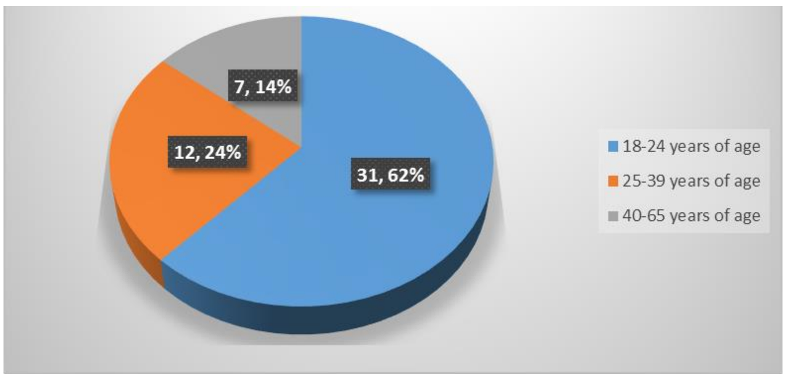

Figure A-2: Participant age.

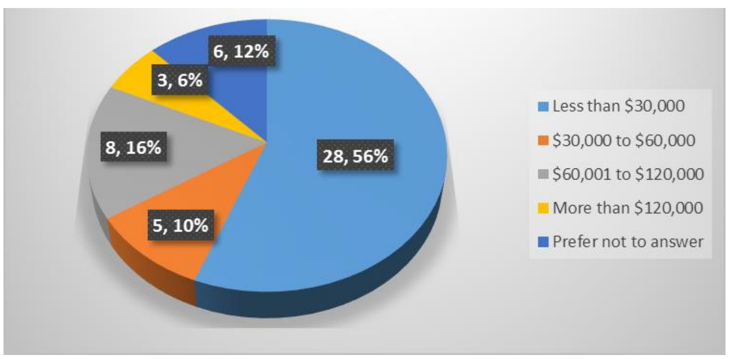

Figure A-3: Participant income.

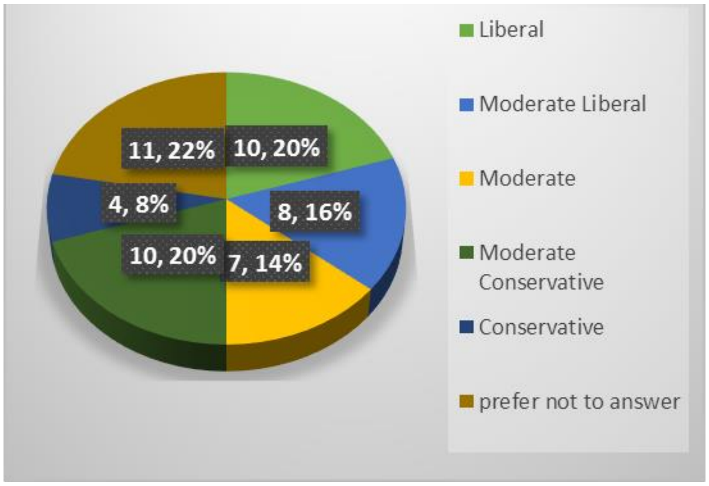

Figure A-4: Participant political views.

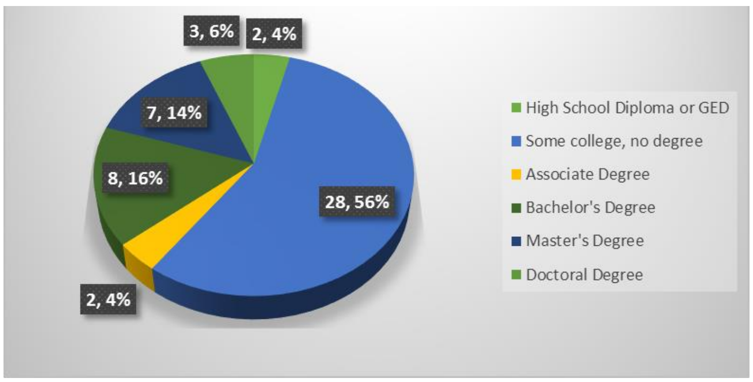

Figure A-5: Participant education.

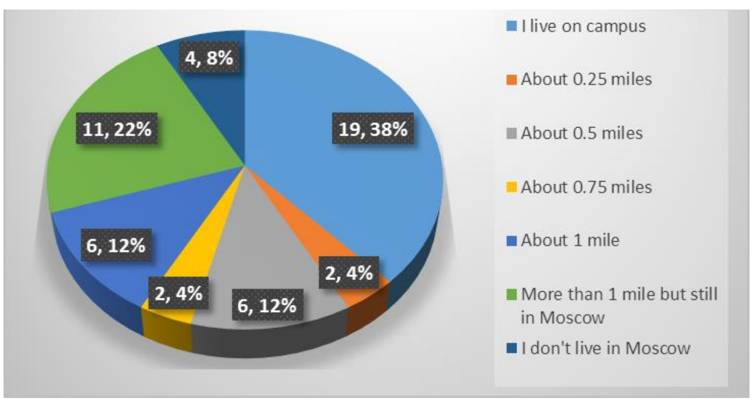

Figure A-6: Participant home distance from campus.

Figures A-7 shows the change in the perception of walking time to travel from the UI campus to a retail center on the other side of town. Figure A-8 shows the change in opinion about the ability to reduce car use. Table A-1 shows the change in willingness to pay for improvements for transit, walking, and cycling.

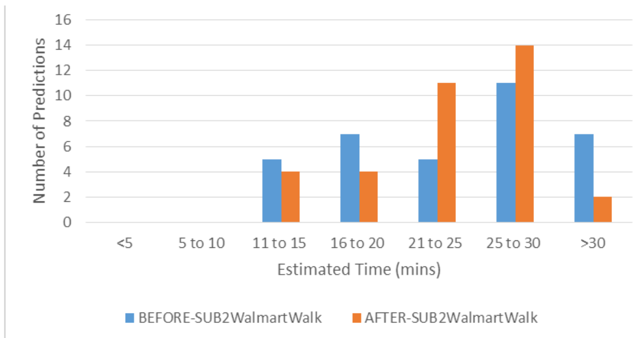

Figure A-7: Perception of time it would take to walk across town.

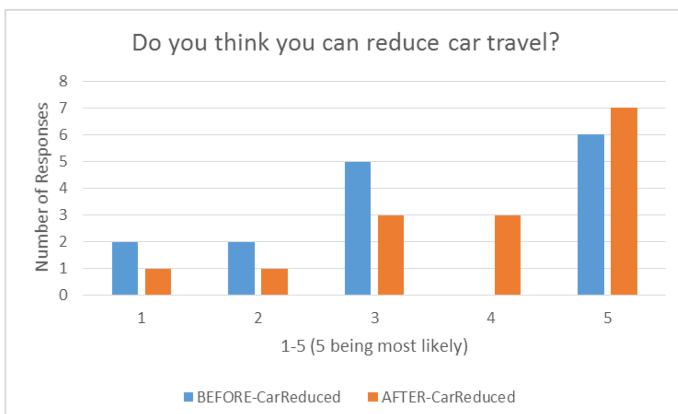

Figure A-8: Opinion concerning ability to reduce car use.

Table A-1: Willingness to Pay for Transportation Facility Improvements

	Transit Facilities			Pedestrian Facilities			Bicycle Facilities		
Willing to pay per yr	Before	After	Change	Before	After	Change	Before	After	Change
$0	2	2	0%	2	1	-50%	2	2	0%
$5	20	21	5%	6	7	17%	7	9	29%
$10	10	9	-10%	15	15	0%	16	14	-13%
$20	11	11	0%	16	15	-6%	10	13	30%
$50	3	3	0%	4	5	25%	8	5	-38%
> $50	4	4	0%	7	7	0%	7	7	0%

APPENDIX B

Publications resulting from this project:

Chang, K. Lowry, M., Seely, B., and Cook, R. (2015). “Using a Responsive Interactive Program to Enhance Daily Travel Feedback” *Transportation Research Board 94th Annual Meeting Compendium of Papers.* National Research Council, Washington, D.C.