Title

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Publication Date
2017-07-01

Peer reviewed

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Leveraging Co-benefits and Metaphorical Metrics in a Mobile App to Promote Walking and Biking for Short Trips

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Abstract. There is an overreliance on personal vehicle travel for short trips in the United States. This paper describes a mobile application, called EcoTrips, that promotes walking and biking for short trips by tracking users' travel behavior and providing a variety of feedback. EcoTrips conveys environmental impacts of travel behavior, and also leverages a variety of co-benefits of green travel by providing feedback related to fitness, finances, and time management. Feedback is conveyed in conventional as well as metaphorical metrics to make the data more comprehensible and meaningful. EcoTrips is unique among similar apps in that it provides a very high degree of flexibility for users to tailor the metrics that are displayed. It is also unique in that it is both the subject of HCI research and publicly available in English and in the United States. In a small pilot field study, participants reported some increase in awareness of the impacts of their travel behavior, and some small changes in their travel mode choices. Participants also highlighted the importance of maximizing the personalization of data. Given the expanding landscape and prevalence of pervasive and personal mobile and wearable technologies, HCI researchers should continue to develop eco-feedback and trip planning technologies to promote green travel modes for short trips.

Keywords: Eco-feedback · Green transportation · Travel modes · Mobile app

1 Introduction

There is an overreliance on private vehicles in the United States [2]. Rails-to-Trails Conservancy [30] estimated that half of all car trips in the US could be biked in 20 min and one quarter of all car trips could be walked in 20 min. They also estimated that there are 60 billion car trips of one mile length or less every year in the US.

Various environmental, social, and economic issues have been attributed to this overreliance on the private automobile [17]. In particular, the resultant vehicle emissions have immense implications for climate change. Extrapolating from the estimate of 60 billion one-mile car trips per year, and assuming an average of 411 g of carbon dioxide (CO_2) emissions per mile [12], these short trips can account for approximately 24,660,000 metric tons of CO_2 emissions in the US every year. Therefore, promoting

A. Marcus and W. Wang (Eds.): DUXU 2017, Part II, LNCS 10289, pp. 60–76, 2017.
DOI: 10.1007/978-3-319-58637-3_5

walking and biking for local trips instead of personal vehicle transport could lead to substantial reductions in CO_2 emissions. For example, a bicycle commuter who rides five miles to work four days a week could save 100 gallons of gasoline and 2,000 lb of CO_2 emissions per year [17].

Improving facilities and infrastructure to increase access, convenience, and safety for walking and biking are crucial to enable greener transportation mode choices (e.g., [27]. However, structural supports alone may be insufficient to create and sustain behavior change [16]. Travel mode choices are also influenced by complex individual learning histories and social norms; they are habitual and may be resistant to change despite changes in the physical transportation infrastructure [4, 40].

Promising behavioral strategies to influence travel mode choices include the use of eco-feedback technologies, i.e., those that "provide feedback on individual or group behaviors with a goal of reducing environmental impact" [14, p. 1]. One behavioral theory particularly relevant to eco-feedback is Schwartz's Norm Activation Model [27, 36], which contends that altruistic (including pro-environmental) behavior is motivated by moral norms, which are promoted by the awareness of the consequences of one's behavior for others (or the environment). Eco-feedback aims to increase awareness of such behavioral consequences.

The recent phenomena of personal data tracking devices like the Fitbit and the game Pokémon GO are examples of the potentially powerful impact of leveraging mobile applications (apps) and wearable technology for health, fitness, and entertainment related to travel behavior [3, 28]. These services emphasize fitness and fun, respectively, and may increase non-vehicular travel, but they do not explicitly discourage driving. The present research details the creation and testing of an eco-feedback mobile app called EcoTrips, designed to promote walking and biking, and discourage driving, for short trips (3 miles one way or less). First, we review relevant HCI eco-feedback research and similar apps.

2 Review of Green Travel Eco-Feedback Apps

HCI researchers have developed mobile apps to promote physical activity [6] and reduce private vehicle use by providing users feedback on their behavior. Moreover, some transportation-focused eco-feedback apps leverage fitness and economic co-benefits to promote green travel behavior [13, 19]. Including information regarding co-benefits is important because motivators for pro-environmental behavior vary, including by culture [10], and presumed universal incentives, like money, are not always effective [5, 9]. Another strategy in green travel apps has been to include trip planning functionalities via information on public transportation and route alternatives, which also serves as an added benefit to users [20, 35]. EcoTrips is an example of the former–providing eco-feedback along with information regarding co-benefits of green travel behavior. See Table 1 for a list of relevant apps.

UbiGreen [13] was the first example of this type of eco-feedback app. It promoted walking, biking, and carpooling via two different interface designs, each involving a linear sequence of images. One was a growing tree and the other a polar bear scene; as the user's green transportation increased, the tree grew progressively or the environment around the polar bear became richer. The app also provided information about possible economic and health co-benefits via icons at the bottom of interface; e.g., a piggy bank icon would light up when economic benefits were achieved via green travel modes. In a field test, authors found that the nature imagery helped users connect emotionally with the data, but they also wanted numerical data to gain a more accurate understanding of their performance.

The tree and polar bear in UbiGreen are examples of iconic representations [21], as opposed to indexical (numbers and graphs), and empathetic gauges [29]. Research suggests that these types of data visualizations can motivate users by creating an emotional connection to the data in eco-feedback interfaces [8, 21, 23, 29]. On the other hand, indexical, or scientific data visualizations support learning and retrospection [21, 29].

Another similar project, Quantified Traveler [19], included a smartphone app to track travel data and a companion eco-feedback website. Like UbiGreen, Quantified Traveler provided information about co-benefits of greener travel modes relevant to a variety of user motivations, i.e., finances, fitness, and time management. Specifically, it provided numeric feedback and graphs reflecting travel time, cost, Calories burned, and CO_2 emissions. Quantified Traveler also provided comparison data for the average American, the average resident of the San Francisco Bay Area, and the average of other subjects in the study.

None of the apps that have been the focus of HCI research are currently publicly available in English, or in the United States; however, there are several publicly available apps with similar goals and strategies (Table 1). For example, CommuteGreener [43] is a trip planning app with the primary advertised goal of helping users avoid traffic congestion. It also provides textual and numeric feedback related to values of environment, finances, and fitness, including CO_2 emissions, travel cost, and Calories burned. Emissions information is also provided in terms of "trees saved" and Calories burned in terms of hamburgers.

Froehlich et al. [15] discussed how metaphorical metrics, like trees saved or hamburgers in CommuteGreener, can be more understandable than abstract, scientific terms, and also more emotionally evocative. Thus, metaphorical metrics represent another kind of "empathetic linking", similar to empathetic gauges. Petersen et al. [29] defined empathetic linking in the context of eco-feedback as "the packaging of information in a form that emotionally or experientially connects consumption decisions to feelings and concern for social and ecological communities" (p. 83). Furthermore, metaphorical metrics and empathetic linking more generally represent a potentially powerful way of increasing awareness of behavioral consequences per the Norm Activation Model of pro-environmental behavior [34].

Table 1. Green travel eco-feedback apps

App name	Values	Conventional metrics	Metaphorical metrics	Subject of HCI research	Publicly available
UbiGreen	Environment	–	–	X	–
	Finances	–	–		
	Fitness	–	–		
Quantified traveler	Environment	X	–	X	–
	Finances	X	–		
	Fitness	X	–		
	Time management	X	–		
Peacox	Environment	X	–	X	–
	Time management	X	–		
MatkaHupi	Environment	X	–	X	–
CityMapper	Environment	X	–	–	X
	Finances	X	–		
	Fitness	X	–		
	Time management	X	–		
CarbonDiem	Environment	X	–	–	X
TripGo	Environment	X	–	–	X
	Finances	X	–		
	Time management	X	–		
CommuteGreener	Environment	X	X	–	X
	Finances	X	–		
	Fitness	X	X		
EcoTrips	Environment	X	X	X	X
	Finances	X	X		
	Fitness	X	X		
	Time Management	X	–		

3 EcoTrips

EcoTrips is a mobile app that promotes walking or biking for short trips (3 miles one-way or less) by raising awareness of personal and environmental impacts of travel behavior. It provides a variety of information to appeal to different value orientations [25, 37]. Within different information categories (fuel consumption, environmental impact, and Calories), EcoTrips supplies numeric data in terms of conventional and metaphorical metrics, paired with illustrative icons as in UbiGreen [15], in order to deliver detailed information and evoke emotional response, thus supporting both understanding of and emotional connection to environmental consequences of travel behavior.

In addition to providing information tailored to users' values, Petersen et al. [29] suggest making it easy for users to select the information they want. In EcoTrips, the user can select which metrics to display (or not). In this way, EcoTrips provides a high degree of flexibility for tailoring information compared to previous similar apps.

3.1 Development

EcoTrips is an Android mobile app. It uses Moves API to track travel mode and trip data. Data collected by the Moves API are based on users' location. Inferences are made by the Moves API about travel mode, i.e., whether the user is most likely walking, biking, or traveling by vehicle.

The EcoTrips back end retrieves Moves data and summarizes it to create the raw data for visualizations in EcoTrips. The synchronization of data between EcoTrips backend and the Moves API is controlled by EcoTrips usage; while actively used, the app sends an update request to the server to trigger updating every two hours. This update can also be forced by the user with the refresh button at the top of the app screen.

Calculations shown on the app are done on the server side to save battery and response time while using the application. The downside to this approach is that every time the user makes a change to configurable data in the settings, e.g., user's body weight or personal vehicle fuel economy, the app has to sync with the server to recalculate the feedback data. This process is done automatically, but there is a slight delay.

EcoTrips back end is a useful resource for data analytics. Data stored anonymously in the server can be pulled in reports without compromising the identity of users. Although not developed yet, it is easily feasible to create a report tool using the back end infrastructure.

Fig. 1. Calendar screen

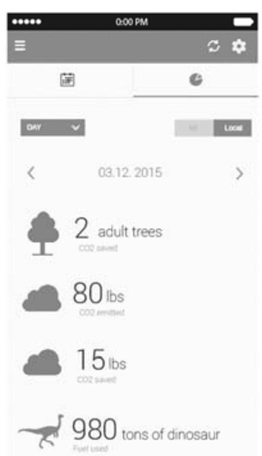

Fig. 2. Statistics screen A

Fig. 3. Statistics screen B

3.2 Design

The app consists of two main screens: the Calendar Screen illustrates predominate daily travel mode and the Statistics Screen presents numeric feedback via conventional and metaphorical metrics paired with illustrative icons. In the Calendar Screen (Fig. 1), days are color-coded according to predominate travel mode (vehicle, walking, or biking), defined as the travel mode with the longest total travel time. A toggle button on the top right allows the user to view data for either all their trips or only their short trips (3 miles one way or less). This feature was intended to avoid discouraging users who have an unavoidable long distance commute and to promote a focus on short trips.

The Statistics Screen (Figs. 2 and 3) conveys costs and benefits of travel behavior in terms of a variety of metrics, including Calories burned, CO_2 emissions, CO_2 emissions saved by biking and walking instead of driving, fuel usage, distance traveled, and travel time. These metrics represent a mix of values in order to motivate users with different value orientations. Specifically, Calories, fuel cost, and travel time appeal to person-centered values, whereas CO_2 emissions and CO_2 savings appeal to environmental values.

Calories burned, CO_2 savings, CO_2 emissions, and fuel usage are not only expressed in scientific terms (i.e., Calories, pounds of CO_2, and gallons of gas), but also in two additional units that attempt to make the information more concrete, relatable, and/or emotional/visceral. For example, Calories burned can be displayed in terms of Calories, as well as the equivalent amounts of grams of butter and minutes of jogging. Fuel consumption can be displayed in terms of gallons of gas, and also monetary cost and tons of dinosaur (i.e., prehistoric plant and animal material converted into oil over time by pressure and heat). The latter is intended to elicit an emotional response and help the user connect their behavior to the ultimate source of fuel (Figs. 4 and 5).

Fig. 4. About EcoTrips, page 1

Fig. 5. About EcoTrips, page 2

Carbon emissions and savings are particularly abstract and therefore important to convey in meaningful terms [18, 26]. EcoTrips calculates and displays CO_2 emissions from vehicle travel in pounds as well as the equivalent in seconds of erupting volcano, as a more visceral metaphorical metric, and monetary cost (i.e., if one were to purchase carbon credits). CO_2 savings from walking/biking rather than driving is also presented in pounds, as well as the estimated number of trees that would offset (i.e., absorb) that same amount of CO_2 in one year, and monetary savings in terms of cost of carbon credits. Carbon credit markets have become popular and growing considerably [22] among some consumers, as evidenced by the variety of brands/systems (e.g., MyClimate, The Conservation Fund, TerraPass and Carbonfund.org); a carbon credit is a certificate representing the reduction of one metric ton, or 2,205 lbs, of carbon dioxide emissions. Carbon credits worth $278 million (USD) were purchased in voluntary carbon markets in 2015 which is increased 10% compared to 2014 [42].

Calculations employed for the above metrics are listed in Table 2. We used a variety of sources to build these equations, including Dr. Bill Haskell's Compendium of Physical Activities (CPA; [1]) for calculating metrics related to Calories burned when traveling by foot, by bike, and by vehicle. Users' weight was also used to calculate Calories metrics. A default of 137 lbs (the average weight of an adult human according to Walpole et al. [39] was used if not otherwise specified.

To calculate fuel consumption and cost, EcoTrips uses a default fuel economy of 25 mpg, which is the average for a 2015 model-year vehicle according to the U.S. Environmental Protection Agency [12]. Fuel cost is set at $2.33/gallon based on current fuel cost according to the US Energy Information Administration [11]. Tons of dinosaur (technically, prehistoric material) required per gallon of gas was estimated at 98, based on a study at University of Utah [7].

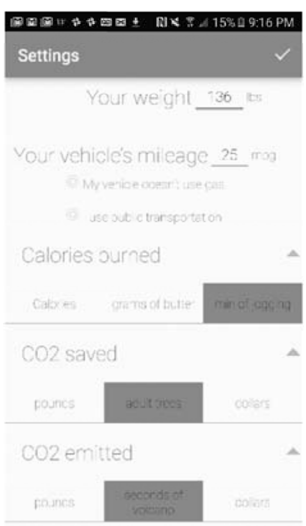

Fig. 6. Settings page 1

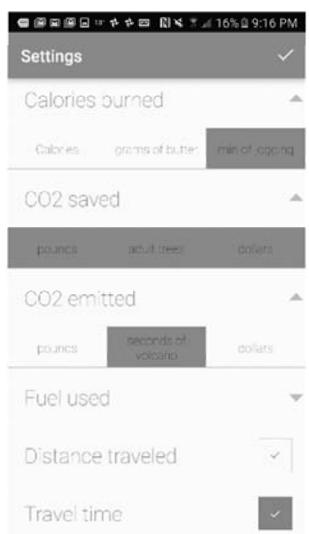

Fig. 7. Settings page 2

For CO_2 emissions and savings calculations, we relied on an estimate by the Environmental Protection Agency (EPA) that one gallon of gas consumed corresponds to 19.4 lbs of CO_2 emissions. We translated CO_2 emissions in pounds into seconds of volcano eruption based on data regarding Yellowstone National Park's Mud Volcano which produces about 176,300 tons of CO_2 per year [41], an average of 11 lbs of CO_2 per second. We used Terrapass carbon credit system to convert pounds of CO_2 emitted and saved into dollar amounts; at the time of our calculations the price for 1,000 lbs of CO_2 was $5.95. To translate CO_2 savings into trees EcoTrips uses an estimate from McAliney [24] that one mature tree absorbs 48 lb of CO_2 per year.

A Settings Screen (Figs. 6 and 7) allows users to select (and deselect) metrics to personalize the Statistics Screen. Users can also enter their body weight (lbs) and personal vehicle fuel economy (mpg) for more accurate calculations of Calories burned, fuel usage, and carbon emissions and savings. The functionality to specify personal vehicle fuel economy was added after our field study.

Table 2. Calculations for EcoTrips metrics

Metric category	Metric	Equation
Calories burned	Calories	(1) Foot = [1.587 × User's weight(lbs)] + [walking time (min) ÷ 60] (2) Bike = [3.08 × User's weight(lbs)] + [biking time (min) ÷ 60] (3) Vehicle = [0.59 × User's weight(lbs)] + [driving time(min) ÷ 60] (4) Total Calories burned(Cal) = (1) + (2) + (3)
	Grams of butter	$\frac{\text{Total Calories burned(Cal)}}{7.14}$
	Minutes of jogging	$\frac{\text{Total Calories burned(Cal)}}{\text{User's weight} \times 3.17} \times 60$
CO_2 emitted	Pounds	$19.4 \times \frac{\text{Driving distance(miles)}}{\text{Vehicle fuel economy(mpg)}}$
	Seconds of volcano	$\frac{CO_2\ \text{emissions(lbs)}}{11}$
	Dollars	$\frac{CO_2\ \text{emissions(lbs)}}{100{,}0} \times 5.95$
CO_2 saved	Pounds	$19.4 \times \frac{\text{Biking} + \text{walking distance}}{\text{Vehicle fuel economy(mpg)}}$
	Adult trees / year	$\frac{CO_2\ \text{saved (lbs)}}{48}$
	Dollars	$\frac{CO_2\ \text{saved (lbs)}}{1000} \times 5.95$
Fuel used	Gallons	$\frac{\text{Driving distance}}{\text{Vehicle fuel economy (mpg)}}$
	Dollars	Fuel usage(gal) × 2.33
	Tons of dinosaur	Fuel usage(gal) × 98

4 Field Study Methodology

We conducted a pilot field study with a beta version of EcoTrips in May 2015. Participants were recruited at University of California, Davis, via department email lists. To be eligible, participants had to be the owner of the vehicle and Android smartphone (EcoTrips only runs on Android OS). Each participant received a $10 gift card at the end of the study.

4.1 Procedure

Prior to using EcoTrips, participants completed a survey regarding their travel behavior, motivations for and barriers to walking/biking for short trips, and environmental attitudes. Immediately after this initial survey, participants were guided through the process of downloading the Moves app. Baseline data on participants' travel behavior (mode and trip frequency, duration, and distance) were collected via Moves for at least one week, then participants downloaded EcoTrips and were instructed to use it for at least one week. Participants were then asked to complete another survey to assess changes in travel behavior, awareness of consequences of mode choices, and environmental attitudes. We also compared travel behavior data while using EcoTrips to baseline levels.

4.2 Participants

Eleven participants completed the study. Eight were students and three were faculty. Six were female and five were male. Age ranged from 18 to 44 (M = 26; SD = 8.18).

Six participants indicated that they considered themselves environmentalists, yet only one participant indicated it was most important to them to 'minimize environmental impact' when choosing a transportation mode for short trips (less than 3 miles one way). Four participants indicated it was most important to 'minimize costs', three selected 'minimize travel time', three selected 'maximize physical activity', and none selected 'maximize scenic beauty and/or contact with nature'. This confirms the importance of emphasizing person-centered co-benefits of green travel behavior.

Biking is an extremely common travel mode for both students and faculty on UC Davis campus, so we expected the potential for shifting from personal vehicle travel to walking or biking would be limited. For example, in the initial survey most participants reported that they 'frequently' (5) or 'always' (1) tried to minimize how much they drive (5 said 'occasionally'; none said 'rarely' or 'never'). When asked if they were willing to commit to walking or biking instead of driving for trips less than 3 miles one way, most (7) responded 'yes', 2 responded 'I already do this all the time', 1 'no', and 1 'not sure'.

Given these sample characteristics, we were less interested in behavior change and more interested in the impact of EcoTrips on participants' awareness of their travel behavior and its consequences, and their environmental attitudes, as well as their reactions to the design and content of the app. We included several open-ended questions in the final survey concerning what, if any, changes in attitudes or behaviors participants noticed while using the app, and what, if anything, they learned from it.

5 Field Study Results

We analyzed travel behavior for seven days of baseline tracked by the Moves app, and seven days after EcoTrips installation (i.e., the testing period); both baseline and testing periods included five weekdays and two weekend days. Upon data analysis, it was noted that one participant did not use EcoTrips and one participant only had three days of baseline data. Data from the former was excluded from all analyses; data from the latter was excluded from quantitative analysis of travel behavior only. Descriptive, but not inferential, statistics are presented for both travel behavior and survey data due to the small sample size. Responses to open-ended survey questions were analyzed qualitatively by coding according to emergent themes.

5.1 Travel Behavior

As suspected, our sample was already driving relatively infrequently for short trips (3 mi or less) before using EcoTrips (Table 3). In fact, five participants took no short driving trips during the baseline week. Quantitative travel data showed no salient or consistent difference in number of short driving trips or associated distance.

Table 3. Number and distance of short driving trips for each participant during baseline week and testing week.

Participant		1	2	3	4	5	6	7	8	9
Number of short driving trips	Baseline	0	8	1	0	1	0	0	0	1
	Testing	0	5	6	0	0	0	1	0	6
Distance of short driving trips (miles)	Baseline	0	6.36	2.79	0	0.25	0	0	0	0.42
	Testing	0	3.08	6.06	0	0	0	1.69	0	5.15

In the final survey, after using EcoTrips, a minority of participants reported that their behavior had changed. In particular, two participants reported walking more (i.e., "I tried to walk more when I could"; "I have walked more for trips under 3 miles"); one participant reported biking more; and one participant reported driving less, crediting raised awareness from the statistics on the app (i.e., "I did drive a little less after seeing the figures").

5.2 Awareness of Consequences

Participants were asked about their level of knowledge concerning consequences of their driving before and after using EcoTrips (Table 4). Before using EcoTrips, participants reported being very knowledgeable about both the amount of gas their driving consumes and money they spend on gas; after EcoTrips, there was no increase in these variables, and in fact a decrease in median awareness of gas used. Participants' median response for awareness of carbon emissions from their driving was "No idea". Unfortunately, they did not demonstrate an increase in awareness of emissions after using EcoTrips by this measure.

Table 4. Median awareness of consequences of personal vehicle travel behavior before and after using EcoTrips. Question text: How knowledgeable are you about the following characteristics of your travel?

	Gas used	Money spent on gas	CO_2
Before EcoTrips	Very Knowledgeable	Very Knowledgeable	No idea
After EcoTrips	Somewhat Knowledgeable	Very Knowledgeable	No idea

Open-ended survey responses, on the other hand, revealed some increase in awareness of emissions:

The information about pounds of CO_2 saved and used was interesting, I hadn't thought about my transportation in that way before.

I already knew biking was better overall, but seeing the numbers reinforced my feelings.

I do like that it makes aware of the emission I'm causing.

Some participants seemed to gain awareness of their short trips in particular, in alignment with the objectives of EcoTrips.

…every little bit counts.

… other times I drove I realized it was really unnecessary. I can easily bike or take the bus.

It made me more aware of the short trips.

I'm now more aware of the shorter distances I drive, and how they would be bikeable if I made the effort.

5.3 Environmental Attitudes

As a brief measure of environmental attitudes, we used the inclusion of nature in self scale [33] in both the pre- and post-EcoTrips surveys (Fig. 8). This scale measures how an individual includes nature within her or his cognitive representation of self. The results indicated that five participants did not change their reported perceptions of connectedness after using EcoTrips, four participants reported an increased level of connectedness, and one reported a decreased level of connectedness (Table 5).

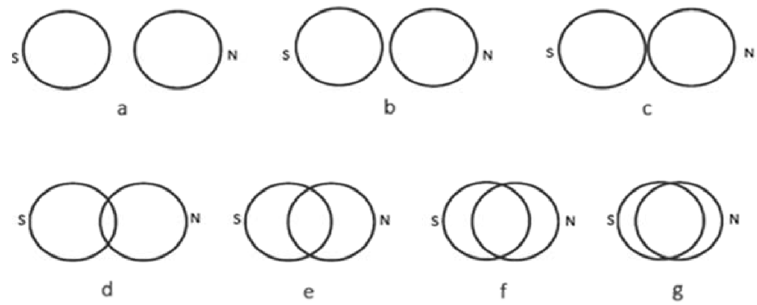

Fig. 8. The Inclusion of Nature in Self Scale. Question text: Which image above best describes your relationship with nature? In other words, how interconnected are you with the natural environment? (S = Self; N = Nature)

Table 5. Inclusion of Nature in Self before and after using EcoTrips

Participant	1	2	3	4	5	6	7	8	9	10
Before EcoTrips	f	d	e	d	d	f	d	d	f	e
After EcoTrips	f	d	e	e	e	f	e	e	e	e

6 Opportunities for Improving EcoTrips

A strong theme in open-ended responses in the final survey was participants' desire for more personalized data. Specifically, participants were unsatisfied with the use of average data for vehicle emissions:

C02 emissions depends on the vehicle, so I couldn't take the value given as true.

*If I really care about the carbon produced by *my* behavior, it doesn't help me much to instead learn how much carbon I would have produced in the average vehicle.*

Some things to note are that some of what is categorized as driving was actually busing through Unitrans' environmentally friendly buses.

7 Discussion and Conclusion

In this paper we described the design and pilot evaluation of EcoTrips, a mobile application that automatically tracks and provides feedback regarding travel behavior. EcoTrips leverages a variety of co-benefits of green travel and uses metaphorical metrics to make emissions and fuel consumption information more comprehensible and meaningful. It is unique among similar apps in that it is both the subject of academic HCI research and publicly available in English in the United States, where there is an overreliance on personal vehicle travel for short trips. In the pilot study of EcoTrips beta version, open-ended survey data revealed some increases in users' awareness of the impacts of their travel behavior and their interdependence with the natural environment.

Limitations of our field study included our unique sample of university students and staff that infrequently drove for short trips (average of 0.17 short driving trips per day per participant during baseline). Our sample's travel data shows they drove on average 27.9 miles per day, which is lower than average American's 29.8 miles per day [38]. We also had a small sample size and short study duration. Furthermore, there were several bugs in the beta version of the app. We hope to conduct a larger, more naturalistic field study with users who download the final version of the app from Google Play Store.

Based on user responses to the app that highlighted the need for more personalized data, we added several functionalities: vehicle fuel economy can now be personalized; users' can also indicate if their predominant motorized travel mode is an electric vehicle or public transportation. These inputs automatically adjust the gas and carbon calculations. We also plan to integrate an API to make fuel prices dynamic. Our goal is to make the app easy to maintain so it can remain publicly available unlike other apps that have been the focus of HCI research but not made (or remained) publicly available.

Past research shows that eco-feedback is more effective when it includes historical comparisons, social comparisons, and goal-setting [29]. Gamification techniques in the context of eco-feedback apps for travel behavior could also be quite effective and warrant further exploration [20]. EcoTrips includes historical comparison via the Calendar Screen. We intended to include unique social comparison and goal-setting features that we designed but lacked the resources to develop. Specifically, a photo-sharing feature would enable users to post and find beautiful or otherwise interesting routes (Figs. 9, 10, and 11). Personal and collaborative goal-setting was envisioned whereby users could set goals in terms of a variety of conventional and metaphorical metrics (Figs. 12 and 13). We hope to include these features in future development phases.

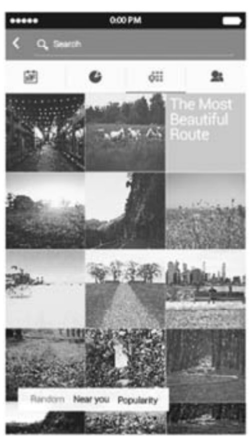

Fig. 9. Most beautiful routes searchable photo-sharing feature (left)

Fig. 10. Beautiful routes photo tagging feature (middle)

Fig. 11. Beautiful routes social media sharing feature (right)

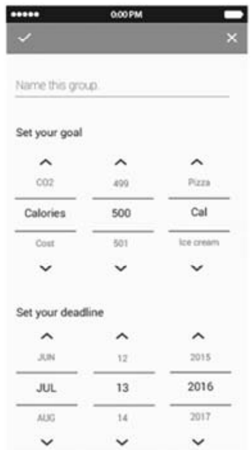

Fig. 12. Goal-setting screen where users can tailor metrics and timelines for personal or shared goals (left)

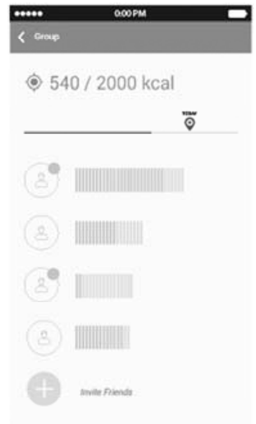

Fig. 13. Progress-tracking screen for goal-setting system (right)

In conclusion, both physical infrastructural and behavioral strategies to promote non-motorized transportation modes for short trips are needed to achieve multiple associated social goals, including reduced carbon emissions and improved human health. Among behavioral strategies, technologies that enable trip planning and eco-feedback are particularly promising given the expanding landscape and prevalence of pervasive and personal mobile and wearable technologies. Leveraging the co-benefits of green travel behavior in these technologies is particularly important, as is harnessing the growing body of HCI knowledge concerning effective data visualization.

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Publicly Available Green Travel Apps

43. CommuteGreener: commutegreener.com
44. TripGo: https://skedgo.com/home/tripgo/
45. CarbonDiem: carbondiem.com
46. CityMapper: citymapper.co
47. EcoTrips: ecotrips.ucdavis.edu