How Vehicle Connectivity Based Eco-Routing Choices Will Impact on Driver Decision-Making

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16. Abstract

The eco-routing navigation system has become a promising application to reduce fuel consumption by optimizing driving routes recommendation through energy efficiency prioritization instead of sole travel time or distance minimization. Current studies paid limited efforts to investigate whether and why drivers will choose and comply with an eco-route recommendation by eco-routing navigation systems, as well as the potential impact of drivers' habitual route choice on their decision-making. To fill this research gap, a field test was conducted from May to June 2019 in Ann Arbor, MI. Forty-three participants were recruited to receive an Android phone pre-installed with an eco-routing navigation application specifically developed for this study. In two weeks, drivers were instructed to interact with the application by completing a route-choice survey and selecting from recommended driving routes prior to the beginning of some of their driving trips. Data analyses were conducted to examine drivers' route choices and compliance behavior when interacting with this eco-routing application, including mixed-effect logistic regression models to explore the impacting factors on the eco-routing choice and compliance, a multi-label random forests (MLRF) model to predict route choice behavior, and a mixed-effect beta regression model to examine the effect of habit on route choice following the framework of Triandis's Theory of Interpersonal Behavior (TIB). To summarize, it was observed that drivers chose the eco-routing option with the most energy-saving feature in approximately 78.6% of all the selected routes in this study. They were more likely to select the eco route when the trip had shorter distance and/or higher gas consumption per mile. Prioritize the eco-route choice among alternatives was associated with higher likelihood of being selected. Route information such as distance saved and average gas consumption ranked the highest in predicting route choice, followed by subjective data such as prior activities and trip purpose. In terms of compliance, drivers who chose the eco or fast routes and rode along with three or more household passengers were more likely to fully follow the recommended route. Habitual route choice showed a strong impact on drivers' compliance to an eco-route navigation advice. More specifically, drivers were more likely to follow a similar route regardless of the eco-route recommendation if a habitual route choice has already been formed. Nevertheless, if drivers yet have a strong habitual route selection towards a specific trip origin and destination pair, they were significantly more likely to follow the eco-route advice given by the navigation application and might even maintained the behavior afterwards. Findings of this study could help improve the understanding of drivers' decision-making in eco-route planning. It could also benefit the design of eco-routing navigation system and education programs targeting transportation sustainability, both of which will contribute to the achievement of a more eco-friendly transportation system.

17. Key Words	**18. Distribution Statement**
Eco-routing navigation system, Route choice, Route compliance, Theory of Interpersonal Behavior, Habit, Human factors, Multi-label random forest, Mixed model analysis	No restrictions.

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Introduction

The transportation sector, as one of the most significant contributors to greenhouse gas emissions, is greatly responsible for the growing environmental problems, such as the fossil fuel shortage crisis, global climate change, air pollution and so on (Aziz and Ukkusuri, 2014; Salvi and Subramanian, 2015). It has been reported that the transportation sector made up the largest proportion (approximately 29%) of the total U.S. greenhouse gas emissions in 2017, of which 41% was represented by passenger cars (EPA, 2019). With the rapid development of intelligent transportation systems, the eco-routing navigation system becomes a potential application to reduce fuel consumption, which optimizes the route based on the most energy efficiency instead of minimizing the travel time or distance (Ahn and Rakha, 2013; Wang et al., 2019; Zhao et al., 2019). The most energy-economic route (hereinafter called "the eco route") is not always consistent with the fastest or the shortest route, due to higher travel speed or traffic congestion (Zeng et al., 2017; Boriboonsomsin and Barth, 2014). If the eco route is adopted by drivers to take the place of traditional route choices (i.e., the fastest or shortest route), a 4% ~ 20% decrease in energy emissions can be achieved (Ahn and Rakha, 2008).

Currently, eco-routing models designed for advanced navigation systems have been proposed and improved, as more influencing factors on vehicle fuel consumption have been investigated and optimized. Besides traditional route recommendations such as the shortest or fastest routes, eco-routing navigation systems offer drivers an extra option, the eco route, so a new question arises: when faced with different routing options, which one drivers would prefer to choose? Drivers' route choice could be affected by their experience and habits, and experienced drivers appeared to be more likely to choose the route with less travel time (Prato and Bekhor, 2007). Personalities may also affect route choices, for example, some drivers would like to select the longer but more scenic route to enjoy the driving time, while other drivers who were interested in driving also preferred a longer route (Handy et al., 2005). Female drivers could trade more additional travel time to choose the eco route than male drivers during both work and non-work trips, while drivers from higher-income families also showed greater willingness to exchange extra travel time for lower emissions due to their generally higher levels of education and awareness of environmental problems (Aziz and Ukkusuri, 2014).

Even if drivers initially choose one route recommended by navigation systems, they may still not follow the route while driving. A study reported that 20% of participants did not comply with their planned routes that took up approximately 44% of the total trip distance, and participants who had shorter trip lengths were more likely to deviate from their planned routes (Papinski et al., 2009). Drivers' route compliance was modeled by Radial basis function networks, where independent variables were socio-economic features, expected savings of travel time, and familiarity with road conditions (Dia and Panwai, 2007). Due to this black-box model used in this study, the detailed correlation between these input factors and route compliance behavior could not be further explained. Real-time information and experience-based knowledge may also

make drivers divert to an alternative route while driving (Tawfik et al., 2010; Abdel-Aty and Abdalla, 2004; Ben-Elia and Shiftan, 2010). However, it is still not clear about drivers' route compliance under the eco-routing condition.

This study focuses on assessing and modeling how eco-routing choices from a navigation application would impact drivers' decision making when provided with different sources of information through a field test. Forty-three participants were recruited to receive an Android based phone device pre-installed with an Eco-Routing choice App for 2 weeks and to complete an eco-route choice process prior to beginning a personal driving trip. Machine learning and statistical modeling methods were used in this study to examine participants' route choice and route compliance, both when given the eco-route navigation advice and the long-term effect considering their past route choice preference.

Findings

Findings of the study are introduced in two-folds. The first study identifies contributing factors to a driver's choice of an eco-route when given multiple route recommendations from the navigation application, as well as the compliance to a selected route. The first part also introduces the eco-routing navigation app specifically developed for the study and the studied population. The second part further considers the potential influence of habitual route selection on a driver's instant and long-term compliance to an eco-route navigation advice by incorporating naturalistic driving data before and after interacting with the eco-route navigation application.

Study 1 - Drivers' Route Choices and Route Compliance when Interacting with an Eco-Routing Navigation System

There are two main purposes of the first study based on naturalistic driving data: one is to investigate and predict what kind of route drivers will choose from recommendations offered by eco-routing navigation systems; the other is to explore whether and why drivers will follow the selected route while driving. Influencing factors on drivers' route choices and compliance are examined from three aspects, including driver characteristics, subjective data, and route information. This study hypothesizes that fuel-saving benefits will attract drivers to choose and follow the eco route.

To collect driving and survey data to examine participants' route choices and compliance to eco-route navigation advice, a smartphone based eco-routing application (app) was developed jointly by the Argonne National Laboratory (ANL) and the University of Michigan Transportation Research Institute (UMTRI). As shown in Figure 1, this app was able to recommend three different routes to drivers with varying the time and the fuel consumption on the routes: (1) the eco route: the least energy consumption; (2) the fast route: the shortest travel time; (3) the balanced route: a balance between energy consumption and travel time. The displayed three

recommended routes (eco vs. fast vs. balanced) showed an estimation of the fuel consumption that was calculated considering three main effects: the average velocity, the traffic and the car used. The app could also offer turn-by-turn guidance using the selected route while recording the GPS data gathered along the route. The route and navigation services were provided by the MapQuest API (application program interface). Trip purpose, drivers' vehicle model, passenger information and other relevant information were also collected in the survey through the app at the beginning of each trip (Figure 2).
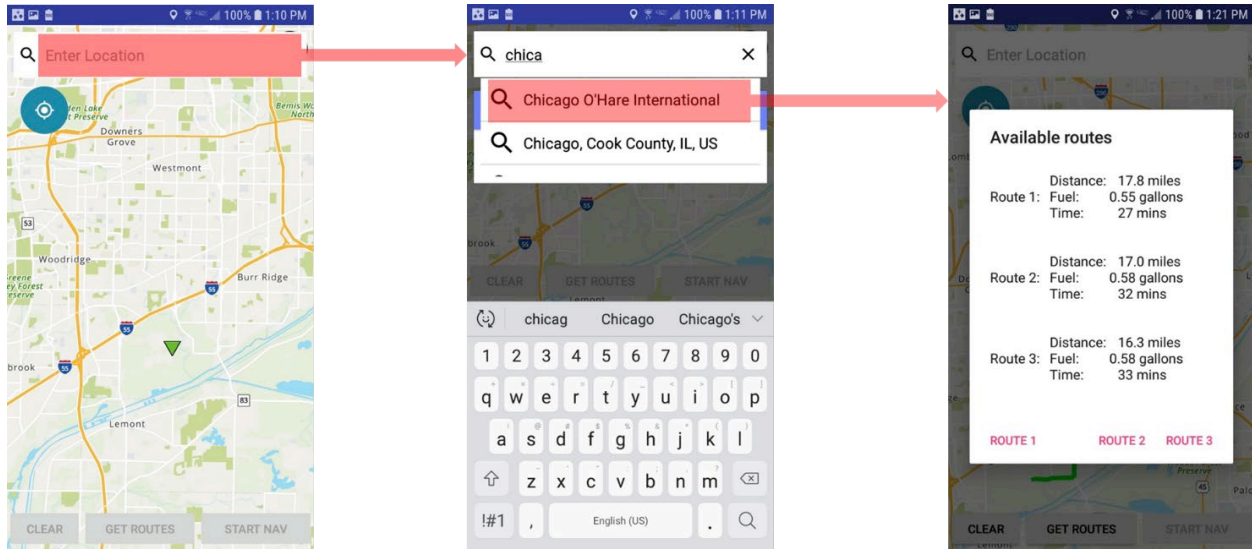

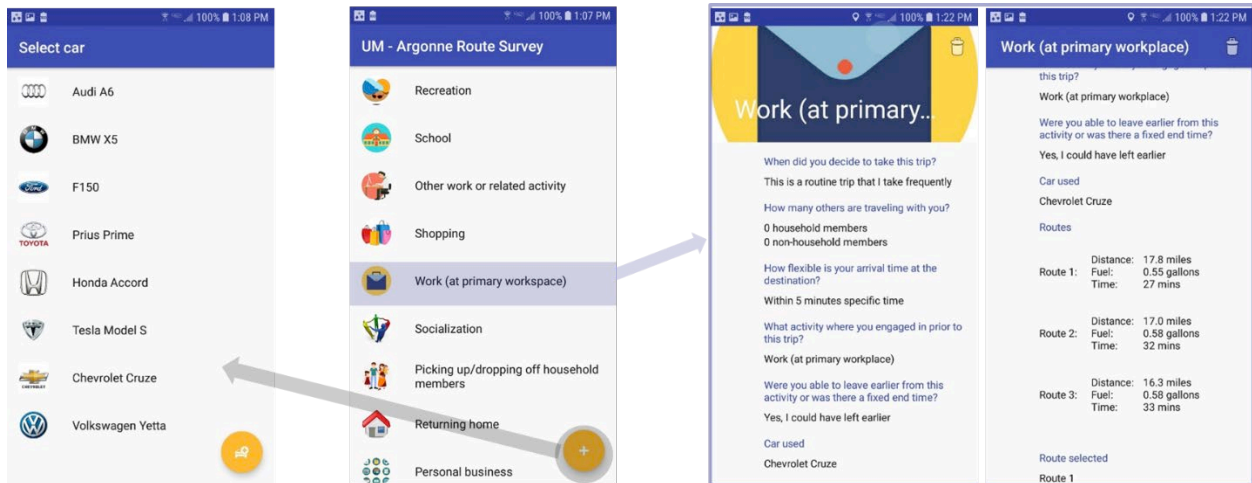Figure 1. Three different routes provided by the eco-routing navigation app

Figure 2. Recording survey data and car types

Forty-three participants with valid driver licenses were recruited and participated in the study from May to June 2019. Each participant received a cell phone handset with the "Eco-Routing" application installed for a period of two weeks. During the two weeks, participants were expected to interact with the app by completing a route-choice survey and selecting from recommended driving routes prior to the beginning of some of their driving trips. Participants received $100 as their participation compensation and were expected to record data for at least 20 trips.

The final dataset for Study 1 contained a total of 737 valid trips from 39 participants, which included the responses to the questionnaire for each trip, information about the selected route, and the GPS data collected on the device for the specific trips. These 39 participants consisted of 22 female and 17 male drivers, aged from 20 to 72 years old (Mean=47.3, S.D.=15.3). In general, drivers were more likely to choose the fast route, having the highest average probability 83.4%, followed by the eco route with a selection probability around 78.6%, while the routes with the balanced feature had the least likelihood to be selected, averagely 70.7% for each driver. Data collected in the study were consistent with national household survey data on trip purposes, with driving back to home accounted for the largest proportion of trip purposes, and the following was driving to work/school. Shopping/errands and social/recreational purposes ranked third and fourth, respectively. Generally, the average probability that drivers would actually follow the route after they chose from the recommended options was 56.7%.

Mixed model analyses were used to investigate the impacting factors on the drivers' eco route choice, i.e., whether the driver would choose the eco route or not. Potential fixed effects were variables from driver demographic characteristics, subjective data, and route information, while individual driver and interactions between individual driver and any fixed effects were chosen as random effects. According to the final model results, distance of a trip had a negative impact on the eco route choice, while average gas consumption of a trip positively affected the eco route choice, indicating that drivers were more likely to select the eco route when this trip had short distance and higher gas consumption per mile. In addition, the route recommendation sequence also had a significant effect on choosing the eco route, and giving priority to recommend the eco route could guide drivers to choose the eco way.

Since each route recommended by navigation systems may have several different features at the same time (e.g., a recommended route is the most fuel-efficient as well as the fast one), drivers' route choices belong to the multi-label problem. Thus, a multilabel random forests (MLRF) model was further applied to predict drivers' route choice as multi-label variable with three candidate features (i.e., eco, fast, and balanced) based on driver demographic characteristics, subjective data, and route information. The final MLRF model was able to achieve a prediction precision greater than 80.0% for all labels. Variables on route information showed the largest impacts on drivers' route choices. That is, distance saving, recommendation sequence, distance, average gas consumption, and the number of recommended routes, ranking the top five of the feature importance. The following were subjective data, such as prior activities, the purposes of

this trip, decision time, etc. However, no obvious relationships were found in demographic data, indicating that drivers' route choices were less likely to be affected by age and gender differences.

Next, mixed model analyses were carried out on the same driver demographic characteristics, subjective data, and route information variables to examine their impacts on drivers' compliance to a selected route, i.e., whether drivers followed the selected route or not. According to the final model results, drivers were more likely to fully drive along the recommended route when chose the eco or fast routes. Additionally, compared with driving alone or with only one household passenger, drivers were more willing to comply with the recommended route when there were three or more household passengers.

Study 2 – Drivers' Instant and Long-Term Compliance to the Eco-Routing Navigation Advice Considering their Past Route Choice Preference

Study 1 examines on drivers' route choice and route compliance to an eco-route navigation advice and mostly focuses on the demographic and trip-level factors, such as drivers' gender and age, trip distance and purpose, and number of household passengers. As mentioned earlier, a driver's route choice could also be affected by his/her experience and habit. The second study thus considers a driver's habitual route choice for a trip, i.e., a specific pair of origin and destination (OD), and the impact of habit on the driver's instant route selection as well as long-term compliance to an eco-route navigation advice.

Since participants of the current study were recruited from participants of the Ann Arbor Connected Vehicle Test Environment (AACVTE) study, the AACVTE naturalistic driving data were extracted for all these participants to understand their route choice before and after using the eco-routing navigation application. More specifically, for each trip a participant made during an eco-route study (i.e., the eco-trip), trips with the same pair of OD (i.e., matched trips) made on a similar day of week (i.e., both on weekday or weekend) and a similar time of day (i.e., both during peak-hour or off-peak hour) were identified and extracted. Difference between the route selection of a matched trip and its corresponding eco-trip was measured by the Dynamic Time Warping (DTW) distance and further converted to a percentile to facilitate the comparison. For this study, the percentile was calculated based on a non-parametric density estimation (kernel density estimation) to account for the fact that the empirical distribution of DTW distance was oftentimes non-normal. The Triandis's Theory of Interpersonal Behavior (TIB) was used as the framework to examine the potential direct and mediating effect of habit on route choice behavior. A mixed-effect beta regression model was applied to examine the influence of an eco-route navigation advice on the driver's route choice both during the trip and afterwards under the TIB framework. The model considered fixed effects on habit- and facilitating-condition-related variables, while used random effects on both participants and eco-trips to account for the "Intention" component of the TIB which cannot be directly measured using naturalistic driving

data. Interaction terms between habit- and facilitating-condition-related variables as well as random coefficients on facilitating-condition-related variables were also considered. Model specification was determined based on leave-one-out cross-validation on the expected log pointwise predictive density.

The final dataset for Study 2 includes 1,940 matched trips of 63 eco-trips from 19 participants (12 females and 7 males) aged between 20 years and 72 years. The final model specification includes treatment status (before, during or after using the eco-routing navigation app), route consistency, and an interaction term between the two variables. Route consistency was a measure of a driver's habitual route choice, defined as the standard deviation on DTW distances for a group of matches of the same eco-trip before the study. Figure 3 shows the marginal effects of DTW distance percentile by treatment status and route consistency, with smaller percentile values representing a route choice closer to the recommended eco-route by the navigation app. It can be observed that, for a specific pair of OD, drivers' route choice were in general very similar before, during or after using the eco-routing navigation app, indicating a strong impact of the habitual route choice on the compliance of following an eco-route. Nevertheless, a significantly lower DTW percentile can be observed during the eco-trip when route consistency was within the highest 25% group. This suggests that if drivers did not have a strong habitual route selection, i.e., they took different routes from time to time, they were more likely to follow the recommended eco-route during the eco-trip, and the lower percentile might be maintained even after the study.
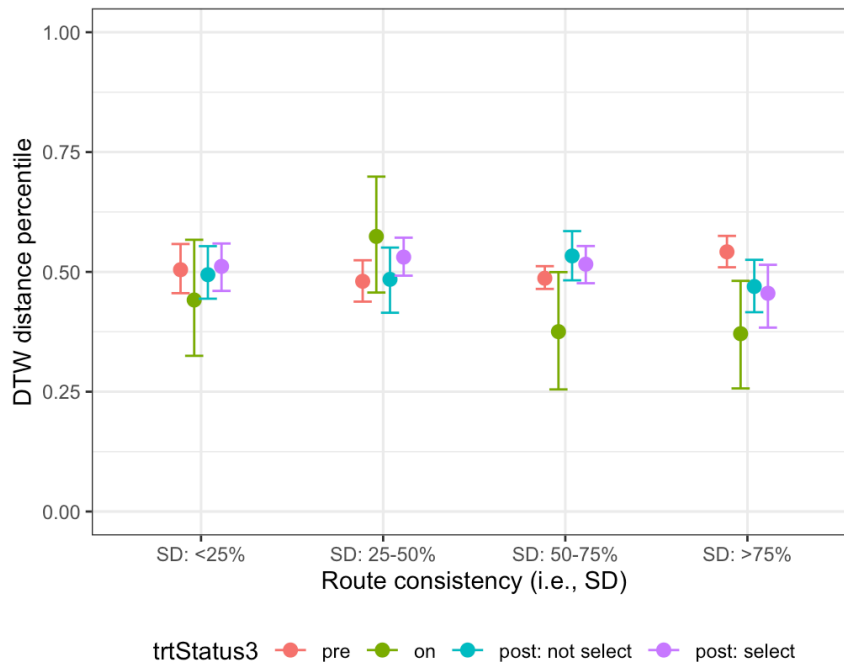

Figure 3. Marginal effects of treatment status & route consistency on DTW distance percentile (error bar representing the 95% HPD)

Recommendations

This study applies machine learning and statistical modeling method on field test data to examine how eco-routing navigation advice would impact drivers' decision-making when provided with different sources of information, and the potential influence of their habitual route preference on the decision-making process. This section summarizes the recommendations based on the study results in terms of the design of eco-routing navigation application and/or relevant education programs to improve drivers' selection and compliance to a more eco-friendly route choice.

Results of the mixed model analyses in Study 1 showed that drivers were more willing to choose the eco route when this trip had shorter distances and higher gas consumption per mile. It was also found that prioritized recommendations for the eco route could make drivers prefer to choose the eco route. An earlier study also reported that the relationship between the fuel saving and trip distance was significantly positive when the distance was not greater than 10 miles, while this kind of relationship became non-significant with a trip distance longer than 10 miles (Boriboonsomsin et al., 2014). A navigation application may thus want to prioritize the recommendation of an eco-route especially for shorter trips. The application may provide the incentive information based on the users' primary consideration of selecting an eco-route. For example, for users who prioritize on fuel saving, the information could be how much gas will be saved by following an eco-route and/or convert the gas consumption to a monetary value (e.g., how much dollars saved) to offer a more direct incentive to the user. For users who prioritize on protecting environment, the application could emphasize on the total emission reduced by using an eco-route.

One challenge of improving drivers' choice and compliance to an eco-route is the strong impact of their habitual choice behavior on their current route choice. More specifically, drivers were very unlikely to change their route selection when a strong habitual choice behavior already exists. A study on context change and travel mode choice utilized a habit discontinuity hypothesis, and found that for environmentally-concerned individuals, context change can activate their ecological values and beliefs and guide them to (re)negotiate sustainable behaviors (Verplanken et al., 2008). Their study thus suggests an intervention being given with the disruption of a context, e.g., when the individual has recently moved. In terms of the design of eco-routing navigation systems, this would be to prioritize the eco-route advice when an individual has recently moved, or in more general cases when a new pair of OD being searched. Behavioral change or habit formation requires at first the intention to perform a specific behavior, the decision to act following the intention, and a repeat of the behavior which often requires continued motivation (Lally and Gardner, 2013). Education programs targeting environment protection especially from the perspective of surface transportation will help to improve individuals' awareness of emerging environmental issues and their intention to drive in a more eco-friendly way. Navigation applications could also be designed to assist users and to

enhance their progression through the different stages of forming an eco-friendly route choice habit, e.g., by providing users how much fuel has been saved recently as a reminder or an incentive and to develop route choice alternatives considering both emission and travel time to cope with users' time constraints.

One limitation of this study is that the real-time traffic condition after selecting the route was not included in the analysis of route compliance. In the future, real-time information about energy consumption and traffic condition changes while driving can be provided in the calculation of the eco-routing option, so that corresponding driver behavior can be further analyzed. Another limitation is that information regarding drivers' intention of following an eco-route was not captured in the survey. Future studies may want to collect the intention information to better predict drivers' route choice behavior, as well as to serve as a foundation for the development and test of different intervention methods to enhance the selection and compliance to an eco-route navigation advice.

Outputs, Outcomes, and Impacts

Outputs

- Publication: Bao, S., Yu, B., Li, Z., Rask, E. M., Liu, H. X., & Sayer, J. (2022). Modeling Drivers' Route Choices and Route Compliance When Interacting with an Eco-Routing Navigation System. Available at SSRN: https://ssrn.com/abstract=4046357 or http://dx.doi.org/10.2139/ssrn.4046357.
- Phone application: "Eco-Routing", an Android-based navigation application. This application has been deactivated and is unavailable per the Data Management Plan.
- Invited Presentation: "How Vehicle Connectivity Based Eco-Routing Choices Will Impact on Driver Decision Making", hosted by USDOT Center for Connected and Automated Transportation, 2020.6.2.
- Seminar Talk: "Eco-routing Choices and Driver Decision Making", Seminar talk at the Civil and Environmental Engineering department, University of Michigan-Ann Arbor, Oct 1st, 2020.

Outcomes

- Demonstrate the design and usage of phone-based eco-routing navigation applications
- Increase the understanding of drivers' route choice and compliance when interacting with eco-routing navigation applications
- Reveal the influence of habitual route choice preference on drivers' instant and long-term compliance to an eco-route navigation advice

Impacts

- Improve the design of eco-routing navigation systems to motivate eco-routing choices
- Guide the education program to increase drivers' awareness of eco-routing options and to

enhance the habit formation of eco-friendly route choice behaviors

- Contribute to the long-term effect on public awareness of energy consumption and the achievement of an eco-friendly transportation system

Reference

Abdel-Aty, M., & Abdalla, M. F. (2004). Modeling drivers' diversion from normal routes under ATIS using generalized estimating equations and binomial probit link function. *Transportation, 31*(3), 327-348.

Ahn, K., & Rakha, H. (2008). The effects of route choice decisions on vehicle energy consumption and emissions. *Transportation Research Part D: Transport and Environment, 13*(3), 151-167.

Ahn, K., & Rakha, H. A. (2013). Network-wide impacts of eco-routing strategies: A large-scale case study. *Transportation Research Part D: Transport and Environment, 25*, 119-130.

Aziz, H. A., & Ukkusuri, S. V. (2014). Exploring the trade-off between greenhouse gas emissions and travel time in daily travel decisions: Route and departure time choices. *Transportation Research Part D: Transport and Environment, 32*, 334-353.

Ben-Elia, E., & Shiftan, Y. (2010). Which road do I take? A learning-based model of route-choice behavior with real-time information. *Transportation Research Part A: Policy and Practice, 44*(4), 249-264.

Boriboonsomsin, K., Dean, J., & Barth, M. (2014). Examination of attributes and value of ecologically friendly route choices. *Transportation Research Record, 2427*(1), 13-25.

Dia, H., & Panwai, S. (2007). Modelling drivers' compliance and route choice behaviour in response to travel information. *Nonlinear Dynamics, 49*(4), 493-509.

EPA. (2019). U.S. *Transportation Sector Greenhouse Gas Emissions: 1990–2017.* Office of Transportation and Air Quality EPA-420-F-19-047.

Handy, S., Weston, L., & Mokhtarian, P. L. (2005). Driving by choice or necessity?. *Transportation Research Part A: Policy and Practice, 39*(2-3), 183-203.

Lally, P., & Gardner, B. (2013). Promoting habit formation. *Health Psychology Review*, *7*(sup1), S137–S158. https://doi.org/10.1080/17437199.2011.603640

Papinski, D., Scott, D. M., & Doherty, S. T. (2009). Exploring the route choice decision-making process: A comparison of planned and observed routes obtained using person-based GPS. *Transportation Research Part F: Traffic Psychology and Behaviour, 12*(4), 347-358.

Prato, C. G., & Bekhor, S. (2007). Modeling route choice behavior: How relevant is the composition of choice set?. *Transportation Research Record, 2003*(1), 64-73

Salvi, B. L., & Subramanian, K. A. (2015). Sustainable development of road transportation sector using hydrogen energy system. *Renewable and Sustainable Energy Reviews, 51*, 1132-1155.

Tawfik, A. M., Rakha, H. A., & Miller, S. D. (2010, September). An experimental exploration of route choice: Identifying drivers choices and choice patterns, and capturing network evolution. In *13th International IEEE Conference on Intelligent Transportation Systems* (pp. 1005-1012). IEEE.

Verplanken, B., Walker, I., Davis, A., & Jurasek, M. (2008). Context change and travel mode choice: Combining the habit discontinuity and self-activation hypotheses. *Journal of Environmental Psychology, 28*(2), 121–127. https://doi.org/10.1016/j.jenvp.2007.10.005

Wang, J., Elbery, A., & Rakha, H. A. (2019). A real-time vehicle-specific eco-routing model for

on-board navigation applications capturing transient vehicle behavior. *Transportation Research Part C: Emerging Technologies, 104,* 1-21.

Zeng, W., Miwa, T., & Morikawa, T. (2017). Application of the support vector machine and heuristic k-shortest path algorithm to determine the most eco-friendly path with a travel time constraint. *Transportation Research Part D: Transport and Environment, 57*, 458-473.

Zhao, Y., Yao, S., Liu, D., Shao, H., & Liu, S. (2019, June). GreenRoute: A Generalizable Fuel-Saving Vehicular Navigation Service. In *2019 IEEE International Conference on Autonomic Computing (ICAC)* (pp. 1-10). IEEE