The impact of Eco-Feedback on sustainable driving behavior: A case study with car2go in Vancouver

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1 ABSTRACT

Providing numerous benefits including environmental effects, carsharing has emerged as a positive societal initiative changing mobility patterns. Recently, car makers and carsharing companies started implementing Eco-feedback technologies in order to influence the individual environmental impact of their drivers. With this paper we present a comparative analysis of empirical data contrasting the fuel consumption of car2go's members before and after the implementation of an Eco-feedback system titled *EcoScore*. Although being able to detect a decrease of fuel consumption, due to limitations within the received data set, no major conclusions could be drawn, only suggestions for future research.

Keywords

car-sharing; mobility pattern; driving behavior; sustainability; eco-friendly; Eco-Feedback, Eco-ScoreBefore-After-Control-Impact; empirical study;

2 INTRODUCTION

Carsharing has emerged as a societal initiative to change mobility patterns and encourage sharing. Studies have shown that carsharing can provide numerous transportation, land use, environmental, and social benefits [Shaheen et.al. 2008]. People waive private vehicle ownership, which saves resources, fewer cars are on the road, which leads to less traffic, and less greenhouse gas emissions (GHG) occur. According to the Environmental Protection Agency [EPA 2007] the transportation sector is responsible for 33 per cent of the annual U.S. GHG.

There are two different models of carsharing systems. Depending on the model of carshare, members pay by the minute (car2go), or hourly and daily (traditional model). Companies offering the traditional model, such as zipcar and modo - the car co-op, give their members access to different cars that have permanent spots from which they need to be picked up and returned to. Whereas in the free-floating model, which was introduced by car2go in 2008, access is provided to vehicles that can be picked up and returned anywhere in an operating area.

Fig. 1: car2go vehicle in Vancouver (Source: http://www.metronews.ca)

There has been a debate on the economic impact of the free-floating carshare model. However, Firnkorn and Müller highlighted that free-floating carsharing systems do contribute to the environmental benefits of carsharing by reducing private vehicle ownership in cities and reaching a larger group of people than companies offering the traditional model of carsharing [Firnkorn and Müller 2011].

The success of carshare ventures relies on viable business models and good urban planning policies, yet an overall strategy is ultimately reliant on individual decision making of consumers. Research has been addressing the understanding of persuasion for sustainable behaviour changes, specifically in the thematization of sustainable interaction design and persuasive technologies.

Sustainable HCI and Sustainable Interaction Design (SID) have rapidly evolved since Blevis articulated sustainability as a central focal point of interaction design and that way situated SID as a focus within HCI [Blevis 2007]. DiSalvo et al. substantiate those enunciations by defining the research field of sustainable HCI through an empirical analysis of literature [DiSalvo et al. 2010]. Among their established genres in the area they articulated persuasive technologies as an important topic, covered by almost half of their reviewed literature. 45% of the literature that was declared to concern persuasive technologies goes back to Fogg's theory, which focuses on the understanding of human behavior and

attitude changes resulting from HCI [Fogg, 2009]. Fogg introduces the term 'captology' (an acronym emerged from the phrase “computers as persuasive technologies”). "[C]aptology focuses on the design, research, and analysis of interactive computing products created for the purpose of changing people’s attitudes or behaviors."[Fogg, 2002 p.5]

Persuasive technology and eco-feedback technology, what can be seen as an extension of the former in the environmental sector, draw on decades of research in human psychology, behaviour change, persuasion and environmental psychology [Fogg, 2003 and Froehlich, Findlater, and Landay, 2010].

Persuasive technologies for environmental behaviour change, such as Eco-feedback technologies have also been implemented in cars in the last couple of years. Honda has been implementing Eco-Scores since 2009, Mercedes presented their first Eco-Score system in 2011 in their research vehicle F 800 Style, and Toyota introduced a system in their Prius in 2012. Car2go, a subsidiary of Daimler, is currently implementing an Eco-Score system into their carshare vehicles, intending to motivate their members to employ more environmental-friendly driving styles. Pierce, Odom and Blevis surveyed Eco-feedback-technologies and Eco Visualizations [Pierce, Odom and Blevis, 2008]. They defined feedback types and use-contexts for classifying interactive, persuasive Eco-visualization systems and furthermore strategies to provide guidelines for designing those systems effectively.

With this paper we present a study that tries to analyze car2go's approach of changing their members driving behaviour with a newly implemented *EcoScore* system. Through a comparative analysis of empirical data received from the vehicles we contrast the fuel consumption of car2go's members before and after the implementation of the EcoScore. With the results of this study we aim to draw conclusions stating the impact of car2go's Eco-Score.

3 METHODS

Through a collaboration with car2go Vancouver we received two data sets that let us survey the fuel consumptions of their rentals. In this paper we present a Before-After-Control-Impact (BACI) study investigating the impact of car2go's EcoScore on their members fuel consumption.

3.1 car2go's EcoScore

The EcoScore monitors how environmentally friendly car2go members drive by measuring the accelerations, the overall driving style, and the decelerations. Each of those three categories is represented by a scored value of for environmentally friendly driving behaviour and a tree representing that value through growth and surroundings including birds and squirrels (see Fig.3a,b). The first tree has a value which increases through slow and smooth accelerations, the second tree’s through calm and consistent overall driving, and the third tree through conscientious driving allowing more coasting and less use of energy. Regardless of a score, if a member drives extremely poor a warning message will be displayed, asking the driver to adapt the driving style (see Fig. 3b). In Vancouver, the EcoScore was implemented in the last week of April 2012.

Fig. 2: The EcoScore in a car2go vehicle. (Source: http://www.topspeed.com)

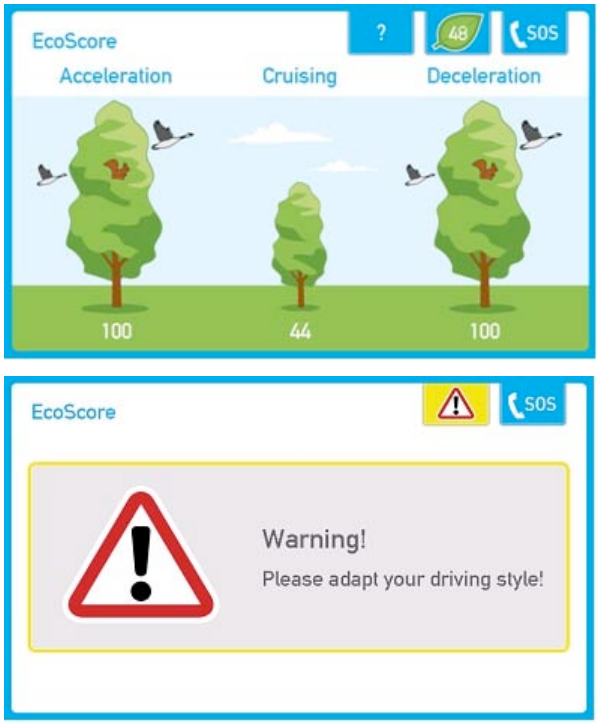

Fig. 3a, b: Screens of EcoScore. (Source: http://blog.car2go.com)

3.2 The data

Due to reasons of confidentiality, the actual EcoScores of the members cannot be saved and analyzed by car2go. Nevertheless, car2go is able to save data from their cars, that give an insight on the fuel-efficiency of individual rentals.

rental ID	userID	distance (km)	fuel level (Start%)	fuel level (end%)	car	from date/time	to date/time	duration (hh:mm)	fuel consumption (%)	fuel consumption (l)
3238968	210714	7	15	12	986WDR	06/25/16 11:18	06/25/16 11:38	0:21	3	0.99
3219431	110689	5	57	54	989WDR	06/23/16 23:24	06/23/16 23:36	0:12	0	0.00
3222651	220250	4	54	54	989WDR	06/24/16 5:49	06/24/16 6:04	0:15	3	0.99
3153643	209428	8	27	24	987WDR	06/19/16 8:05	06/19/16 8:21	0:16	3	0.99
3201668	220250	16	81	69	989WDR	06/22/16 19:21	06/22/16 19:56	0:35	12	3.95

Fig. 4: An extract from our data sets with each row showing information of one rental including rentalID, UserID, distance in km, fuel level before and after the rental, car ID, time window and calculated fuel consumption.

The data sets we received directly from car2go monitored all rentals of 15 randomly picked cars for two weeks, one week before the implementation of the EcoScore and one after. The data tables listed a rental identification (ID) number, a driver ID number (not the actual member number), distances, fuel levels (before and after each rental), the cars license plate number as an ID, and the time window and duration of each rental (see Fig.4). Another table showed the registered fuel refills of the car2go fleet. Due to reasons of confidentiality, no information on the individual drivers such as gender or age was available.

The first data set monitored the rentals of a week of the 15 selected cars in March 2012 (12th - 19th) and the second one rentals of a week of the same 15 cars in June 2012 (11th - 18th), leaving the members a bit more than a month to get used to the new technology.

After cleaning out rentals in which the cars tank was filled, we ended up with 587 usable data sets of rentals in the first week and 576 in the second week.

3.3 Participants

Car2go Vancouver currently has about 10.000 members. 62 % of them are female and 38 % are male. 10 % of the members age from 18 to 25, 42 % from 26 to 35, and 31 % from 36 to 49.

Through the membership agreements, members give their consent to let car2go save certain data, which includes the data that is used in this study. Members did not explicitly know about this study and the data gathering for this research. Therefore, they were completely naive.

3.4 Defining Variables

The dependent variable in this study is represented by the fuel consumption per 100km of a rental, which can be calculated with the data we received using a rentals distance and its fuel levels before and after the ride. The independent variable in this study is the implementation of the EcoScore in the car share vehicles, which is a change in the drivers environment.

BACI studies, which are primarily used in environmental studies, have a lack of genuine control.

Beside the EcoScore other confounding factors that could not be controlled could have influenced the driving behaviour of the members as well. These are the gender, age and individual stress level of a driver; the time of the day a rental was done, the weather conditions during a rental, the time of the month, and individual attitudes of members regarding finances, because the price of a rental goes by the minute.

However, those factors were tried to be kept as identical as possible. Both monitored weeks were in the first half of a month. The weather conditions were slightly different, as it was a little warmer in June than in March.

3.5 Experiment Procedures

A paired-samples t-test was conducted to compare the means of 15 car2go cars (n=15) before and after the implementation of the EcoScore. Within each of our two data samples we calculated the mean fuel consumptions of each car and then of all 15 cars to compare it with the result of the second data sample. For our test analysis we used jmp as a statistics software.

4 RESULTS

The mean fuel consumption of the rentals of 15 car2go cars (n=15) before the implementation of the EcoScore is 9.13 liter per 100km (or 3.88 gallons (US) per 100miles). The mean fuel consumption of the rentals of those 15 car2go cars (n=15) after the implementation of the EcoScore is 8.64 liter per 100km (or 3.67 gallons (US) per 100miles). There was not a significant difference in the means of fuel consumption before (M=0.29, SD=1.08) and after (M=0.49, SD=1.83) the implementation of the EcoScore; $t(26)=-0.87$, $p=0.39$.

4.1 The Analysis

Although we are able to detect a decrease of 0.49l/100km (or 0.21gallons(US)/100miles) of fuel consumption from week one to two, it is not significant ($p > 0.05$) (see Fig.4).

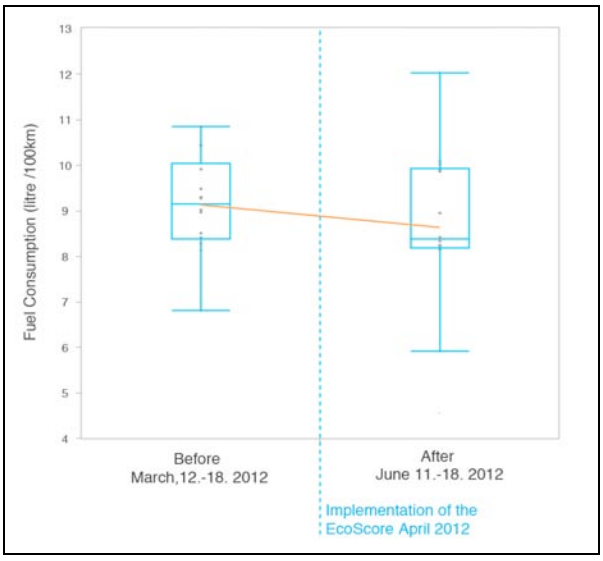

Fig. 4: Comparison of the mean fuel consumption of 15 car2go cars (n=15) before and after implementing the EcoScore.; paired sample t-test, df = 21.09, p = 0.39.

4.2 Limitations

Overall, the accuracy of the data was questionable and we detected a lot of noise in the data. Although we can assume the random noise in both sets is the same, we found the fluctuation in the data was very strong. The decrease that we were able to detect in the final test result could not be observed consistently when looking at the individually calculated fuel consumptions of each car (see Fig.5). Even though 9 from 14 sets of fuel consumption values decreased, the values strongly fluctuated, which could be due to noise in the data sets.

Moreover, the majority of rentals had a distance between one and five kilometres, which also means that the fuel consumption was minimal and therefore difficult to read. However, even trying to leave out rentals with distances less than 6km or with no detected fuel consumption did not deliver significant results either.

Another limitation could have been the low number of cars used in our study with only 15 cars surveyed.

Lastly, the fuel consumption measured (9.13 and 8.64l/100km) seems much higher than what car2go stated as the smart cars are supposed to have: City 5.8l/100km, Highway 4.7l/100km, and Combined 5.3l/100km.

data set 1	
Car	l/100km
985WDR	8.28
986WDR	8.14
987WDR	9.28
989WDR	9.02
990WDR	8.97
991WDR	9.48
992WDR	8.51
993WDR	10.85
994WDR	8.41
995WDR	10.46
996WDR	9.92
997WDR	10.43
998WDR	6.82
999WDR	9.30
	Average 9.13

data set 2	
Car	l/100km
985WDR	8.20
986WDR	10.02
987WDR	8.96
988WDR	9.87
989WDR	10.09
990WDR	5.92
991WDR	8.42
992WDR	8.23
993WDR	8.15
994WDR	8.34
995WDR	4.56
996WDR	8.25
997WDR	12.04
998WDR	9.90
	Average 8.64

Fig. 5: Calculated mean fuel consumptions of 15 surveyed cars before (left) and after (right) implementing the EcoScore.

5 DISCUSSION AND CONCLUSION

Although the study showed a tendence towards a minimal reduction of fuel consumption in Vancouver's car2go's after the implementation of the EcoScore, due to several limitations, we cannot draw the conclusions intended from our test results. Therefore, we can neither reject nor confirm our hypotheses.

After conducting the presented study, we assume that the reading mechanism of the fuel levels in the cars is not accurate enough to produce valuable data sets that can be used to make strong assumptions about the driving behaviour of members.

For future research, we suggest to get long-term data from more vehicles and additional access to detailed re-fuelling data with information about the amount of gas for double-checking fuel consumption data. Furthermore, qualitative data will be a suggested addition. For example, conducting a questionnaire with members of car2go, would lead to more insights in the cognition of the EcoScore system.

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