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Evaluation of Driving Behavior and Attitude towards Eco-Driving: A Southern California Case Study

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Introduction and Data Collection

Among several strategies to reduce greenhouse gas emissions from motor vehicles, "eco-driving" is one that had not received much attention in the United States until recently. The basic idea of any eco-driving program is to provide drivers with a variety of advice and feedback to minimize fuel consumption (and emissions) while driving. This study evaluated how an on-board eco-driving device that provides instantaneous fuel economy feedback affects driving behavior, and the resulting fuel economy, of a limited number of gasoline-engine vehicle drivers under real-world driving conditions.

Driving data were collected from 20 participating drivers in Southern California *[Table 1]*, 2 weeks without an on-board eco-driving device and another 2 week with the device. The device is connected to the on-board diagnostic (OBD)-II port and reads vehicle and engine parameters from the CAN bus. The parameters were used to estimate instantaneous fuel economy and carbon dioxide emission, which were displayed to the driver on the screen in a color scheme from red (poor) to green (good) *[Figure 1]*.

At the end of the data collection period, the participants were asked to complete a survey about their attitude and likelihood towards adopting eco-driving practices.

Figure 1. Eco-driving device used in the study

Table 1. Description of participating drivers and their vehicles

Driver		Vehicle				EPA's Fuel Economy Rating		
No.	Gender	Make	Model	Year	Transmission	City	Highway	Combined*
1	F	Subaru	Impreza	2008	Automatic	20	27	23
2	M	Toyota	Sequoia	2005	Automatic	14	17	15
3	F	Nissan	Murano	2006	Automatic	18	23	20
4	F	Honda	CRV	2007	Automatic	20	27	23
5	M	Scion	tC	2005	Automatic	20	27	23
6	F	Toyota	Camry	2009	Automatic	21	31	26
7	M	Honda	Pilot	2007	Automatic	16	22	19
8	F	Lexus	RX330	2006	Automatic	17	23	20
9	F	Toyota	Sienna	2007	Automatic	17	24	20
10	M	Toyota	Tundra	2005	Automatic	14	17	15
11	F	GMC	Yukon XL	2007	Automatic	14	20	17
12	M	Toyota	Tundra	2005	Automatic	14	17	15
13	F	Ford	Expedition	2007	Automatic	12	18	15
14	M	Volvo	S60	2006	Automatic	19	27	23
15	M	Honda	Civic	2006	Manual	26	34	30
16	F	Toyota	Camry	2005	Automatic	21	31	26
17	F	Chevy	Silverado	2003	Automatic	14	19	16
18	F	Kia	Rio	2007	Manual	27	32	29
19	M	Chevy	Cobalt	2006	Automatic	21	29	25
20	M	Toyota	Solara	2002	Automatic	21	30	25

Source: http://www.fueleconomy.gov/
**EPA assumes 55% city driving and 45% highway driving.*

Driving Behavior Results

The collected driving data include vehicle position and speed (via GPS) as well as fuel consumption rate (through OBD interface) every 2 seconds. The data were filtered for quality assurance and later map-matched to differentiate between city and highway driving. Then, vehicle specific power (VSP), in kW/metric ton, for each data record was calculated as:

$$\mathrm{VSP} = v \cdot (1.1a + 0.132) + 0.000302 \cdot v^3$$

where v is vehicle speed (m/s) and a is vehicle acceleration (m/s^2). After that, the average fuel consumption rate for each VSP bin was determined *[Figure 2]*. These average fuel consumption rates were used to estimate the fuel economy both without and with the eco-driving device based on vehicle speed and acceleration alone. This normalization methodology is aimed at removing the possible effects of other factors (e.g. weight, road grade, weather) on the real-world fuel economy without and with the device.

The results shows that the changes in fuel economy for individual drivers vary *[Figure 3]*. For city driving, the changes range from -5% to +24%, with an average of 6%. For highway driving, they range from -12% to +13%, with an average of 1%.

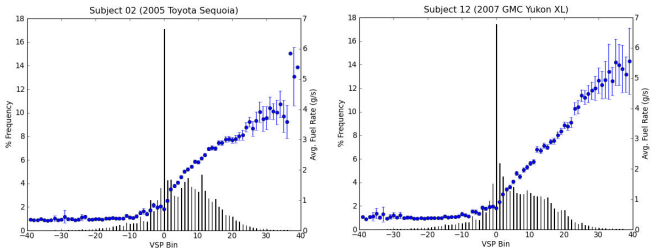

Figure 2. Fuel consumption rates for each VSP bin for two different vehicles

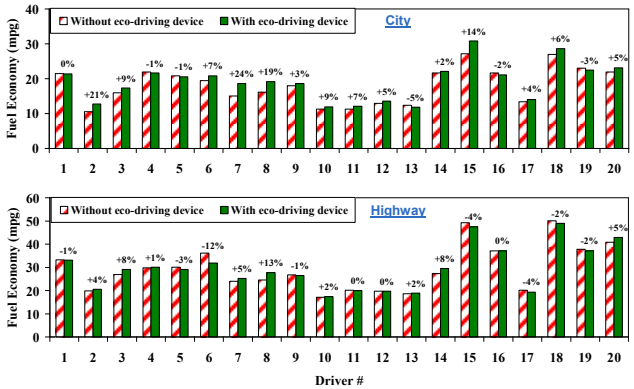

Figure 3. Comparison of fuel economy without and with eco-driving device

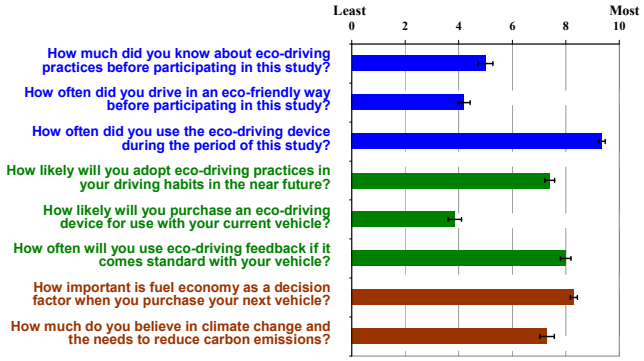

Figure 4. Participants' responses regarding background and attitude towards eco-driving

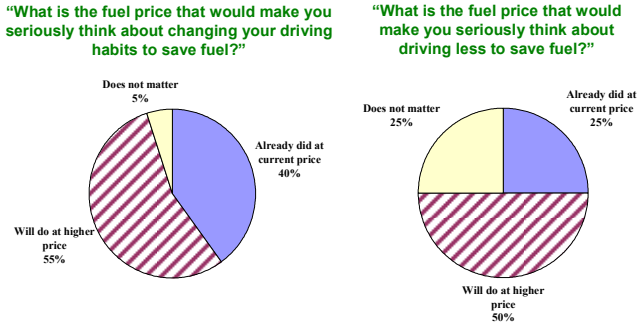

Figure 5. Effect of fuel prices on willingness to change driving behaviors

Attitude Survey Results

According to the survey responses, the participating drivers did not often drive in an eco-friendly manner (mean score of 4.2), but are willing to adopt eco-driving practices in the near future (mean score of 7.4) *[Figure 4]*. In fact, 40% of them have already practiced eco-driving *[Figure 5]*, which may be one of the reasons for the relatively low fuel economy improvements found in this study. For this group of drivers, the eco-driving adoption rate could go up to 95% if the gasoline price increased to $4.4 per gallon.

Additional research is needed at a larger scale and for a longer time period to better understand the impact of on-board eco-driving devices on driving behavior and vehicle fuel economy.

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