

# A Study of Fuel Consumption Reduction Effect of Eco-Driving

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## 1 Introduction

Eco-driving is considered to be effective to improve the fuel efficiency and is being promoted in various ways. One of the representative activities in Japan is “10 tips for fuel-conserving Eco-Driving” promoted by Team Minus 6% [1]. “10 tips for fuel-conserving Eco Driving” recommends the driver’s techniques such as a soft starting with gentle acceleration, called “e-start”, and driving without excessive accelerating and decelerating. In this paper, such driving techniques are collectively referred to as Japanese eco-driving. On the other hand, in Europe especially in Germany, the driving technique to accelerate quickly to reach the fuel efficient range as fast as possible, which differs from Japanese eco-driving, is being widely implemented as eco-driving [2]. This driving technique is called German eco-driving. The biggest difference between Japanese and German eco-driving is how to accelerate when the vehicle starts moving. This study aims to evaluate quantitatively the difference in the fuel consumption rates during driving between Japanese eco-driving and German eco-driving.

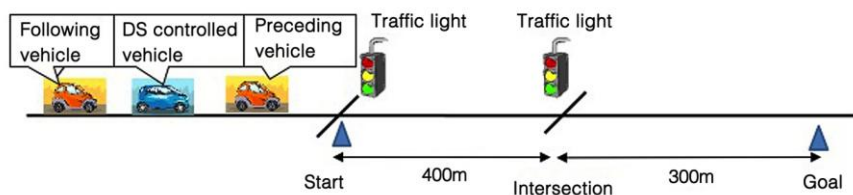


Figure 1. Summary of experiment scenario

## 2 Experimental overview and Results

In this experiment, the travel time from the starting point to the goal in experimental scenario of Figure 1 was compared between the normal driving, Japanese eco-driving and German eco-driving.

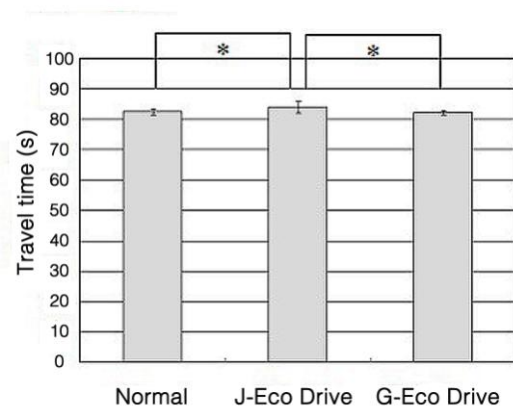


Figure 2. Comparison of travel time (n=25)

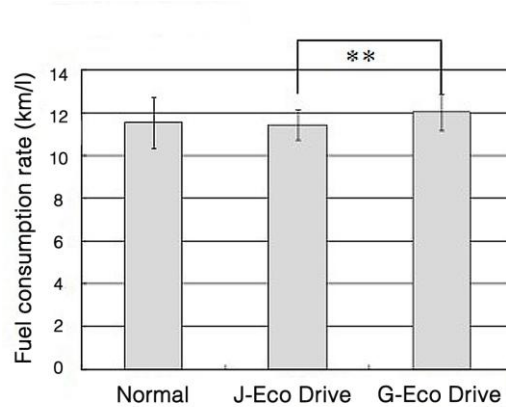


Figure 3. Comparison of fuel consumption rate with each driving technique (n=25)

Figure 2 shows that the travel time with Japanese eco-driving is longest of all and is longer than that with normal driving by 1.8% (1.4 s), and than that with German eco-driving by 2.1% (1.8 s) ( $p < 0.1$ ). Why the travel time with Japanese eco-driving is the longest of all is considered to be due to “e-start” which accelerates gently, one of the characteristics of Japanese eco-driving. On the other hand, there is no statistically significant difference in the travel time between German eco-driving which accelerates as fast as possible and normal driving. Based on these findings, the comparisons of German eco-driving and Japanese eco-driving with regard to the way of accelerating reveal that “e-start” used in Japanese eco-driving affects travel time more.

Figure 3 indicates that the fuel consumption rate with German eco-driving is 4.1% (0.48 km/l) higher than that with normal driving, and also that of Japanese eco-driving is 0.87% (0.1 km/l) lower than that of normal driving. However, no statistically significant differences were observed in these results. It is shown that the fuel consumption rate with German eco-driving is 5.1% (0.56 km/l) higher than that of Japanese eco-driving ( $p < 0.05$ ). In general, it is said that driving with Japanese eco-driving would reduce the fuel consumption rate compared to normal driving. However, the results of this experiment do not indicate that Japanese eco-

driving, which minimizes accelerating and decelerating, will reduce the fuel consumption rate when the intervals between intersections are short. Next, we define the state with 1) no accelerator pedal input nor brake pedal input and 2) a negative acceleration as the coasting state. The ratio of coasting state, which is the proportion of the driving time in the coasting state to the total travel time, is calculated.

### **3 Conclusion**

In this study, the fuel consumption rates with normal driving, Japanese eco-driving and German eco-driving on a straight open road were compared quantitatively using TS/DS integration, which enables the performance of experiments repeatedly under the same conditions. The result indicated that German eco-driving reduced the fuel consumption rate by approximately 4% compared to Japanese eco-driving. In addition, there were no statistically significant differences between normal driving and Japanese eco-driving or German eco-driving. This result suggests that Japanese eco-driving would not be always helpful to reduce the fuel consumption rate if the distance from the start to stopping is shortened due to a traffic signal, or other reasons. Furthermore, the relationship between velocity and acceleration and between velocity and inter-vehicle distance were shown focusing on the difference in the driving behavior with each eco-driving. The result suggested that acceleration tends to be less overall with Japanese eco-driving and that brake pedal input tends to be less on the whole with German eco-driving. With regard to the inter-vehicle distance, the result shows that Japanese eco-driving creates the distance about twice as long as that by normal driving.

In the future, we intend to study quantitatively the effect of eco-driving on the whole traffic flow in case of the traffic of a high volume. We also intend to study in detail the difference between those subjects who drive with eco-driving techniques routinely and those who don't, by performing an experiment with an increased number of subjects. Furthermore, we plan to try a new condition of experiment where a DS controlled vehicle is driven while reading the movement of the preceding vehicle in order to drive in the most fuel efficient manner.

### **References**

- [1] The Eco-Drive Promotion Liaison Committee, "10 tips for fuel-conserving Eco Driving", 2005.
- [2] Ford-Werke GmbH, "Ford Eco-Driving Kompakt", <http://www.ford-eco-driving.de/>