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Short-term effects of training in economical driving: Passenger comfort and driver acceleration behavior

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Abstract

A field study was undertaken to determine whether bus passenger comfort is influenced by driving style, especially the difference expected to occur after training of drivers in economical (fuel efficient) driving. Data was gathered by the means of a passenger questionnaire, distributed on board city buses, as well as by measuring the mean acceleration and deceleration levels of the drivers during the same trips, before and after training. Therefore, the subjective views of the passengers could be compared to objective acceleration data. It was found that after training of drivers, which resulted in very small changes in driving style, passengers experienced their bus riding as slightly more uncomfortable, noisy, jerky and dangerous. These dimensions were also found to be strongly intercorrelated, and determined to a part by the behavior of the drivers. The reason for the change could be that the drivers had only used one facet of the fuel-efficient driving style; strong accelerations. However, the driving en route was still rather different from that taught during training, i.e. there was very little change, if any. From the correlations between comfort ratings and acceleration and deceleration, it may be predicted that a full-blown fuel-efficient driving style would result in a worse experienced comfort. Given these results, training in fuel-efficient driving for drivers of commercial vehicles who carry passengers should not stress the acceleration part.

Keywords: Bus driver; Passenger comfort; Acceleration; Deceleration; EcoDriving

1. Introduction

In the new, environmentally friendly thinking that is spreading through Europe, transportation problems loom large. The carrying of people and cargo around seem to be one of the main polluters in our society, and much work is therefore undertaken to lessen the emissions from vehicles. This seems mostly to be achieved through development of technical solutions. However, there is also another way of reducing some emissions as well as fuel consumption; the training of drivers in economical driving styles.

This approach seem to have been most thoroughly developed and implemented in the Netherlands, Switzerland, Germany, Finland and Sweden (see for example ecodrive.org; Siero et al., 1989; van de Burgwal and Gense, 2002). However, although the practical teaching side of fuel-efficient driving is fairly well developed and unified,[1] the research on effects of training is scant. What is well known is that driving style heavily influences fuel consumption (Nader, 1991; Ericsson, 1999), and many people can achieve reductions of 20 percent or even more in fuel consumption during training sessions (Laurell, 1985; af Wåhlberg, 2002a, b) and simulator driving (e.g. van der Voort et al., 2001). But what happens when the driver returns to his normal driving environment is relatively unknown concerning fuel consumption, and even less so for other possible variables which are often thought to be influenced, such as accident frequency and wear and tear on vehicles (af Wåhlberg, 2002a).

In the present study, the interest will chiefly be laid in a factor that has not received much interest in the general discussion; passenger comfort. What happens with passenger comfort when (if) a driver alters his driving behavior

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[1]There seem to be a general consensus among driving teachers and technicians what driving behaviors are desirable.

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towards a more fuel-efficient way of driving? Will this be perceived as negative or positive for the ride quality of the passenger, or will it not be noticed at all? As economical driving is now becoming popular amongst bus companies (at least in Sweden), these questions are gaining weight.

Most of the (very scant) research on passenger comfort seems to have focused on vibration,[2] noise, temperature and traveling postures (Oborne and Clarke, 1973). This would seem to indicate a focus on the technical side of comfort, while the behavior of the driver is not discussed at all (see for example Oborne, 1978; Leatherwood et al., 1980; Parsons et al., 1979; Demic et al., 2002). Given the scenario sketched above on the developing training programs and the general lack of knowledge about how the driver influence the passengers' experience, there seem to be a need of hypotheses and research concerning the relation between driving style and passenger comfort.

However, the first problem is how to quantify driving style objectively in such a way as to be able to relate this to passenger experience, but, for the present purpose, also to measure changes when drivers learn to drive economically. Building upon earlier research on driving style (af Wåhlberg, 2000, 2003, 2004), this question was addressed in a study of EcoDriving training (af Wåhlberg, 2002b), where it was found that the mean of acceleration increased, and mean deceleration decreased substantially (see the method section of this paper for a more thorough description of this sort of calculation), as predicted from the training principles in Heavy EcoDriving (see Appendix A and the Method section), while mean speed did not change. Mean acceleration (positive and negative) values are therefore good measures of how driving style changes when drivers are taught to drive economically, but the general levels may also be determinants of passenger comfort experiences.

The inclusion of acceleration behavior as a variable was also necessary because the first step in the study was to determine whether there had actually been a change in driving style among the drivers trained. Although the differences in fuel consumption and acceleration levels during training of the subjects for the present study were very substantial (af Wåhlberg, 2002b), these results do not necessarily imply that the drivers will continue to drive in this way when they return to their normal driving environment (af Wåhlberg, 2002a). Therefore, whatever the result in terms of perceived comfort before and after training in the present study, the result can not be interpreted in a satisfactorily safe way without a calculation of acceleration values as a measure of whether drivers have actually changed their driving style after training.

It would seem obvious that experienced comfort is first and foremost a subjective concept; it is the experience of the individual. The measurement of comfort can therefore scarcely be physiological, and behavioral data from passengers would be hard to gather and interpret. A questionnaire method would therefore seem inevitable.

After deciding on an objective parameter for the measuring of driving style, hypotheses must be put forward as to what subjective dimensions might be important for passenger comfort, and converted into questionnaire scales.

First, a general question regarding overall comfort was deemed the most straightforward way of gathering information. Second, the inclusion of acceleration/deceleration levels made the unevenness of the ride an obvious choice. The exact wording (what to call a dimension that should be a direct counterpart to mean acceleration level) was not as straightforward, but the Swedish word finally used was the exact translation of 'jerky'.

Third, as noise levels might be altered by the stronger accelerations demanded by economic driving[3] (see Appendix A and the Method section), it is possible that there would be perceived differences on this parameter that would influence the overall view. Finally, it might be hypothesized that perceived safety could be important for the overall comfort. It has also been found that there is a clear link between the perceptions of risk and the general attitude towards a phenomenon (Sjöberg, 2000).

As a result, we end up with a dimension of comfort, and noise, danger and jerkiness. Although it could be suspected that the latter three would determine the overall comfort, this was not a research question. Instead, it was hypothetisized that they would all be related to driving style, in such a way that increased mean acceleration would decrease experienced comfort, while weaker deceleration would have the opposite effect. As there is a continuum of driver behavior from strong to weak accelerations and decelerations in a normal population of bus drivers (af Wåhlberg, 2003), it could therefore be expected that correlations between these variables and passenger comfort would be found, i.e. weaker and less frequent speed changes would predict high comfort ratings.

The passenger comfort study was undertaken as part of a project on the effects of a training program in economical driving implemented by a bus company. The use of bus drivers as subjects has many methodological and practical advantages (see af Wåhlberg, 2000, 2002b), such as repeated driving of the same route. In the present study, they were mainly the possibility to study the drivers in their 'natural environment', en route, rather than on some test-track, where people know they are being studied. On the other hand, a bus route still retains the advantage of the test-track as a standardized piece of road that will be

[2]Vibration is recurring accelerations with small amplitude and high frequency, changing direction rhythmically (see Oborne (1977) and Leatherwood et al. (1980) for studies on vibration and comfort, with exact values of the parameters involved).

[3]Only one study on this subject could be located, Sandberg, Ejsmont, Ronowski and Dong, 2001. Despite their conclusion that EcoDriving (the dominant economical driving style in Sweden) did not have any negative noise effects when measured on a test track, the hypothesis about an increase in subjectively experienced noise was still retained.