The Netherlands
Research School for
Transport, Infrastructure
and Logistics
TRAIL

11th TRAIL Congress
November 2010

THREE WAYS OF OBSERVING DRIVERS USING NAVIGATION SYSTEMS

Allert Knapper MSc, Dr. Marjan Hagenzieker, Prof. dr. Karel Brookhuis
Faculty of Technology, Policy and Management, Department of Transport and Logistics,
Delft University of Technology, the Netherlands

ABSTRACT

This paper discusses driving simulators, field studies and naturalistic driving observations as possible methods for systematically observing driving behaviour when using navigation systems. The pros and cons of the three methods are discussed, concluding to the recommendation to try using more than one method to strengthen research.

KEYWORDS

Driver, behavioural observation, method comparison, navigation systems.

INTRODUCTION

Traffic safety is, besides by road and car design and traffic regulations, strongly influenced by driver behaviour. Driver behaviour comprises for example longitudinal and lateral movements, glancing, planning and talking. This behaviour may be altered by experience, the presence of passengers, surroundings, or in-vehicle devices like navigation systems, leading to an improvement or deterioration of driving quality. However, it is difficult to tell exactly in what respects the changes occur. Navigation system use has both a visual and an auditory task component, which could lead to visual as well as cognitive distraction from the driving task, thus changing driving quality.

Driving behaviour is predominantly investigated in three ways: first, one can simply ask drivers how they think they change their behaviour, for instance when using a navigation system. This can be done using interviews or questionnaires. One problem with self-reported behaviour is that most people are not aware of possible alterations and can therefore provide inaccurate reports, another is that they may answer socially desirable. Next, driving behaviour is investigated by analysing post hoc data, for example police reports or crash data. Obviously, these indirect data are limited in the sense that driver behaviour cannot be inferred accurately; one can often not conclude whether an accident was due to, for example, a driver

using a navigation system, or just a concidental lapse of attention. The focus in this paper is on a third method, which is observing the actual driver behaviour itself.
These observations may be performed in roughly three ways: driving simulators, in-car observations using instrumented vehicles and naturalistic observations. The three methods allow for different levels of experimental control, realism and measurements, probably leading to different results, as described and analysed hereafter. The conclusions provide recommendations for using more than one method, in case of investigating navigation systems.

DRIVING SIMULATORS

Driving simulators have been available for several decades and are often used for studying driver behaviour. They exist in different classes, from cheap and simple computer plus steering wheel to expensive moving base simulators, but all try to imitate driving in a safe environment, with the major advantage of having full experimental control over conditions. Although, certainly the moving base simulators at glance seem to resemble real life quite well, it has only occasionally been examined to what extent they really do so over different situations and conditions. Researchers have compared drivers' behaviour in simulators to, for example, instrumented cars (Godley, Triggs, & Fildes, 2002; Shechtman, Classen, Awadzi, & Mann, 2009) and instrumented vehicles and laboratory settings (Santos, Merat, Mouta, Brookhuis, & Waard, 2005); for a validation study overview, see Hoskins & El-Gindy (2006). However, the value of driving simulator research is still questioned, pointing for example to lack of kinaesthetic information in the fixed-base driving simulator; no feel of tires, engine and corners (Alm, 1995; Carsten & Gallimore, 1996), although in moving base simulators those circumstances can be imitated quite well. Still, it remains unclear whether drivers use route guidance and feed their destinations into navigation systems in the simulator the same way as in the real world, especially with respect to attention and distraction (see Young, Regan & Lee, 2009). On the other hand, definite advantages of driving simulator research are the possibility to safely investigate potentially dangerous acts like changing a destination in a navigation system, in a very controllable environment.

FIELD STUDIES

Field studies use real, often instrumented cars, studying drivers' behaviour closely by using a test track or by letting participants drive public roads. A set route is used often, but sometimes researchers choose to let participants drive freely. Besides behaviour measuring equipment, usually observers are present in the car too, possibly causing Hawthorne-like effects, e.g. leading participants to adapt their behaviour to more socially accepted levels. Most variations in field test studies are due to resources available to the researchers; some research institutes own their own vehicle, method or test track, and use it accordingly often. A field study may be part of a Field Operational Test (FOT), but a FOT may also include a more naturalistic study, see the next paragraph.
In a field test, a reasonable amount of experimental control is feasible, although not as much as in driving simulators, as for example weather conditions and traffic in itself are not always predictable. It is a clear advantage that certain controlled conditions can be inserted in a real life environment, thereby improving external validity (generalizability). Moreover, communication processes with other road users can be studied relatively easily, and a more general view on driving behaviour can be obtained. Internal validity (causality) may be about equal to the driving simulator. A disadvantage is, that observers have to be well trained to overcome data differences due to subjective judgments, they can get fatigued, and they could

fail to observe certain behaviours and situations. Moreover, field studies can be costly and it may sometimes be hard to compose a representative sample.
One example of a regularly used field study method is the Wiener Fahrprobe (Vienna driving test, see Chaloupka & Risser (1995)), which uses a standardised route. 2 observers drive along, one for observing particular standardised behaviour (lane keeping, speed, etc), and one 'free' observer, paying attention to interaction with other traffic participants, errors and conflicts. Drivers can drive the test route for example with and without an in-vehicle system, thereby enabling researchers to investigate clear behavioural changes that occur because of using the systems. The developers claim that participants 'forget' about the observers' presence in about 15 minutes (see Turetschek (2009), p42), therefore the observations start after 15 minutes. Disadvantages are again observers' concentration, their intensive training, unforeseen construction work at the route, and other unexpected traffic events or intensities (Turetschek, 2009). Using this method, navigation systems can be set to follow the predetermined route easily, making it feasible to investigate their effects on driver behaviour.

NATURALISTIC OBSERVATIONS

Naturalistic observations avoid some of the simulator and field test disadvantages by observing drivers in their own cars, mostly for an extended time, sometimes without them knowing about the observations. The latter can, for privacy reasons, only be done from outside a car, for example the study by Walton and Thomas (2005), who observed drivers' hands position to determine whether it is related to task complexity.
Recently, it has become feasible to do in-car naturalistic observations. Dingus et al. (2006) did their 100-car study showing that techniques for storing and retrieving large amounts of data are now relatively easily available. These driving observation data provide insight in drivers' habits and patterns of use, in other words their normal behaviour, which is assumed to be very naturalistic and helpful, for example, to investigate in-vehicle technologies (Bonnard & Brusque, 2008). Naturalistic data are thought to be the next step in traffic behaviour research.
However, naturalistic driving observations often involve small, non-representative samples and drivers' thoughts are hard to analyse (McEvoy & Stevenson, 2009). Furthermore, data analyses can take tremendous amounts of time, especially if video data is involved. Still, well-positioned cameras and other recording devices can provide insights in effects of using a navigation system, for example by comparing trips with and without them, and on known and unknown routes. Additionally, it can be inferred to what extent drivers change their destination during driving or whether they always stop to do so.

CONCLUSIONS

The three ways of observing driving behaviour described here are useful, can be profitable and have their own merits, provided they are applied properly. However, they all have limitations, in the sense of behavioural validity, experimental strength or observatory reliability. In case of investigating navigation systems, for example, one could study how actual driver behaviour changes when drivers are changing their destination, but if their patterns of use from naturalistic investigations show that most never do so during driving, relevant but yet insignificant lessons are learnt. On the other hand, one could also argue that destination entry is too unsafe a task to fulfil during a field test, and still safely investigate it in a driving simulator. As a last example, route guidance in a field test study might so overtly be the variable under investigation that a participant changes his/her behaviour accordingly, while this effect may be smaller in naturalistic settings.

These problems can partly be overcome using a combination of the methods. Knapper (2009) intends to incorporate the three methods in his navigation system and mobile phone PhD research. The driving simulator will be programmed to follow an equivalent route as the participants drive in a Wiener Fahrprobe test, while the same participants will drive their own cars naturalistically, with several cameras, a GPS tracker, and a number of sensors installed, as a result allowing for a statistically strong repeated measures analysis.

REFERENCES

Alm, H. (1995) *Driving simulators as research tools - a validation study based on the VTI driving simulator*, VTI report.

Bonnard, A., C. Brusque (2008) *Naturalistic Driving Observations to investigate distraction exposure and IVIS patterns of use: interests and constraints of the approach,* paper presented at the HUMANIST, Lyon.

Carsten, O.MJ., S. Gallimore (1996) The Leeds Driving Simulator: A New Tool For Research In Driver Behaviour, in: A. G. Gale (Ed.), *Vision in Vehicles - V* (pp. 11-18), Amsterdam, Elsevier Science Publisher B. V. (North Holland).

Chaloupka, C., R. Risser (1995) Don't wait for accidents -- possibilities to assess risk in traffic by applying the [`]Wiener Fahrprobe', in: *Safety Science, 19*(2-3), pp. 137-147.

Dingus, T.A., S.G. Klauer, V.L. Neale, A. Petersen, S.E. Lee, J.D. Sudweeks, et al. (2006) *The 100-Car Naturalistic Driving Study, Phase II - Results of the 100-Car Field Experiment*, p. 422.

Godley, S.T., T.J. Triggs, B.N. Fildes (2002) Driving simulator validation for speed research, in: *Accident Analysis and Prevention, 34*, pp. 589-600.

Hoskins, A.H., M. El-Gindy (2006) Technical report: Literature survey on driving simulator validation studies, in: *International Journal for Heavy vehicle Systems, 13*(3), pp. 241-252.

Knapper, A S. (2009) PhD research proposal. Delft University of Technology.

McEvoy, S.P., M.R. Stevenson (2009) Measuring Exposure to Driver Distraction, in: M.A. Regan, J.D. Lee & K.L. Young (Eds.), *Driver Distraction - Theory, effects & mitigation* (pp. 73-83), Boca Raton, Taylor & Francis Group.

Santos, J., N. Merat, S. Mouta, K.A. Brookhuis, D. d. Waard (2005) The interaction between driving and in-vehicle information systems: Comparison of results from laboratory, simulator and real-world studies, in: *Transportation Research Part F, 8*, pp. 135-146.

Shechtman, O., S. Classen, K. Awadzi, W. Mann (2009) Comparison of Driving Errors Between On-the-Road and Simulated Driving Assessment: A Validation Study, in: *Traffic Injury Prevention, 10*(4), pp. 379 - 385.

Turetschek, C. (2009) *Effects of ISA-like IST, Dissertation,* Vienna University, Vienna.

Walton, D., J.A. Thomas (2005) Naturalistic observations of driver hand positions, in: *Transportation Research Part F, 8*, pp. 229-238.

Young, K.L., M.A. Regan, J.D. Lee (2009) Measuring the Effects of Driver Distraction: Direct Driving Performance Methods and Measures, in: M.A. Regan, J.D. Lee & K.L. Young (Eds.), *Driver Distraction - Theory, effects & mitigation* (pp. 85-105), Boca Raton: Taylor & Francis Group.