Article:

Carsten, O.M.J. and Brookhuis, K. (2005) Issues arising from the HASTE experiments. Transportation Research Part F: Traffic Psychology and Behaviour, 8 (2). pp. 191-196. ISSN 1369-8478

https://doi.org/10.1016/j.trf.2005.04.004

Issues Arising from the HASTE Experiments

Oliver Carsten[1]* and Karel Brookhuis[2]

[1]Institute for Transport Studies, University of Leeds, Leeds LS2 9JT, UK
Tel +44 113 343 5348, Fax +44 113 343 5334, Email o.m.j.carsten@its.leeds.ac.uk

[2]Department of Psychology, University of Groningen / Delft University of Technology, The Netherlands
Tel +31 50 363 6772, Fax +31 50 363 6784, Email k.a.brookhuis@ppsw.rug.nl

*Corresponding author

The HASTE project work discussed in the foregoing papers can be depicted as being aimed at answering two questions: "Does greater secondary task load from an In-Vehicle Information System (IVIS) lead to an identifiably worse performance in the primary task of driving?" and "How much distraction is too much?". There is, of course, a huge amount of literature examining the effect of distraction on driving. Some of this concerns visual distraction (e.g. Holohan, Culler & Wilcox, 1978; Dingus, Antin, Hulse & Wierwille, 1989; Wierwille & Tijerina, 1996; Wallace, 2003), while other parts cover distraction from cognitive (auditory) tasks such as mobile phone use (e.g. Stevens & Paulo, 1999; Svenson & Patten, 2003). But, in spite of this large background of research, it can be argued that the HASTE work was pioneering in the sense that it attempted to differentiate between the effects of visual and cognitive distraction and at the same time it attempted to carefully control the "dose" of distraction administered at any one time. These dose-response studies were carried out in three common but quite different experimental settings, a laboratory set-up, advanced driving simulators, and in instrumented vehicles in the field. The project also examined the reliability of the evaluation, with for example six replications of the rural road studies across a variety of driving simulators in five different countries.

In many respects this very structured approach has paid off. In particular quite contrasting effects on driving have been found for the two types of distraction (Carsten, 2004). The visual task, not unexpectedly, led to poor steering behaviour and degradation of lateral control of the vehicle. By contrast, with the cognitive task, the major negative effect was more on longitudinal control, particularly in car following, rather than on lateral control. Thus in the Leeds simulator study, there was a tendency for minimum time headway to decrease as the cognitive task becomes more difficult. In addition, with the cognitive task, there was the phenomenon of an apparent 'improvement' in steering behaviour with increased cognitive task load, as shown, for example, in steering patterns: reversal rates decreased with increased level of the surrogate IVIS indicating 'better' lateral control. This phenomenon has been observed before (e.g. Brookhuis, De Vries & De Waard, 1991), however, as discussed in Victor, Harbluk and Engström (this issue), eye movement analysis, carried out in some of the studies, provides a possible explanation. With increased task load there was greater concentration of glances on the road straight ahead as opposed to the periphery, i.e. greater visual funnelling. This greater concentration of gaze and the accompanying "improvement" in steering has two possible explanations. One is that it is a conscious adaptation by drivers to the presence of distraction: aware of the increased risk, they focus on road ahead to maintain stable control. The other possible explanation is that the change in the concentration of gaze is autonomic and accounts for the improved tracking in that the drivers are then subconsciously aiming for the point at which they are gazing. A detailed investigation of the phenomenon should be able to identify the causal mechanism.

Nevertheless, identifying that secondary visual and cognitive tasks have different impacts on driving does not directly indicate how to specify a test regime for the assessment of an IVIS. In some ways, the finding complicates matters. For example, how is one to interpret an observed improvement in steering? It may well be necessary to combine assessment of steering with assessment of eye movement patterns. There is also the additional complication that most real-world IVISs are likely to impose a combination of task loads — visual, cognitive and manual. This may well be the case even for a single task, such as reading and interpreting a screen or destination entry. Any real-world visual task is likely to have more substantial cognitive elements than the arrows task used in the HASTE experiments. If so, real-world tasks could even produce effects that vary within the task duration — poorer lateral performance during the initial visual phase of looking at a screen, followed by improved lateral performance as the information acquired is digested and interpreted.

Next there is the problem of translating the observed effects into some overall criterion such as increased accident risk. This is a notoriously difficult area in that taking an single parameter of driving performance such as speed and translating that parameter into a calculation of risk of crash (or change in risk with a change in behaviour) is notoriously difficult. Brookhuis, De Waard and Fairclough (2003) have proposed the use of both absolute thresholds and relative changes for a number of measures of driving performance (e.g. speed, time headway, standard deviation of lateral position, time to line crossing, etc.) as indicators of individual driver impairment. Hoedemaker and Janssen (2000) have proposed the use of certain mathematical relationships from the literature on speed, speed variance, lane keeping performance and headway as a method for assessing the safety impacts from the introduction of a driver support system. It should be noted that this latter assessment is to be carried out on group overall performance, rather than at the individual level.

But even if agreement can be reached on what are the appropriate thresholds for severely elevated risk or on what relationships should be applied to observed indicators to calculate changes in risk, there is still the problem of what to do when there are changes in more than one of the criteria. It is highly likely that, for example, an increase in speed combined with a reduction in time headway will have a multiplicative effect on risk of a crash occurring. But there is little literature on exactly what is the relationship between the effects on risk of those two parameters and various others in combination with each other. In the future it may be possible to use micro-simulation models without constraints against unsafe behaviours to make predictions about the safety implications of changes in behaviour with, for example, new in-vehicle technologies (Carsten, 2002). This would allow the assessment of complex changes in behaviour. But currently such models are not available. For this reason, the HASTE project has been conducting a survey among safety experts to obtain estimates of how the impacts of various safety-related criteria interact with each other. This survey, which has not yet been analysed, should provide some guidance for interpreting the results obtained in HASTE and elsewhere.

However, even with such additional information on the relationship between driving performance and safety, it will not be possible to assess the overall effects on safety in driving from the distraction caused by using a given IVIS. An additional factor, namely the exposure to the distraction, needs to be considered. Whereas fatigue and alcohol, for example, impose continual risk, distraction imposes only momentary risk (although there may be a time halo effect of cognitive load). Therefore we need to consider the duration of the distraction in predicting its impact and we need to consider the trade-off between duration of effect and intensity of effect. What is worse: a short but very substantial distraction or a longer but more moderate distraction? There is no obvious and immediate answer to this question and part of the answer must depend on the traffic context in which the distraction occurs. The COMUNICAR project (Amditis, Montanari, Polychronopoulos & Bellotti, 2002) and the CEMVOCAS project (Bellet et al., 2002) have been developing strategies for suppressing or delaying messages at times of high workload, for example around intersections or when making manoeuvres. However, such strategies are not always viable: it is precisely while negotiating a complex intersection that a driver may require immediate support from a navigation system, in order to be told, for example, which exit to take in a gyratory.

Another important issue for a future safety assessment regime for in-vehicle information systems is where the assessment is to be conducted. Efficiency and reproducibility of assessment environment would argue for the evaluation to be conducted in a driving simulator. Field studies may have final validity in their favour, and, depending on the conditions, even genuine naturalness. So it is important to examine whether the simulator studies captured the same performance and behavioural responses to the presence of distraction from an IVIS as is observed in the on-road drivers. The real-road drives are expected to constitute a “ground truth”, i.e. we can generally assume that effects observed in such circumstances are not open to questions about validity, as can be the case with effects observed in an artificial laboratory environment. But the real road data also suffer from the extra noise induced by the varying conditions of each drive — it is not feasible to reproduce precise scenarios in real traffic. Simulators offer the capability of precise duplication of scenarios, so that each driver can be exposed to the same conditions and the same set of events. It is even possible to control the severity of the events. In the simulator car-following scenarios on the rural roads (Jamson & Merat, this issue), we attempted to have the "time leadway" of the lead car constant, so that the lead car would close up to the subject's car when the subject was driving more slowly and move further away when the subject drives faster.

In fact there was quite substantial difference between effects observed in the simulators and effects observed in real road driving. In part this can be attributed to what data was captured in each environment: lateral position could not be collected systematically in the field, while observer ratings of driving quality were omitted in the simulators. But aside from data issues, there were some important differences in the effects of distraction on driving in the two environments. In particular, greater amounts of distraction produced an almost total breakdown in some situations of the driving task on real road, but this same breakdown could not be observed while driving in the simulator. It might be argued that simulator driving is, because of the more simple visual environment in a simulator, less demanding than real-road driving, but the contrary has been shown as well: driving on a simulator is generally more demanding than comparable driving in the real world. For example, De Waard and Brookhuis (1997) found that the amount of effort subjects put into driving in a simulator, as measured by the Rating Scale of Mental Effort (RSME) was substantially higher than the effort when driving in a real car.

So, why did driving break down on real roads but not in the simulators, when for safety reasons the maximum level of distraction to which the drivers were exposed was lower in real-road driving than in the laboratory? The answer can perhaps be found in the situations to which the drivers were exposed. Most simulators are, at the moment, not capable of capturing driving situations in which the primary task of driving becomes really cognitively demanding, i.e. situations where the driver has to make a considerable effort to understand and interpret what is happening in the information-dense road environment. Simulator experiments tend to use driving-related cognitive tasks that are quite simple, such as whether the driver understood a road sign or the message content of a Variable Message Sign. Such tasks place quite low demands on the driver and do not require much higher-order reasoning. This may in part explain why the expected exponential increase in the performance indicators in line with increasing distraction was not generally found in the simulator studies. Besides, the actual road environment is much richer, more "stimulating" and distracting than the usual (low-resolution) simulator projection.

Some real-road situations are highly demanding. If a driver is approaching a zebra crossing with a pedestrian present, that driver has to decide whether to maintain speed, decrease speed in order to give way to the pedestrian or even increase speed in the hope of deterring the pedestrian from crossing. And the situation has to be continuously re-evaluated. If the driver has decided to increase speed, maybe the pedestrian has decided to walk anyway, so that the driver now has to decide to brake in a split-second. This is exact the type of complex interaction that broke down when the drivers were exposed to cognitive distraction in the real-road drives in Helsinki (see Figure 1). Here it is interesting to note that the drivers did not surrender the secondary task. Workload arises not only from each task but also from task switching itself (Pashler, 1998). In the dual task situation, a driver will have to make an evaluation of the effort required for the secondary task as compared with the effort required for the primary task in order to decide whether to surrender the primary task. Perhaps it is not altogether surprising that it was the elderly drivers who had the greatest problems in task prioritisation. This can be seen from Figure 2, which shows lane discipline when driving with the visual task on real roads in Helsinki. The "average drivers" (aged 25-50) were able to manage the problem to some extent, and appeared to surrender performance on the secondary task at its most difficult level. On the other hand, for the elderly drivers (aged 60 or more) there was a severe impact of the secondary task and the negative effect increased by S-IVIS level. They do not have the resources required for task switching.

[Figure 1 here]

[Figure 2 here]

Overall, the various studies reported in this issue have confirmed that an assessment regime primarily based around using driving simulators can produce meaningful and potentially reliable results. They have pointed to very important differences between the impacts of the two types of distraction — visual and cognitive. They have also pointed to some deficiencies in the current capability of driving simulators to represent the full complexities of the driving task. And finally they have confirmed the need to consider further how safety indicators can be changed into safety criteria that can serve as benchmark for assessing the safety of an IVIS in actual use.

References

Amditis, A., Montanari, R., Polychronopoulos, A., & Bellotti, F. (2002). Definition of an information management structure through an on-vehicle HMI: the COMUNICAR project. *Proceedings of the e-Safety Congress,* 16-18 September, Lyon.

Bellet, T. et al. (2002). 'Real-time' analysis of the driving situation in order to manage on-board Information. *Proceedings of the e-Safety Congress*, 16-18 September, Lyon.

Brookhuis, K.A., De Vries, G., & De Waard, D. (1991). The effects of mobile telephoning on driving performance. *Accident Analysis & Prevention, 23,* 309-316.

Brookhuis, K. A., De Waard, D., & Fairclough, S. H. (2003). Criteria for driver impairment. *Ergonomics, 46,* 433-445.

Carsten, O.M.J. (2002). From behavioural adaptation to safety modelling: predicting the safety impacts of new technology. *Behavioural Research in Road Safety: Eleventh Seminar*. London: Department for Transport, Local Government and the Regions.

Carsten, O.M.J. (2004). Implications of the first set of HASTE results on driver distraction. *Behavioural Research in Road Safety 2004: Fourteenth Seminar*. London: Department for Transport.

De Waard, D., & Brookhuis, K.A. (1997). Behavioural adaptation of drivers to warning and tutoring messages: results from and on-the-road and simulator test. *International Journal of Heavy Vehicle Systems (Series B of International Journal of Vehicle Design), 4,* 222-234.

Dingus, T.A., Antin, J.F., Hulse, M.C., & Wierwille, W.W. (1989). Attentional demand requirements of an automobile moving-map navigation system. *Transportation Research A, 23,* 301-315.

Hoedemaeker, M., & Janssen, W.H. (2000). Driving behaviour parameters and accident risk with driver support. *Presented at ICTTP 2000, 2nd International Conference on Traffic and Transport Psychology*, 3-7 September, Bern, Switzerland.

Holohan, C., Culler, R., & Wilcox, B. (1978). Effects of visual distraction on reaction time in a simulated traffic environment. *Human Factors, 20,* 409-413.

Östlund, J., Nilsson, L., Carsten, O., Merat, N., Jamson, H., Jamson, S., Mouta, S., Carvalhais, J., Santos, J., Anttila, V., Sandberg, H., Luoma, J., de Waard, D., Brookhuis, K., Johansson, E., Engström, J., Victor, T., Harbluk, J., Janssen, W., & Brouwer, R. (2004). Deliverable 2 - HMI and Safety-Related Driver Performance. (Report No. GRD1/2000/25361 S12.319626). Human Machine Interface And the Safety of Traffic in Europe (HASTE) Project.

Pashler, H.E. (1998). *The Psychology of Attention*. Cambridge, Mass.: MIT Press.

Stevens, A., & Paulo, D. (1999). The use of mobile phones while driving. *TRL Research Report 318.* Transport Research Laboratory, Crowthorne, UK.

Svenson, O., & Patten, C. (2003). *Information technology in cars: mobile phones and traffic safety — review of contemporary research*. Department of Psychology, Stockholm University and Swedish National Road Administration, Borlänge, Sweden.

Wallace, B. (2003). *External-to-vehicle driver distraction*. Scottish Executive, Edinburgh.

Wierwille, W.W. and Tijerina, L. (1996). An analysis of driving accident narratives as a means of determining problems caused by in-vehicle visual allocation and visual workload. In A.G. Gale, I. D. Brown, C. M. Haslegrave, and S. P. Taylor (Eds.), *Vision in Vehicles V*. Amsterdam: North-Holland.

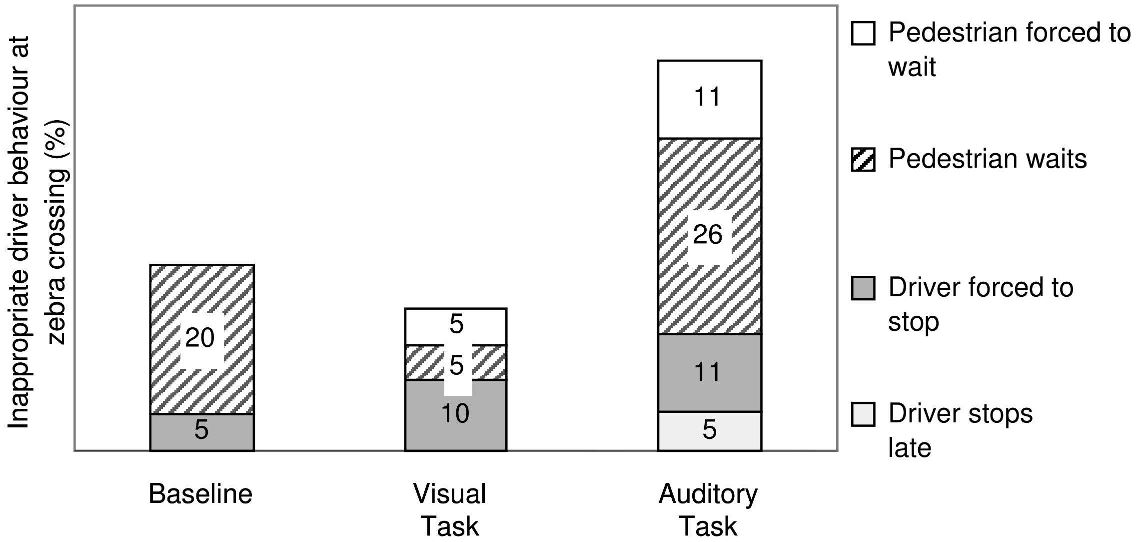

Figure 1: Interaction with pedestrians at zebra in Helsinki (from Östlund et al., 2004)

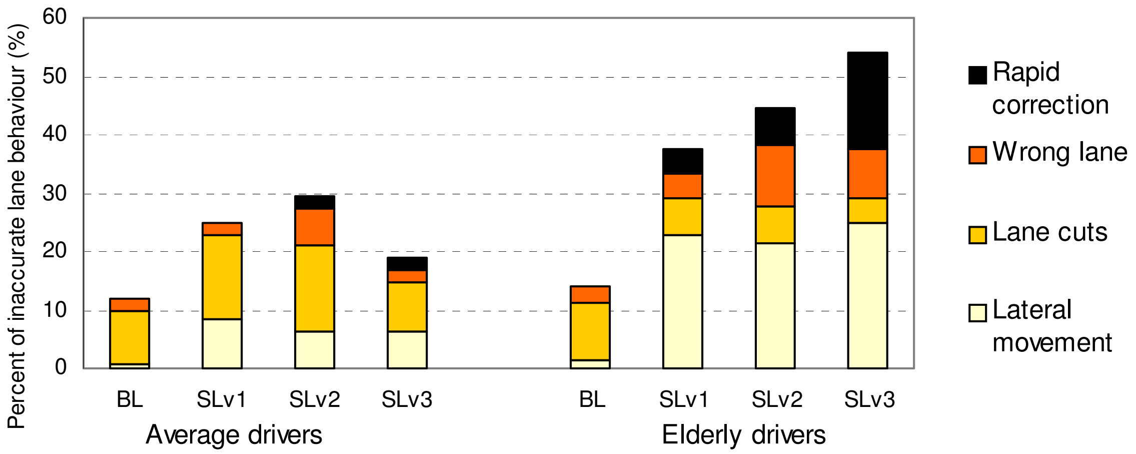

Figure 2: Lane behaviour in real-road driving with visual task in Helsinki (from Östlund et al., 2004)