BEHAVIOR AND SAFETY WHEN DRIVING WITH IN-VEHICLE DEVICES THAT PROVIDE REAL-TIME TRAFFIC INFORMATION

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SUMMARY

Five in-vehicle systems providing real-time traffic information were compared to an accepted standard (listening to radio congestion information while driving). The safety of the devices was evaluated during the execution of a number of driving manoeuvres in actual traffic, as well as in a car-following and braking task on a closed track. Driving performance was rated in terms of expert safety judgments, as well as in terms of responses and reaction times to relevant queries asked while driving.
Results showed that driving with these systems is not necessarily less safe than driving in the accepted standard condition. This applied to the Philips Carin 520 and the Volvo/Mitsubishi RTI systems. Two other systems, the Traffic Master YQ and the Renault/Sagem Carminat, showed evidence of being less safe than the standard. These results were related to fairly elementary ergonomic features, i.e., display and handling characteristics.

INTRODUCTION

There are now in-vehicle information systems that provide drivers with congestion information on the way. While these may be beneficial to route selection they may also carry risks of distracting the driver from safely executing the primary driving task.

The present study focused on precisely this aspect as a step preceding the large-scale dissemination of so-called RDS-TMC systems (Radio Data System – Traffic Message Channel) in the Netherlands. These systems select broadcast information that is specifically relevant for the individual driver. They may have auditory or visual displays, and may be combined with other functions (e.g., active route guidance).

In the present study safety effects of different systems were evaluated while drivers executed a number of driving manoeuvres. Being informed by congestion information on radio was used as a safety standard, since it is already accepted that drivers can listen to this kind of information while driving. In addition, a comparison was made between the effects of driving with this standard and driving without any in-vehicle congestion information being presented at all.

The study was commisioned by Bridgecraft BV on behalf of the Transport Research Centre of the Netherlands Ministry of Transport, Public Works and Water Management.

METHOD

Subjects

Seventy-two subjects were randomly selected from the HFRI's subject pool. The group consisted of men and women, ranging from 23 to 45 years of age, who had had a driving license for at least 5 years, drove more than 10,000 kilometres a year, and were not using any medication that could affect their driving behavior.

Apparatus

An instrumented vehicle (ICACAD) was used, which is a Dodge RAM van instrumented with an IBM 486 PC and various possibilities for generating stimuli and measuring driver behavior.

In-vehicle systems evaluated

Six different systems were tested, four of which are – or will soon be – commercially available, and the remaining two of which were for comparison purposes :

- *RDS Speech.* This functioned as the safety standard. It provided up-to-date congestion information on a selected set of relevant roads, interrupting ongoing radio or tape. In the experiment at each predefined event ('query'; see 'Stimuli' section) congestion messages were provided by a prerecorded male voice. This system was, therefore, a simulated rather than an existing system.
- *RDS Map* provided similar information to RDS Speech, but congestion information was now presented visually instead of auditorily on a display fixed on the dashboard centre. This system was therefore also a simulated system (see Fig.1)
- The *Philips Carin 520 Navigation System ('520')* provided only route guidance. At the time of investigation the congestion information providing function was not yet available. The 520 system computed the shortest route to a certain destination and both depicted this route on a map and gave direct oral navigation instructions. Fig. 2 shows the display and its remote control.
- The *Traffic Master YQ ('YQ')* system provided congestion information by means of a map display. Congestion locations blinked, and along each congested road current driving speeds were indicated in miles per hour. See Fig. 3.
- The *Volvo/Mitsubishi RTI System ('RTI')* was capable of providing both route guidance and congestion information. See Fig. 4.
- Finally, the *Renault/Sagem Carminat ('C1') system* has the capability of providing several types of traffic information (e.g., congestion, road works, parking lots, and fuel stations). See Fig. 5.

Figs. 1-5 here

In addition to the evaluated systems there was a 'control' condition, in which the radio was on while no congestion information was presented at all.

Stimuli

While subjects (Ss) were driving appropriate stimuli were presented, that is, stimuli fitting the slightly different modes of functioning of the individual systems. On the basis of these, yes/no queries were to be answered, like:' You are on your way from Utrecht to Amsterdam. Is there congested traffic?'

Study design and procedure

Subjects were divided into 6 groups of 12, forming the following conditions:
'Control' – Continuous radio (no congestion information) versus RDS Speech.
'RDS Map' – RDS Map versus RDS Speech.
'520' – 520 versus RDS Speech.
'YQ' - YQ versus RDS Speech.
'RTI' – RTI versus RDS Speech.
'C1' – C1 versus RDS Speech.
Thus, each subject had the RDS Speech system as the standard against which to compare his performance with one of the actual systems to be evaluated. This was done in two different environments:

(1) In actual traffic within a built-up area. Care was taken to ensure that drivers encountered four specific traffic situations during which he could be confronted with congestion information. these situations involved the following driving manoeuvres:

- Driving straight ahead
- Making a right turn
- Approaching a 'general rule' intersection
- Approaching a priority intersection.

A number of submanoeuvres within these manoeuvres were distinguished. For example, when approaching a priority intersection a distinction was made into 'braking and decelerating', 'course keeping', 'anticipating', 'looking at priority traffic', and 'giving priority'. These separate elements were rated by an experienced driving instructor in the vehicle in terms of whether they were performed in a safe manner

(2) On a rural closed track, without other traffic present. Here a second vehicle drove in front of the S's vehicle. Ss were instructed to follow this vehicle and to brake whenever they noticed the vehicle braking. Braking of the preceding vehicle was timed to coincide with the presentation of RDS-TMC stimuli (queries) to the subject. S's task performance was analysed in terms of percentages of correct answers and reaction times (to the braking vehicle). Control runs were without RDS-TMC information being presented.

After the experiment, Ss filled out qustionnaires regarding their opinions on the systems with respect to safety, the effort required to drive with a system, and the extent to which they thought this was a desirable system to have in their own car.

RESULTS

Real-world driving

Table I shows the proportions of unsafe judgments per system, as well as for the control condition. The data are broken down according to the manoeuvre performed. Of the commercially available systems two, the 520 and the RTI systems, do not distinguish themselves from the accepted safety standard. The two others show problematic results in at least one of the manoeuvres. The YQ system, in fact, is only up to the standard when the manoeuvre is to execute a right turn. It is also interesting to note that the accepted standard (RDS Speech) is worse than the control condition (just listening to the radio) in two manoeuvres.

Car-following and braking task

Table II shows percentages correct to queries and reaction times to sudden braking of the leading vehicle.

No effect of 'system' was found for the percentages correct to queries presented while car-following and braking. With respect to reaction times, there was an overall significant difference in RTs with and without RDS-TMC queries. However, no differential effects were obtained for the different systems.

Table I. Proportions of unsafe behavioral judgments per system and per manoeuvre (number of asterisks indicates significance level of .001, .01. or .05), as well as overall.

	Straight ahead	Turning right	General rule intersection	Priority intersection
Control	10	5	13	9
RDS Speech* **	20**	7	18	16*
RDS Map	13	19	20	14
RDS Speech* **	10	15	4***	5***
520	13	12	11	13
RDS Speech	14	13	20	12
YQ	30	19	37	23
RDS Speech* **	14***	14	24**	13**
RTI	11	12	15	17
RDS Speech	15	9	15	12
C1	24	13	36	17
**RDS Speech* **	21	14	24*	14

Table II. Correct response to queries given while car-following; and reaction times to braking of leading vehicle, with and without queries being given simultaneously.

	Percentage correct to queries	RT to braking, with queries (ms)	RT to braking, without queries (ms)
RDS Speech	77	1268	1007

RDS Map	76	1300	1148
520	77	1432	999
YQ	77	1503	1011
RTI	73	1324	949
C1	78	1368	940

<u>Subjective opinions</u>
Subjects' opinions after the experiment are summarized in Table III. The pattern is that the 520 system is judged to be superior on all relevant counts. Inspecting the opinions on 'safety' it may be noted that the expert judgments on driving behavior were well replicated in the subject's opinions on this aspect: RDS Speech and the 520 system were the winners here. Among the losers the RTI system is an exception to the results of the expert judgment. Opinions on the YQ and C1 systems, as well as the RDS map condition, however, again scored in line with the behavioral expert judgments.

Table III. Percentage positive opinions on relevant aspects per system.

	Safety	**Effort**	**Desirability for own use**	**Overall**
RDS Speech	75	33	67	58
RDS Map	58	17	50	43
520	92	83	83	86
YQ	43	25	33	33
RTI	58	58	58	58
C1	57	88	50	65

DISCUSSION

The present study investigated the safety of a variety of real-time information providing devices relative to an accepted standard (driving while listening to radio conegstion information). Five devices were tested in a field experiment. the standard itself was compared to a control condition (just listening to the radio). Safety was evaluated on the basis of:
- Expert safety judgments.
- Subjects' performance.

- Subjects’ opinions.

The results showed that driving with this type of in-vehicle device is not necessarily to be considered less safe than driving with conventional congestion information. However, the variety in results across systems over a range of situations shows that there is still a dependency between the design of the system and the extent to which safety may be jeopardized.

Expert safety judgments and performance measures

Expert safety judgments for all systems were compared to those when driving while listening to congestion information on radio.

Driving behavior without congestion information in itself was judged to be safer than this standard.

The 520 and the RTI systems elicited driving of a quality that was comparable to that for the standard. The YQ and C1 systems were significantly less safe than the standard. Although this was not specifically evaluated in this study, informal observation suggests that these results are related to fairly elementary display and handling ergonomics. It may sound somewhat surprising, but it appears that there is still the need for the recommendation to devote more attention, in the design stage, to the appropriate use of color, the size of characters, the positioning of buttons, etc. The effects of the modality in which information is presented should also be mentioned here. On the one hand, systems that use visual displays permit, by nature, more driver self-pacing than having to listen to radio messages. Information from a visual source, while presented at a set moment, permit drivers to determine themselves when to take in congestion information. This may result in a decrease in mental workload, because drivers have the opportunity to adjust their interaction with the system in such a way that drivin performance will not be affected (1). However, the other side to visual information presentation is that it requires actually inspecting the display at some time, thereby producing some amount of visual workload which may, in turn, elicit unsafe driving behavior (2). Some systems tested here may have been worse than others in generating this type of workload.

Effects of manoeuvre type

The safety effects of RDS-TMC systems also turned out to be related to the specific manouevre to be performed. Interference was highest when negotiating intersections, priority intersections in particular. Also, the car-following and braking task showed that reactions to unexpected braking were significantly slower with an RDS-TMC system. Again, usability factors appeared often crucial (i.e., reach distance, distance between buttons, etc.).

Subjective opinions

Subjects’ opinions on the safety of the involved systems showed that, of the commercial systems, the 520 obtained highly favorable ratings, while those for the YQ were relatively unfavorable. The two remaining systems – RTI and C1 – rated about equal, without obtaining a clearly favorable rating. These results are in partial agreement with the expert judgments on driving behavior: the divergence is for the RTI system, that showed the same quailty as the 520 system in these judgments. It is not clear what may have caused this.

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