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A BEHAVIOUR AND INTERACTION STUDY FOR ASSESSING SAFETY IMPACTS OF A NEW ELECTRONIC CAR EQUIPMENT

Abstract

The study examines the impact of a new electronic in-car navigation system on driver behaviour with special reference to road safety. A sample of 25 drivers was accompanied before, shortly after and 6 months after implementation of the device in their own cars. They were navigated by the system from the same sources to the same destinations in all three study phases. A modified version of the Vienna driving test was used to count driving errors, conflicts and exposition data. Shortly after the installation of the system, drivers behaved safer then before, but after they had got used to the system and could anticipate what the device would be going to propose, drivers fell back to their original behaviour patterns. So, no overall, long-term safety impacts could be demonstrated on the routine routes.
In an additional study, 18 of the drivers were accompanied by the same observer in areas they did not know. The same data gathering logic was applied and situation-specific error rates for several driving manoeuvres were calculated. Results show no decrease in driving performance in comparison with the well-known areas with respect to error rates between the intersections. We interpret this finding as a gain in safety, because accident statistics prove, that driving in unknown areas is far more dangerous in terms of accident causation risks for strangers. Inside the intersections, error rates rose to the extent that we had expected from accident investigations compared to the routine routes. Here, no advantage could be drawn from using the navigation system.

1. Introduction

LISB is a navigation and information system currently tested in a large scale test in Berlin. Modern information technology supplies drivers on the road with current and individual route recommendations which are transmitted to and displayed in the cars.

The main aims of the system are to achieve

* shorter travel times
* more effective use of the existing road network
* less congestions and more economic and ecological driving
* more comfort

* gain of planning data, e.g. to optimize the signalling of junctions
* protection of residential areas by means of strategic recommendations
* more safety because of a better orientation of the drivers.

The last point is what we wanted to check in the studies described in this paper.

2. Operating Principles of LISB

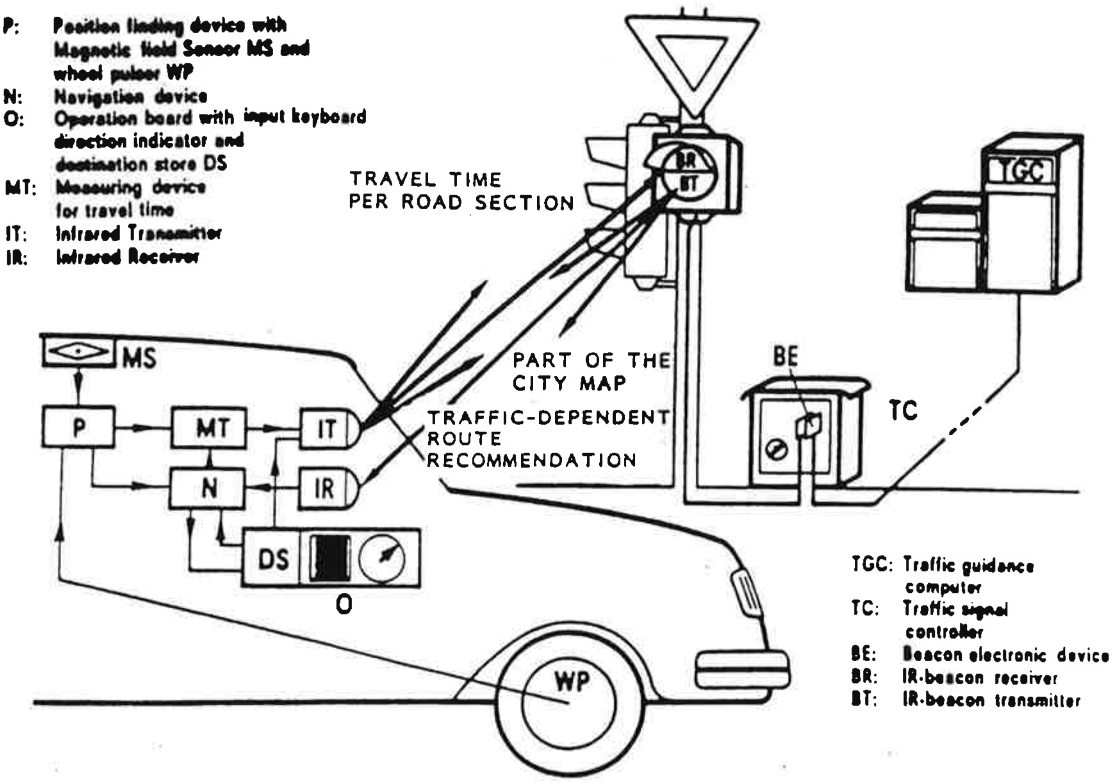


Illustration 1. Operating principle

The basic components of the system are information beacons installed at 220 selected traffic lights in Berlin. They transmit navigation information to some 700 vehicles with the necessary reception equipment. A traffic navigation computer determines which route should be used to reach a given destination based on the principle of central route search. To determine the best suitable route the computer requires current traffic data, which it gets from the equipped cars by means of infra-red transmission to the beacon receivers.

Illustration 2 shows the in-vehicle display unit and the entry keyboard for the desired destination.

At the beginning of the trip the driver enters the coordinates of his destination via the keyboard. The coordinates can be looked up in a digitalised map. Frequent destinations can be stored electronically as well. On entering the destination at the beginning of the trip, the driver at first only receives the air-line direction of and the distance to his destination, as the crow flies (see No. 2 in illustration 2). In this mode he has to decide himself which route to take. Passing the first beacon-equipped intersection, the car starts getting navigated by the computer in a traffic-dependent way.

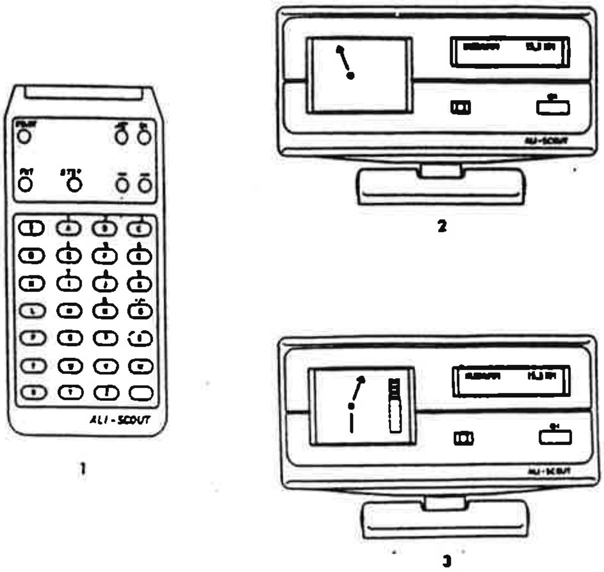


Illustration 2. Entry keyboard and display unit

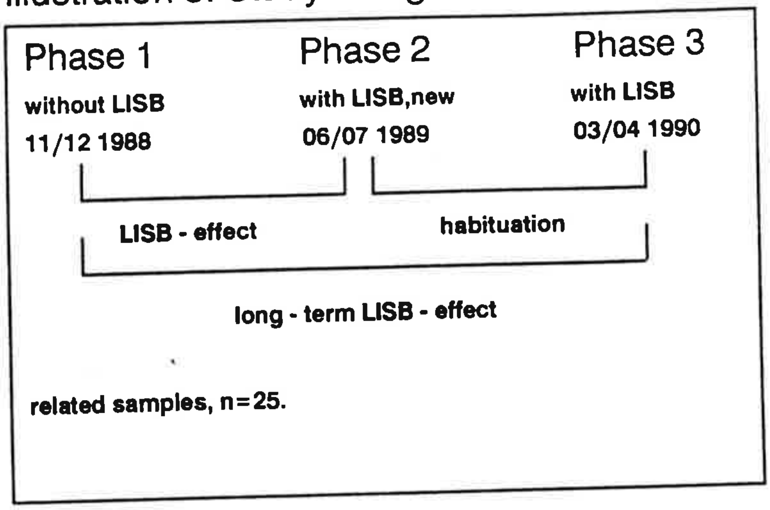
In this beacon-supported mode the process of recommending a route is as follows (see Part 3 in illustration 2): The arrow, which can take 16 different positions indicates the direction of travel. The bar graph is used to clearly indicate a turn-off point. When the direction display comes on, the entire graph is visible. The closer the car comes to the turning point, the more the bar graph shrinks and vanishes when the turn-off point is reached.

In addition to having the navigation information displayed visually the driver may also choose to have it read out by voice output. Another system feature is the recommendation of traffic lanes in the approach to intersections, displayed visually and/or acoustically. For a detailed description of the technical operating principles and the algorithms of the navigation computer see Hoffmann et al. (1987).

3. Study Design and Observation Method

To get an idea of if and how the system has an impact on safety and driver behaviour, we studied a sample of 25 drivers out of the 700 in total in the large scale test. These selected drivers were accompanied by an observer at three different project phases (see illustration 3): without LISB, shortly after the installation of LISB and after the drivers had got used to the system.

Illustration 3: Study Design



In each phase the same drivers drove in their own cars from the same source to the same destination but , of cause, not necessarily on the same route. They drove at the same weekdays and times of day in all three phases. Most of the trips were from home to work or vice versa.

How can you get information about safety in such a case? We decided to work with a modified version of the "Vienna Driving Test", developed by Risser and colleagues (Risser & Brandstätter (1985). The observer scored errors of the drivers and traffic conflicts on a standardized observation sheet.

The observer also collected several kinds of exposition data: he described the characteristics of road segments and intersections by indicating their type in the top row of the sheet. In addition, he counted the frequency of different manoeuvres of the drivers. e.g. lane-changing, overtaking and turning manoeuvres. The idea is to have these measures as exposition information. So we could calculate error rates for different driving tasks in defined classes of the traffic environment.

Illustration 4: Observation Sheet

SHEET _____ situation type Driver Behaviour	C1 C2 C4 C6 C8 A		C1 C2 C4 C6 C8 A		C1 C2 C4 C6 C8 A		C1 C2 C4 C6 C8 A		C1 C2 C4 C6 C8 A	
Display Running (E=Error)										
Speed too fast Speed too slow Inadequate acceleration Inadequate deceleration										
Headway too short Distance too small left Distance too small right										
Lane change left (E=Error) Lane change right (E=Error) Overtaking (E=Error) Lane traversed (E=Error) Road narrows (E= Error)										
Signalling too late(l) too early(E) No signalling when necessary Other signs (+pos./-neg.)										
Adjusted too late Adjusted wrong lane Deceleration too late										
Traffic light error Insufficient attention Right turning error Left turning error										
Impedes cyclist/pedestrian Endangers cyclist/pedestrian										
Conflicts Miscellaneous										

4. Main Results

1. The observation method worked well. The observer was able to score all information - though I should mention that he was a very skilled person especially in working with the road and intersection taxonomy, which he had helped to develop. The event classification proved to be quite complete and detailed enough for the purpose of our study. We can therefore recommend this kind of data gathering logic for similar studies.

2. Exposition data showed marked changes with respect to the types of roads and intersections used. With LISB the proportion of main roads rose and the relative number of signalised junctions grew. The number of lane-changing, overtaking and turning manoeuvres went down.

3. With only few exceptions the error rates followed a V-shaped distribution over the three different investigation periods: After the introduction of the navigation system drivers behaved safer and drove more cautious and exact. The overall error rate dropped significantly from 32 to 27 percent. The number of speed errors was smaller than before. Nine month later, nearly all of these positive effects had vanished or at least had become smaller; the overall error rate was up to 30% again at that time.

Illustrations 5 and 6 give more detailed information about the changes in the error rates. A detailed discussion is given by the report (Galsterer, Fastenmeier & Gstalter, 1990).

Illustration 5. Error rates

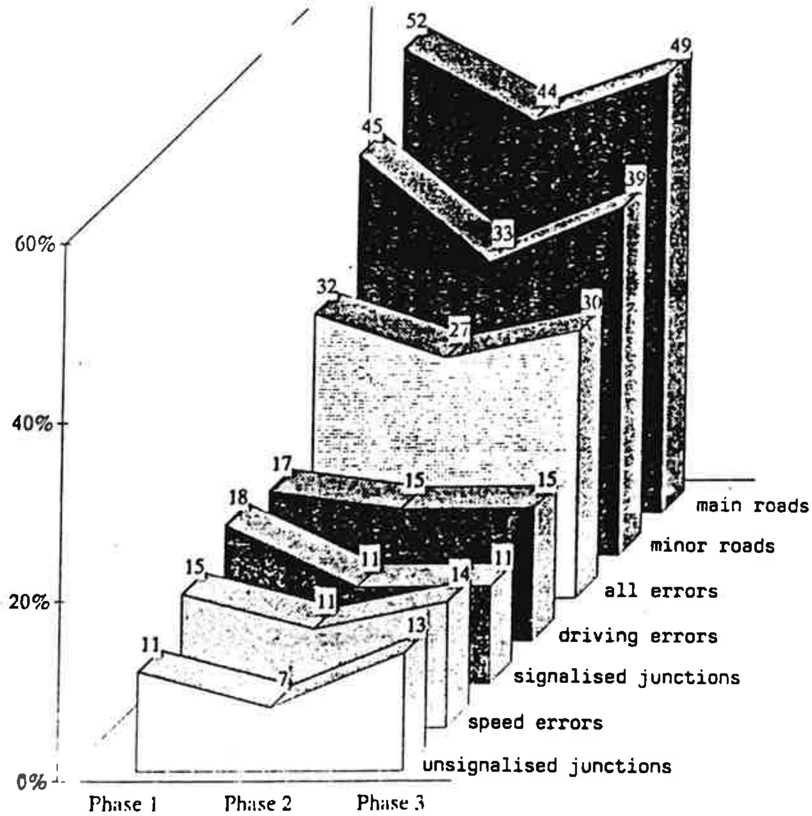
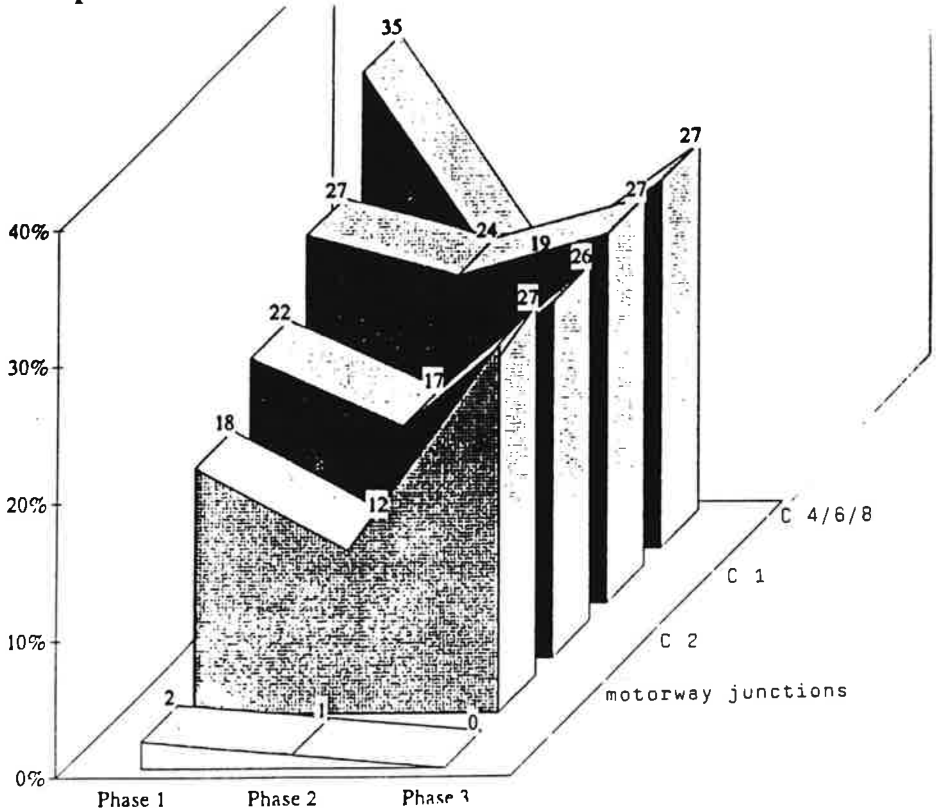


Illustration 6. Speed error rates for different kinds of roads



Without going into the details too far we will try to give you a comprehensive interpretation of these results. At the beginning of the navigation recommendations - in phase 2 - the drivers did not know what streets would be recommended to them by the system. They were very alert and paid much attention. Will the system give a recommendation or not? What driving manoeuvres will be forced by the advice of LISB? In this situation the drivers could not anticipate the future recommendations and decisions of the LISB system. A longer term planning - across various sections of roads and junctions - was not possible and that meant that certain manoeuvres lost their sense. Changing to a lane with faster traffic or overtaking were not really useful any more, if the driver did not know what the system was going to propose in the next moments. The same explanation holds true for the fewer speed errors in phase 2 of our experiment. In total, driving behaviour was more cautious and controlled to be ready to react with lane-changing or turning manoeuvres if the navigation system would give a recommendation. To use a metaphor for this kind of behaviour, we said that the drivers had been on a dog's lead.

Nine month later this effect was gone. Our explanation is, that it is a typical habituation effect. The initial tension and attention had become routine. During the nine months that the drivers had been guided from the same sources to the same destinations they had been driving all variations of streets possible. If a system message came now at the beginning of the trip, the driver could clearly guess which alternative would be used that particular day. And that meant that longer term planning was possible again and the driving behaviour shifted into the direction of the initial behaviour.

To sum up, the LISB-effect and the habituation effect defined as in illustration 3 have both occurred. Because they change the driving behaviour into opposite directions, no overall, long-term effect could be observed in our study.

5. LISB in Unknown Areas

The usefulness of a navigation system like LISB should clearly increase with decreasing knowledge of the area the driver has to find his way in. The orientation task increases the mental workload of the driver and less cognitive resources are left for the guidance and control level of the driving task.

The increased accident risk of strangers could be demonstrated lately by Engels & Dellen (1989). They analysed all injury accidents in Germany's towns with more than 100 000 inhabitants from 1979 to 1988 that had occurred between one native and one strange driver. If the accident risk would be the same in both populations, the proportion of accident causation should be equal in both samples. This hypothesis could be rejected clearly: the average accident causation proportion was 23% higher than could be expected by chance for the strange drivers.

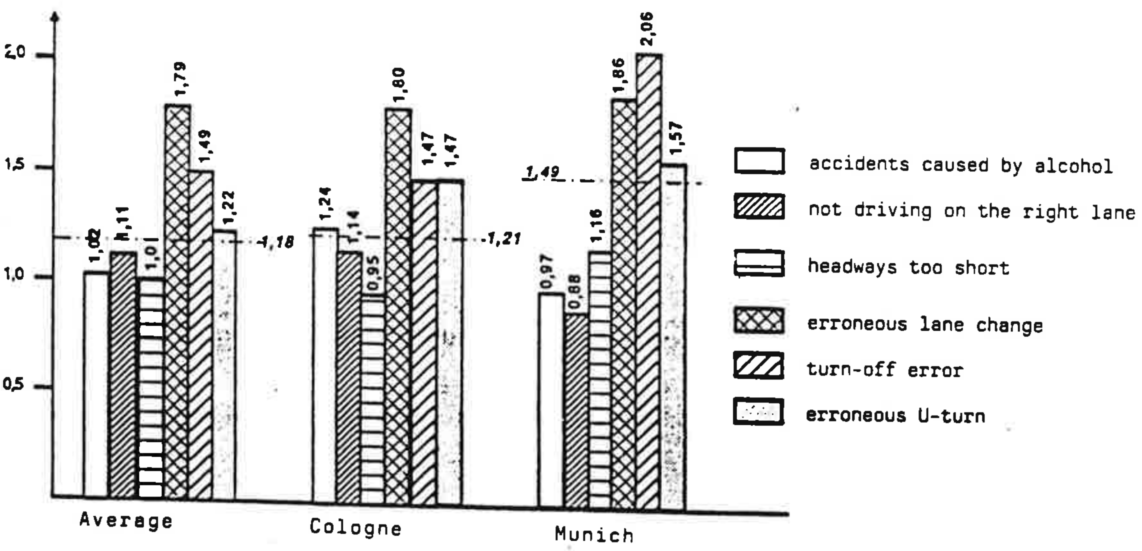


Illustration 7: Strangers accident causation risk

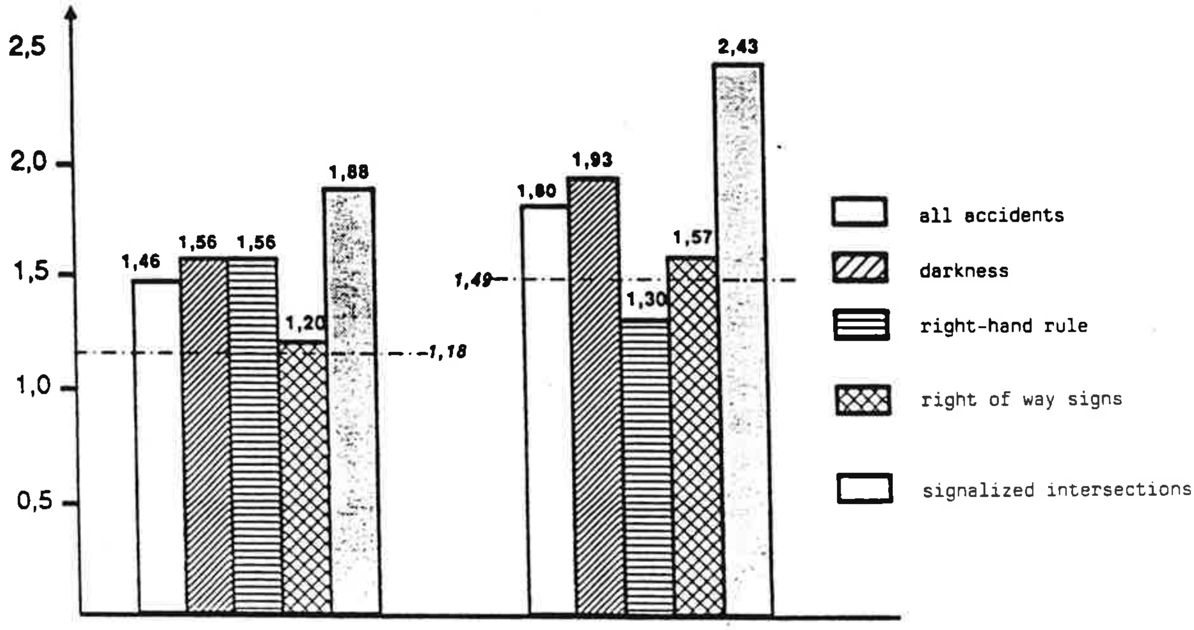


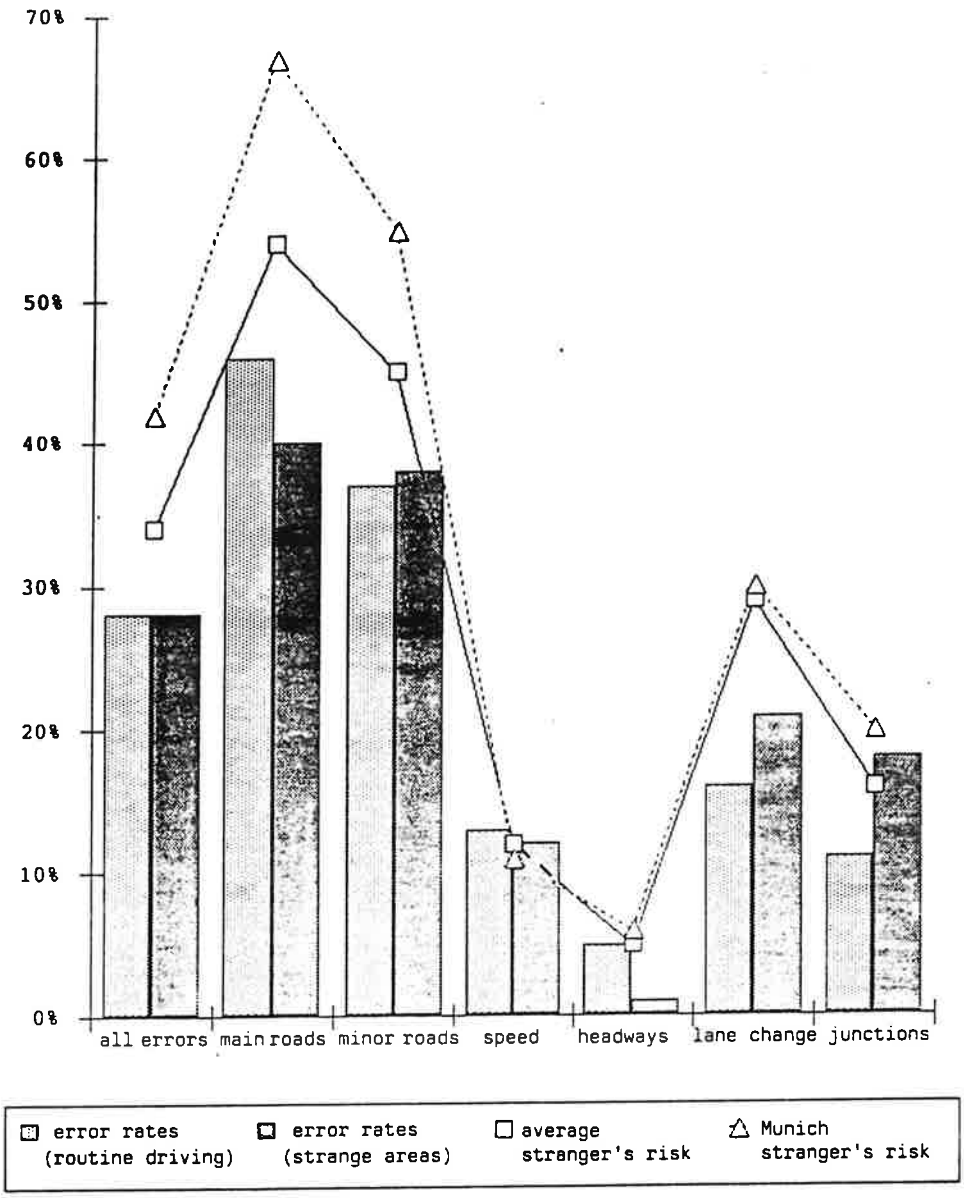
Illustration 8: Strangers risk at intersections

Obviously, those accident types which can often be explained by difficult orientation are overrepresented for drivers in unknown traffic networks. Knowing these relations we were curious what would happen if we had our LISB- subjects drive in Berlin areas that they did not know and we use our error counting methodology once again.
So we let 18 of our original subjects make a trip in an unknown part of the Berlin network and held all other independent variables constant to be able to compare their driving performance with the phase 3 results.

Illustration 9 gives a summary of the main results.

The illustration shows the error rates for the routine routes in phase 2 (left column) and the corresponding values for the strange areas (right column). The rectangular and the triangle represent estimates of an expected error rate value that we had calculated using the average accident risks for strangers (rectangular) and for Munich respectively (triangles). Unfortunately, no data exists for Berlin from the accident study.

Illustration 9: Comparison of error rates



The total error rate remained unchanged. The expected rate was clearly higher, so we conclude that the navigation system had been helpful. The next two pairs of columns show the error rates on broad main roads (C1/C2/A) and on minor roads (C4/C8). Here the influence of LISB is quite clear: Error rates between the intersections do not rise in strange areas but even show a strong tendency to drop, whereas the normal strangers risk is high for these classes. Obviously, the early announcement of the travel direction, the lane recommendation and the bar graph had been a powerful means of supporting the drivers orientation task. Thus, the approach to intersections is very effectively supported by the device.

Errors in speed (driving too fast) and distance (too short headway) are not specific for the orientation problem. Therefore, the accident causation risk is equal for these accident types for native and strange drivers. For that reason we did not expect the error rates to change in the unknown environment. Indeed, speed and distance errors even went down in the new study.

A different result could the observed in the intersections: Error rates went up for all types of errors inside the junctions in the strange parts of the road networks. Indeed, LISB has nothing to offer to help the drivers in their orientation tasks **inside** the junctions. The rise of the error rate for all intersection errors is as big as we had expected from the strangers risk data.

The structure of the accident risk data and of the error rate data show a very interesting correspondence that should attract some more attention in the future.
Perhaps, there is a good chance to arrive at some kind of construct-validation of error data concerning road safety that way.

6. References

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