Proceedings of ROADS AND TRAFFIC SAFETY ON TWO CONTINENTS in Gothenburg, Sweden, 9-11 September 1987

- Driver Behaviour and Licensing
- Alcohol and Drugs
- Driving and Elderly
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PREFACE

The Swedish Road and Traffic Research Institute (VTI) and the US Transportation Research Board (TRB) of the National Research Council were jointly organising this international conference. The objective was to cover the present and future road research with special emphasis on the Strategic Highway Research Program (SHRP), as well as the research concerning drivers and vehicles as related to highway safety.

Under development for 2-3 years, SHRP is a fully funded, $150 million (US), five year program of research directed at asphalt, concrete and structures, highway operations, and long term pavement performance.

In the different road safety sessions there were presentations of actual research in different countries and discussions of the differences that exist between Europe and the USA, trying to explain the reasons for them and examine whether they are reasonable and acceptable.

In the sessions of roads, the emphasis on the Strategic Highway Research Program (SHRP) was intended. Presentations did highlight differences between European and US practices and needs, and the discussions was concentrated on how to promote international involvement in SHRP and application of its research.

Linköping January 1988

Kenneth Asp

Proceedings of ROADS AND TRAFFIC SAFETY ON TWO CONTINENTS in Gothenburg, Sweden, 9-11 September 1987:

VTI RAPPORT 328 A
- Opening
- Traffic Safety - Open Session
- Traffic Safety - General

VTI RAPPORT 329 A
- Long Term Pavement Performance
- Asphalt

VTI RAPPORT 330 A
- Highway Operations
- Concrete and Structures

VTI RAPPORT 331 A
- Driver Behaviour and Licensing
- Alcohol and Drugs
- Driving and Elderly

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Dr Anders Hedin, Dept of Ophthalmology, The Karolinska Institute, Mr Jan Törnros, VTI, Sweden

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Dr R Wade Allen, Systems Technology Inc, USA

#### DRIVER RISK-PERCEPTION IN SPAIN AND THE USA
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#### THEORETICAL REQUIREMENTS FOR DRIVERS LICENCE IN AUSTRIA
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DRINKING AND DRIVING: INSTITUTIONAL AND SOCIAL ASPECTS OF LAW ENFORCEMENT
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ENFORCEMENT OF DRINK-DRIVING LAWS BY USE OF "PER SE" LEGAL ALCOHOL LIMITS: BLOOD AND/OR BREATH CONCENTRATION AS THE DEFINITION OF IMPAIRMENT
Dr A Wayne Jones, Department of Alcohol Toxicology, National Laboratory of Forensic Chemistry, Sweden

DRIVER IMPROVEMENT AND REHABILITATION OF DWIS. THE INFLUENCE OF AMERICAN APPROACHES ON THE ESTABLISHMENT OF TREATMENT PROGRAMMES IN CENTRAL EUROPE
Dr Edgar Spoerer, Inst for Education, Perfection and Driver Improvement, The Federal Republic of Germany
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VTI RAPPORT 331 A
DRIVING AND ELDERLY

EXPERIENCES IN FATALITIES BY AGE AND ROAD USER GROUPS - USA VS. WESTERN EUROPE 1970-1983
Prof Ruediger Lamm, Dr Elias M Choueiri, Clarkson University, USA, Dr Juergen H Kloeckner, Federal Republic of Germany

ELDERLY DRIVERS IN EUROPE
Prof Kåre Rumar, VTI, Sweden

CONSEQUENCES OF TRAFFIC INJURIES IN SENIOR CITIZENS
Dr Claude Hamonet, Dr A. M. Begue-Simon, F. Borgel, Henri Mondor, University of Créteil, G Dobias, laboratoire Athéna, M Muhlrad, INRETS, France

DRIVING AND THE ELDERLY
Prof Günther Kroj, Bundesanstalt für Strassenwesen (BAST), The Federal Republic of Germany
ABSTRACT

The papers presented at the seminar were as follows: A Method for Studying the Effect of Visual Field Defects, which could be a Tool when Formulating Standards for Visual Fields (Loevsund, P, Hedin, A and Toernros, J); Crash Avoidance Models and Driver/Vehicle Handling (Allen, RW); Driver Risk Perception in Spain and the USA (Sivak, M and Soler, J); Theoretical Requirements for Drivers Licence in Austria (Michalik, C); Computerized Driver Aptitude Testing in Austria by means of the Act & React Test System (Michalik, C); Why can we Expect new Scandinavian Driver Education Programmes to set International Standards and Improve Future Skills of new Drivers? (Nygaard, B); Effects of Minimum Drinking Age on Highway Fatalities in the United States (Hoxie, P and Skinner, D); Licence Removal at time of Arrest for Driving While Intoxicated. An Approach with Promise in the United States (Lacey, J); Drinking and Driving: Institutional and Social Aspects of Law Enforcement (Jayet, M); The Drinking and Driving Problem in Norway. The Scandinavian Approach. Success or Failure? (Assum, T and Glad, A); Enforcement of Drink-Driving Laws by use of per se Legal Alcohol Limits. Blood and/or Breath Concentration as the Definition of Impairment (Jones, A); Driver Improvement and Rehabilitation of DWIS. The Influence of American Approaches on the Establishment of Treatment Programmes in Central Europe (Spoerer, E and Ruby, M); Experiences in Fatalities by Age and Road User Groups. USA vs Western Europe 1970-1983 (Lamm, R, Choueiri, E and Kloeckner, JH); Elderly Drivers in Europe (Rumar, K); Consequences of Traffic Injuries in Senior Citizens (Hammonet, C, Bgue-Simon, AM, Borgel, F, Mondor, H, Dobias, G and Muhrad, M); Driving and the Elderly (Kroj, G).
WEDNESDAY SEPTEMBER 9

9.30 OPENING

Opening speeches
Mr Å Norling, County Governor, Gothenburg, Sweden

Objectives of the conference
Mr K.B. Johns, Director, Transportation Research Board, (TRB), USA
Mr Hans Sandebring, Director General, The Swedish Road and Traffic Research Institute (VTI), Sweden

9.45 Roads and Traffic Safety
Safety and SHRP from the Viewpoint of the States
Mr John Tabb, President of AASHTO, USA

10.15 An introduction to the Strategic Highway Research Program (SHRP)
Dr Damian Kulash, Executive Director of SHRP and Dr Thomas Larson, Chairman of SHRP, USA

11.15 European Trends in Road Safety and Road Safety Research
Professor N O Jergensen, Technical University, Denmark

11.45 Traffic Safety Research in the FHWA and the United States
Mr David Phillips, Associate Administrator, R & D Technology, Federal Highway Administration, USA

PROMETHEUS — The European Automotive Industry Research Project
Dr Tage Karlsson, AB Volvo, Sweden

12.30 LUNCH

LONG TERM PAVEMENT PERFORMANCE

14.00 – 17.00
Chairman: Dir Kaare Flaate, Head of the National Road Research Laboratory, Norway

Long Term Pavement Performance Portion of SHRP
Mr James Brown, Engineer of Pavement Design, Texas, State Dept of Highways and Public Transportation, USA
Mr Ray Forsyth, Chief Transportation Lab, California Dept of Transportation, USA

The Role of Long Term Pavement Performance Monitoring as a Link between Research and the Implementation of Pavement Management Systems in Switzerland
Dr Ivan Scassiga, Swiss Federal Institute of Technology, Switzerland

Pavement Management Research in the Federal Republic of Germany
Dr Gerhard Schönberger, Staatliche Technische Überwachung, the Federal Republic of Germany

The Research of LTTP in France
Dr J Bonnot, Laboratoire central des ponts et chaussées, France

The LTTP Research in the Nordic Countries
Dr Ermann-Larsen, Road Research Laboratory, Denmark

17.00 – 18.30 BREAK

18.30 – 21.00
Full Scale Pavement Research in the United Kingdom
Dr Norman W Lister, TRRL, England

The Finnish Pavement Research Program 1987 – 92
Esco Saarela, Technical Research Center of Finland

Accelerated pavement testing — the OECD program
Dr Ivan Scassiga, Swiss Federal Institute of Technology, Switzerland

U.S. Accelerated Pavement Testing Facility
Dr David Anderson, Penn. State Univ., USA

Panel discussion

TRAFFIC SAFETY — GENERAL

14.00 – 17.00
Chairman: Dir David Phillips, Federal Highway Administration, USA

The OECD Road Transport Research Programme
Director General Hans Sandebring, VTI, and Chairman of the OECD Road Transport Research Programme

Traffic Safety Research Policy in the United States
Dir K.B. Johns, Transportation Research Board (TRB), USA

R & D Policy in France in the field of Road Safety
Director General G Dobias, Institut National de Recherche sur les Transports et leur Sécurité (INRETS), France

Road Safety Research in the Federal Republic of Germany
Prof Dr H Praxenthaler, Head of Bundesanstalt für Strassenwesen (BAST), the Federal Republic of Germany

Road Safety Research — Possible European Cooperation
Dr A Hitchcock, Head of Safety and Transportation Group, Transport and Road Research Laboratory (TRRL), U.K.

Discussion on how to improve the cooperation between Europe and the United States within the field of traffic safety research.

DRIVER BEHAVIOUR AND LICENSING

14.00 – 17.00
Chairman: Prof Kåre Rumar, The Swedish Road and Traffic Research Institute

A Method for Studying the Effect of Visual Field Defects, which could be a Tool when Formulating Standards for Visual Fields
Dr Per Lovsund, Dep of traffic safety, Chalmers technology, Sweden

Crash Avoidance Models
Dr Wade Allen, Principal Research Engineer, Systems Technology Inc, USA

Driver Risk Perception in Spain and the USA
Dr Michael Sivak, University of Michigan, USA

Theoretical Requirements for Drivers License in Austria
Dr Ch. Michalik, Kuratorium für Verkehrssicherheit, Wien

Why can we expect New Scandinavian Driver Education Programmes to set International Standards and Improve Future Skills of New Drivers?
Dr Birger Nygaard, VTI, Sweden

Discussion

VTI RAPPORT 331 A
Panel discussion

Overview, Sweden
Dr Kent Gustafsson, VTI, Sweden

Highway Snow and Ice Control — Nordic and control Systems
Dr L-E Bergfalk, National Road Administration, Sweden

Asphalt Characteristics Portion of SHRP
Mr A D Andreas, Dep secretary of Transportation, Washington DOT, USA

Driving and the Elderly
Mr Stephen R Godwin, Senior Program officer, Transportation Research Board, USA

Chairman: Mr Francis Francois, Executive dir of AASHTO, USA

Chairman: Dr General George Dobias, INRETS, France
Effects of Minimum Drinking Age on Fatalities in the United States
Mr John H Lacey, Program manager — Alcohol Studies, Univ of North Carolina, USA

License Removal at Time of Arrest for Driving While Intoxicated:
An Approach with Promise in the US
Mr Paul Hoxie, Transportation Systems Center, USA

Dr J Bonnot, Laboratoire central des ponts et chaussées, France
Bituminous Binders — Nordic Overview

Dr OIEEE Ruud, Norway
Dynamic Testing of Recycled Asphalt

Chairman: Prof Dr H Praxenthaler, Head of the Road and Traffic Research Laboratory (SLG), 3 M Europe Switzerland

Asphalt and Drugs — OPEN SESSION
Chairman: Dr A Hitchcock, TRRL and Chairman of the COST Technical Committee on Transport

Highway through Towns — Road with Safety and Environmental Priority
Winner of the 1986 Volvo International Traffic Safety Award

Dr Otto Schiötz, The Road Directorate, Denmark

Volvo Safety Design Philosophy
Anders Eriksson, Volvo Car Corp, Sweden
An Evaluation Study of the Effectiveness of a Combination of Enforcement and Information on Improving Seat Belt use

Dr C M Gundy, Institute for Road Safety Research (SWOV), Netherlands

Road Traffic Signing on Two Continents — A call for Harmonization
Dr Michael Bernhard, Swiss Lighting Assoc (SLG), 3 M Europe Switzerland

Road Sign Research in the Federal Republic of Germany
Prof Dr Siegfried Giesa, Hessisches Landesamt für Strassenbau, the Federal Republic of Germany

Discussion

LUNCH

13.30—17.00
Chairman: Dr L-E Bergfalk, National Road Administration, Sweden

Chairman: Dr K.B. Johns, Transportation Research Board, USA
Experiences in Fatalities by Age and Road User Groups — USA vs Western Europe 1970—1983
Prof Ruediger Lamm, Clarkson University, USA

Elderly Drivers in Europe
Prof K &e Rumav, VTI, Sweden
Driving and the Elderly
Mr Stephen R Godwin, Senior Program officer, Transportation Research Board, USA

Chairman: Mr Francis Francois, Executive dir of AASHTO, USA

Chairman: Dr General George Dobias, INRETS, France
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Discussion

19.00 Presentation of the winner of the 1987 International Volvo Traffic Safety Award and music played by the Gothenburg Philharmonic Ensemble

20.00 COCKTAIL AND DINNER
### FRIDAY SEPTEMBER 11

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### 12.00 LUNCH AND CLOSING REMARKS
A METHOD FOR STUDYING THE EFFECT OF VISUAL FIELD DEFECTS, WHICH COULD BE A TOOL WHEN FORMULATING STANDARDS FOR VISUAL FIELDS.

Per Lövsund*, Anders Hedin**, Jan Törnros***

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**Department of Ophthalmology, The Karolinska Institute, S-104 01 Stockholm, SWEDEN
*** Swedish Road and Traffic Research Institute (VTI) S-581 01 Linköping, SWEDEN

The extent of the visual field has a theoretically great significance for driving. It has, however, been hard to prove its importance in practical driving. One of the reasons for this difficulty has been the fact that crude methods were used for measuring the fields. When perimetry was used in a recent study, it was shown that subjects with bilateral field defects were significantly more often involved in accidents.

This lack of knowledge has meant a large difference in standards between countries in the world. In Europe as well as in the United States, there are regulations for professional drivers. When it comes to passenger car driving, there are, however, European countries with no demands on the visual field at all. In the US, some states have standards and others not and the current ones differ widely.

In Europe, the most common requirement is one normal field. In the US a minimum extent of the horizontal meridian is mostly needed. These differences probably depend on the different methods used for field testing. Perimetry, the ideal method, is expensive and time-consuming. Confrontation methods are crude and only disclose large peripheral defects. A moveable object or a few test lights in the horizontal meridian unmask at best only deep scotomas in those areas.

When considering the introduction of standards for visual fields, it is first necessary to determine the influence of the various defects on the driving performance. It is extremely difficult to standardize a practical driving test. It can be done in a simulator, however, and in the present study the detection capacity of two groups of normals and a number of subjects with visual field defects was studied in the driving simulator at VTI in Linköping.

On a screen quadratic light stimuli of three different sizes are generated, one at a time, in any of 24 different positions and the reaction time is measured. In the groups of normals, the median values for the reaction times are fairly homogenous. There is a slight difference between the central and peripheral stimuli, which is somewhat larger among the older volunteers. Among the subjects with visual field defects the individual variations are very dominant. Most subjects do not compensate the deficiency, which indicates the need of standards for visual fields.
A METHOD FOR STUDYING THE EFFECT OF VISUAL FIELD DEFECTS, WHICH COULD BE A TOOL WHEN FORMULATING STANDARDS FOR VISUAL FIELDS

Per Lövsund*, Ph.D., Anders Hedin**, M.D., Ph.D., Jan Törnros***, M.A.

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** Dept. of Ophthalmology, The Karolinska Institute,
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*** Swedish Road and Traffic Research Institute (VTI),
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1. INTRODUCTION

It has long been considered important for traffic safety that the visual fields of drivers are normal or near-normal. In theory, normal fields make possible the early detection of objects in the peripheral field. Although there are cases where a visual field defect most probably has influenced an accident, it has been difficult to prove the importance in large-scale studies. The low frequency and the multifactorial causes of accidents set a demand for very large driver groups followed for several years. In several large-scale studies, it was nevertheless not possible to prove a correlation between the extent of the visual fields and the driving performance (Council & Allen, 1974; Henderson & Burg, 1974; Hills & Burg, 1977; Cole, 1979). In these studies, however, non-standard perimetric techniques were used and only the horizontal meridian was tested.

In a more recent study incorporating over 17,000 volunteers, it was found that subjects with bilateral visual field defects had a rate of accidents more than twice that of other drivers (Johnson & Keltner, 1983). In this study a fast but accurate perimetric procedure was followed.

Subjects with visual field defects usually claim that they learn to see in the blind areas by frequent eye and head movements. Drivers, almost without exception, deny any problems with detection in the direction of the blind zone.

The divergence of scientific data and opinions has had two consequences: it is extremely difficult to set a standard for the visual field of driving applicants, and to make up rules for which experienced drivers should be given a waiver for their field defects. Therefore, standards differ widely between countries as does the attitude to dispensation. Of the two problems, the former is easier to describe since the standards are found in the statutes on licenses. In Europe as well as elsewhere, there are regulations for professional drivers. When it comes to passenger car driving, there are, however, countries with no demands on the visual fields whatsoever. This category will be further discussed below with examples from some representative nations:

Great Britain: No standard. 'Any considerable deterioration of the binocular field should be regarded as a defect which renders driving a hazard and a prospective disability.' '... it is reasonable to suggest that \( <90^\circ \) is unsafe...'
France: Defects-of-importance are peripheral restrictions in one-eyed subjects and those with an acuity <0.2 in the other eye. Hemidefects should be judged by a 'specialist'. If the visual acuity is not less than 0.8 in each eye, 30° + 60° horizontally and 20° + 40° vertically is sufficient.

West Germany: A normal visual field of one eye or of the two eyes together.

Holland: 40° nasally and 80° temporally in driving applicants. 100° more in one-eyed subjects. At renewal of licenses, 100° less is necessary.

The Nordic countries: In Denmark, all bilateral defects must be judged by the National Health Authority. In Finland, there is no standard. In Norway, one eye must have a normal visual field. The Swedish standard corresponds to the West German.

It follows that there is a great divergence even between neighbouring countries (cf Finland and Sweden). Some countries set a standard for the whole field, others for certain meridians. If a figure given for a meridian should have any meaning, one must also specify test procedure; this is not always done.

In Japan, there is no standard for the visual field in passenger car drivers. In Canada, the extent of the horizontal meridian must be binocularly 120°. In the United States, there is a large difference between states. To the best of our knowledge, only 20 states have visual field standards. Without exception, they only concern the horizontal meridian, and values between 100° and 140° are given. In the other states, there is no visual field test although such a standard has been discussed in several of them.

The extent of a field meridian depends on the contrast and size of the test object. It is usually recommended a round object to be moved in a circular pathway from behind the testee. A large object with high contrast to the background is observed further peripherally; differences in test procedure thus make possible large variations in the field size measured.

A special American problem concerns the possibility in certain states to drive with a telescopic device which increases visual acuity. It is impossible to fulfill reasonable visual field demands when wearing such a biotic aid, and their use has been questioned (Fonda, 1983). In practice, it is said that most drivers rather use the full visual field than the better acuity given by the glasses.

The brief description above should make evident the large differences between the character and the extent of the standards in different countries and also the importance of the test procedure. The recent Californian study by Johnson & Keltner (1983) shows that bilateral field defects are of importance for traffic safety. Our own simulator study, described below, has concentrated on the possible compensatory mechanisms in subjects with homonymous visual field defects.

2 METHOD

This study has been undertaken in the driving simulator at VTI (Swedish Road and Traffic Research Institute) in Linköping, where the detection capacity of normals and subjects with visual field defects as well as one-eyed drivers has been studied.
The volunteers drive a real car body in a computer generated landscape projected on a wide-angle screen by three colour-TV-projectors. On the screen flickering (6 Hz) black and yellow quadratic light stimuli of three different sizes are presented. The stimuli appear randomly, one at a time, in any of 24 positions, located in areas of traffic safety and ocular pathology interest (Fig. 1).

The volunteer has to drive with a speed of 100 km/h on the right side of the road and respond to a stimulus by immediate braking. The driving task is rather difficult and it demands constant attention.

Through the method, which is further described by Lövsund & Hedin (1986) and Hedin & Lövsund (1986), both the detection and the driving capacities are measured.

By this method two groups of volunteers with normal visual acuity and fields have been tested, 10 in each group, one group aged 20-30 and the other 50-60. 30 subjects with visual field defects have been studied so far. Also one-eyed subjects and normals wearing spectacles have been tested.

3. RESULTS

In this paper just a summary of the results will be presented, as the study will continue and the method will be further developed.

The volunteers usually showed good driving capacity with no correlation to visual field defects.

The detection capacity, however, varied to a great extent among the different groups of volunteers. In the groups of normals the median values were about 0.8 s with small differences between the reaction times for central and peripheral stimuli. The differences were somewhat larger among the older volunteers and especially pronounced for the smallest stimulus (Fig. 2).
Among the volunteers with visual field defects the individual variations were very dominant and no correlation between the type or the localisation of the field defect and the ability to compensate was found. Out of these 30 subjects with different kinds of visual field defects we found just four persons compensating for their field loss (Table 1).

Table 1 Number of subjects with different types of field defects and their ability to compensate for the defect (-impaired detection capacity, + compensation)

<table>
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<tr>
<th>Number of subjects</th>
<th>Type of field defect</th>
<th>Compensation ability</th>
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<tr>
<td>2</td>
<td>Local scotoma</td>
<td>- +</td>
</tr>
<tr>
<td>3</td>
<td>Irregular defects</td>
<td>- - -</td>
</tr>
<tr>
<td>4</td>
<td>Partial quadrant</td>
<td>- - + +</td>
</tr>
<tr>
<td>7</td>
<td>Quadrant</td>
<td>- - - - - - - - -</td>
</tr>
<tr>
<td>8</td>
<td>Partial hemidefect</td>
<td>- - - - - - - - - - -</td>
</tr>
<tr>
<td>6</td>
<td>Hemidefect</td>
<td>- - - - - +</td>
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4. DISCUSSION

As it is very difficult to measure in a standardized way the detection capacity in real traffic, this method was developed. The driving task in the simulator is considered quite realistic, but no validation studies have so far been undertaken. Through this method it is probably possible to gain knowledge that could be a base when formulating standards for visual fields and hereby get a harmonisation between different countries.

This study shows that most subjects with homonymous defects cannot compensate for their deficiency. Neither this study nor Johnson & Keltner (1983) give any clue to which field defects could be accepted without lost...
safety. It is reasonable to assume that defects in the central field are more important than peripheral ones, that deep scotomas are more significant than shallow, and that the horizontal meridian is the most traffic relevant. Unfortunately, the knowledge necessary will demand further studies of very large scale.

In any case it is important that the defects will be discovered. Some countries, like Sweden, have a fairly strict visual field standard but a crude method for screening license applicants. Here, it is assumed that the "health declaration" signed by each applicant should disclose all diseases which could give rise to a field defect (all these subjects examined with perimetry).

Only perimetry discloses all visual field defects of traffic safety importance. Automatic perimetry can be performed in a short time (Johnson & Keltner, 1983) but calls for expensive equipment. Furthermore, in spite of the few minutes required, it has been calculated that a very large amount of manpower would be needed if perimetry were introduced in the US. An even faster "ergoperimeter" might be the solution, or another screening procedure that would make it possible to pick up the few applicants with visual field defects of importance.

Just four of the 30 volunteers did compensate. Those persons had different types of abnormalities. These persons are at present being compared with others with the same type of visual field defects. This is done in a parallel study by recording the eye movements both at driving in the simulator and in real traffic. A NAC eye mark recorder (model V) is used, which records the eye movements of the driver superimposed on his/her visual field of view. Such recordings have so far been made with a couple of subjects in the driving simulator. Some very preliminary results point to differences in the eye movement patterns. One subject with the ability to compensate for his defect thus appears to have scanned his "blind" area repeatedly at very short time intervals, whereas this appears not to have been the case for another subject lacking this compensation ability. If the results could be used for training persons with visual field defects is too early to say.

In Sweden one-eyed persons are allowed to drive a passenger car after an adaptation period of six months. Even this standard varies between different countries. So far we have just managed to test two one-eyed persons; one compensating and the other not. Thus we cannot support the opinion that one-eyed persons more often run into collisions than normals as is claimed by Keeney & Garvey (1981).

ACKNOWLEDGEMENT

The project has been financed by the Swedish Transport Research Board and VTI.
5. REFERENCES


COMPUTER MODELS FOR THE ANALYSIS OF DRIVER/VEHICLE/ROADWAY INTERACTION

by Dr Wade Allen, Principal Research Engineer, Systems Technology Inc, USA

This paper describes a set of computer programs prepared under the sponsorship of the National Highway Traffic Safety Administration, U.S. Department of Transportation designed to study the interactive dynamic behavior of drivers controlling vehicles on roadways described by specified curvature profiles and frictional properties. Several modeling advancements are incorporated in this work. A tire model has been evolved from previous U.S., European and Japanese work that performs properly over the complete range of vehicle maneuvering conditions and pavement frictional properties. The vehicle dynamics model, developed from previous U.S. and European work, responds laterally and longitudinally to tire cornering and braking forces, and exhibits plow out and spin out characteristics under limit cornering and/or braking conditions. The driver model stems from past U.S., Canadian and European work, and includes visual and motion cue feedbacks and responds to road curvature and lane change (obstacle avoidance) commands.

The computer models have been validated against past data from vehicle field tests and real world and simulator driver control experiments. The paper will describe computer analysis of several road situations that result in driver accident avoidance maneuvering, including unexpected encounters with road curvature and/or slippery surfaces and obstacle or other vehicle encounters. The analysis of these cases will explore the effects of driver and vehicle behavior, and tire/roadway interaction on maneuvering performance and loss of control. The paper will address differences between U.S. and European approaches to driver/vehicle performance research including the modeling of driver and vehicle behavior, vehicle testing and tire/roadway interaction.
CRASH AVOIDANCE MODELS AND DRIVER/VEHICLE HANDLING

R. Wade Allen
Systems Technology, Inc.
Hawthorne, CA 90250, USA

ABSTRACT

This paper reviews analysis and computer simulation work designed to study interactive driver/vehicle dynamic behavior and performance. The review covers both driver and vehicle modeling which has been carried out in Europe, the U.S. and Canada, and Japan over the last three decades. Vehicle dynamics include both inertial properties and tire force response characteristics. Tire characteristics dominate severe maneuvering and recent tire models have addressed the detailed interaction of cornering and braking forces. Recent simulations have also successfully addressed closed loop driver/vehicle interaction and incorporated crash avoidance scenarios designed to analyze system performance under severe maneuvering conditions.

INTRODUCTION

The purpose of this paper is to review a series of models and analysis and simulation computer programs that have been developed to study the crash avoidance capability of the driver/vehicle system under limit maneuvering conditions. The crash avoidance concept for reducing accident exposure has been articulated elsewhere (Refs. 1,2). Most vehicles have reasonable handling qualities under moderate maneuvering (i.e. braking and/or steering) conditions. Under severe maneuvering conditions typical of accident avoidance situations vehicle handling can change dramatically, however, resulting in potential loss of directional control and/or rollover. The objective of this work was to provide models and analysis procedures for determining the relative contribution of driver behavior and vehicle characteristics to driver/vehicle system performance under extreme maneuvering conditions associated with crash avoidance situations. Much of the background analysis for this work extends back over the past three decades, with international contributions coming from Europe, the US as well as Canada and Japan as will be acknowledged herein.

In analyzing driver/vehicle system performance from a crash avoidance point of view both moderate and extreme maneuvering characteristics must be considered. Under moderate maneuvering conditions vehicles are designed to have desirable handling properties. Under limit maneuvering conditions vehicle characteristics can vary dramatically from ideal handling behavior, however, and issues of controllability and ultimately system stability are of concern as a vehicle approaches limit understeer or oversteer. A vehicle model reviewed here covers the entire maneuvering range, primarily due to a comprehensive tire model that
accounts for the interaction between steering and braking forces. The driver model is optimized for moderate maneuvering conditions, and is assumed to remain invariant under the brief and rapid onset conditions of typical crash avoidance scenarios.

**DRIVER/VEHICLE SYSTEM**

The overall driver/vehicle system model can be usefully partitioned as illustrated in Figure 1. Driver steering, braking and throttle inputs cause the vehicle to respond longitudinally and laterally in terms of the derivatives of key variables. The vehicle dynamics include all inertial, compliance and damping effects plus tire characteristics. The vehicle response derivatives are integrated and combined with system inputs by various kinematic relationships in the vehicle/road kinematics model to produce system performance variables and visual feedback for the driver. The driver model then integrates visual and motion cues and accounts for certain inherent behavioral penalties (i.e. psychomotor time delay), to produce control inputs for the vehicle dynamics.

The general structure of the Figure 1 system model is useful for detailed computer simulations as well closed loop stability and performance analyses. System performance can be limited by open loop vehicle characteristics alone under extreme maneuver conditions such as plow out (limit understeer) or spin out (limit oversteer). System performance can be limited in a closed loop sense due to the interaction of the driver's behavior and vehicle

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**Figure 1. Driver/Vehicle System Model**
dynamics, particularly under extreme understeer conditions where the vehicle lateral/directional response becomes oscillatory. The driver can also provide some limited control of directionally unstable vehicle dynamics (extreme oversteer conditions) which is an example of improved closed loop system performance over unstable open loop vehicle dynamics.

VEHICLE DYNAMICS

Vehicle dynamics models have been actively developed in the US and Europe (Refs. 3-6) and steering or lateral/directional models have tended to follow the roll axis concept. When inertial, suspension and tire effects are taken into account, as in simulation models (e.g. Refs. 7-9), the equations can become quite complicated. A two degree of freedom approximation to vehicle lateral/directional dynamics has been developed, however, that captures the important characteristics from a driver/vehicle interaction point of view (Ref. 10). The steering input to yaw rate response transfer function for the two degree of freedom approximation is summarized in Table 1 which is noted to be dominated by the side force characteristics of the tires.

The Table 1 steering transfer functions describe the basic vehicle directional response characteristics that are of importance to the driver for steering control. As noted in Ref. 10 the vehicle yaw rate response to steering characteristics which drivers find desirable include a rapid initial rise time to a steady state value, with little overshoot following the initial rise, and no residual oscillation. As derived in Ref. 10 and summarized in Table 1 the basic steering transfer function coefficients given in terms of vehicle and tire parameters can be manipulated to give parameters which describe the vehicle's transient response in terms of a steady state gain, a basic time constant, and a stability factor which is proportional to the SAE understeer coefficient. The damping of the second order response can be expressed in terms of the stability factor and vehicle speed, and the gain is a function of the stability factor, wheel base, steering ratio and speed.

Past research has shown that drivers desire a certain range of optimum steering gains, and yaw time constants that are less than about 0.3 seconds (e.g. Refs. 8,11). Understeer coefficients in the range of 2-6 degrees per g (i.e. acceleration due to gravity) give desirable damping properties and also give a relatively constant steering gain over a wide speed range (Ref. 9). Handling parameters developed at Volkswagen (Ref. 12) give similar results. Through an evolutionary design process most modern passenger cars meet these desirable handling qualities criteria. It should be noted from Table 1, however, that the yaw response characteristics are a function of both forward speed and tire side force characteristics. Handling characteristics deteriorate at high speeds, although they are adequate below typical speed limits.
TABLE 1. TWO DEGREE OF FREEDOM YAW RATE TO STEERING TRANSFER FUNCTION AND HANDLING PARAMETERS (REF. 10)

\[
\frac{\dot{\gamma}}{\delta_{aw}} = - \frac{mU_0 I_z}{J \alpha_{aw} \alpha_{aw}} s^2 + \left[ \frac{m}{2} \left( \frac{a^2}{\alpha_{aw}} + \frac{b^2}{\alpha_{aw}} \right) + \frac{I_z}{s} \left( \frac{1}{\alpha_{aw}} + \frac{1}{\alpha_{aw}} \right) \right] s + \frac{1}{U_0} \left( \frac{b}{\alpha_{aw}} - \frac{a}{\alpha_{aw}} \right)
\]

\[
\left( s + \frac{1}{T_r} \right)
\]

where

- \( m \) = vehicle mass
- \( I_z \) = vehicle yaw moment of inertia
- \( a \) = front axle distance from c.g.
- \( b \) = rear axle distance from c.g.
- \( l \) = wheel base = \( a + b \)
- \( U_0 \) = forward speed
- \( s \) = Laplace transform variable
- \( \alpha_{aw} \), \( \alpha_{aw} \) = front and rear axle composite side force coefficients
- \( \nu \) = axle load ratio
- \( \nu = b \alpha_{aw}/a \alpha_{aw} \)
- \( K \) = stability factor
- \( K = \frac{m}{2l^2} \left( \frac{b}{\alpha_{aw}} - \frac{a}{\alpha_{aw}} \right) \)
- steady state gain
- \( \frac{\dot{\gamma}}{\delta_{aw}} |_{ss} = \frac{G_s U_0}{\xi(1 + KU_0^2)} \)
- yaw rate time constant
- \( \frac{1}{T_r} = \frac{2\xi}{mU_0 a} \cdot \alpha_{aw} = \nu \cdot \frac{1}{U_0 K} \)
- yaw rate damping
- \( \xi_r = 1/\sqrt{1 + KU_0^2} \) for \( (1 - \nu)^2 \approx 1 \)
Under extreme maneuvering conditions tire side force characteristics can degrade significantly which leads to serious deterioration in handling as discussed next.

MANEUVERING EFFECTS ON VEHICLE HANDLING

Vehicle handling characteristics are dominated by tire side force characteristics (as indicated in Table 1) which in turn are a function of maneuvering conditions. Under significant steering and braking conditions that occur in accident avoidance situations large lateral and longitudinal forces are generated by the tires. The tire forces are a rather complex function of normal load, and the tire's relative orientation and motion with respect to the road surface and velocity vector. Detailed models for predicting combined lateral and longitudinal tire forces have recently been developed in the US and Europe as well as Japan (i.e. Refs. 9, 13, 14). The importance of these models over previous efforts lies in the treatment of composite tire force under combined braking and cornering conditions, a common accident avoidance scenario.

Vehicle handling under significant maneuvering conditions (e.g. cornering and braking) depends on the performance of all four tires, each of which may be under different loading conditions and relative motion and orientation with respect to the road. In order to determine tire side force characteristics under these conditions requires solving a set of force equilibrium conditions for various maneuvering conditions taking into account the load transfer conditions illustrated in Figure 2, then calculating the perturbation side force coefficients at each operating point.

![Figure 2. Load Transfer and Tire Forces Under Combined Cornering and Braking Conditions](image-url)
These side force coefficients can then be used in the Table 1 equations to predict vehicle handling dynamics. The numerical solution to this problem has been accomplished (Refs. 9, 15), and example results are given in Figure 3 for two different vehicle configurations as defined in Table 2. These results show equivalent per axle side force coefficients as a function of the steady maneuvering accelerations which define the load transfer and required tire force output for the solutions as indicated in Figure 2.

The tire side force plots can be used to directly interpret vehicle maneuvering limits. When the side force coefficient of a given axle goes to zero the tires on that axle have reached their combined force limit. If the front axle saturates first, then the vehicle plows out and the driver essentially loses steering control. If the rear axle saturates first then the vehicle becomes directionally unstable which presents a very difficult steering control task for the driver (e.g. Ref. 16). The points of first axle saturation in Figure 3 basically define a given vehicle's maneuvering limits. Tires typically saturate well before axle lockup and so antilock brake systems would not have a significant influence on the Figure 3 results. Front to rear brake balance has a significant effect on the Figure 3 results, however, which were computed assuming an optimum nonlinear proportioning valve characteristic (Ref. 9).

<table>
<thead>
<tr>
<th>TABLE 2. PARAMETERS FOR EXAMPLE VEHICLE CONFIGURATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARAMETERS</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>m (lb-sec²/ft)</td>
</tr>
<tr>
<td>I_x (lb-ft-sec²)</td>
</tr>
<tr>
<td>a (ft)</td>
</tr>
<tr>
<td>b (ft)</td>
</tr>
<tr>
<td>Center of Gravity Height, h_{cg} (ft)</td>
</tr>
<tr>
<td>Track Width, T(ft)</td>
</tr>
</tbody>
</table>
Braking Deceleration, $A_x (g's)$: 0 ■, .2 ◆, .4 ▲, .6 ▼, 8 ▼

Figure 3. Side Force Coefficient Plots for Two Vehicles Over a Range of Maneuvering Conditions
Given side force coefficients we can then compute the handling parameters noted in Table 1 that are meaningful to the driver’s control task. Plots of stability factor and yaw rate time constant for the Figure 23 side force coefficients are given in Figure 4. Under cornering-only conditions vehicles are normally set up to give limit understeer, and up to significant cornering levels (i.e. $a_y < 0.5 \text{ g}$) the stability factor is in the desirable handling range (i.e. 2-6 deg/g, Ref. 9). Note, however, that hard braking (e.g. $a_x > 0.3 \text{ g}$) routinely leads to limit oversteer, which is more pronounced for the utility vehicle which has a higher center of gravity to track width ratio and hence more load transfer under maneuvering conditions than the front wheel drive passenger car. The oversteer under braking-in-a-turn conditions is generic and arises because of significant unloading of the rear axle. This condition is not significantly improved by antilock brake systems because it occurs well before wheel lockup (Ref. 17). It is influenced by the front-to-rear brake balance, however, which through the use of nonlinear proportioning valves accounts for hard braking conditions (Refs. 9,18).

The Figure 4 results suggest that under very hard cornering conditions drivers are typically faced with the oscillatory dynamics of significant understeer, while under significant combined cornering and braking conditions they face directionally unstable (extreme oversteer) dynamics. Thus extreme maneuvering conditions can present the driver with a wide range of handling characteristics which are never experienced in ordinary driving and it is not surprising that crash avoidance maneuvers frequently result in control loss.

In addition to directional control effects noted above, severe maneuvering also influences the yaw rate time constant which sets the bandwidth or responsiveness of the vehicle’s lateral/directional response. As shown in Figure 4 the speed normalized inverse yaw time constant falls off with increasing cornering and braking acceleration. Thus under crash avoidance maneuvering conditions the vehicle becomes less responsive in addition to the decreased directional stability discussed above.

**DRIVER/VEHICLE INTERACTION**

The driver uses both visual and motion feedbacks to control and maneuver the vehicle. Past analysis (Ref. 19) and in-vehicle field test research (Ref. 10) on driver disturbance regulation tasks (e.g. wind and road inputs) has demonstrated that drivers effectively use feedbacks to achieve near ideal control over vehicle lateral/directional dynamics. In addition to disturbance regulation the driver must also respond to path inputs imposed by road curvature, lane change commands and obstacle avoidance situations. Driver response to road curvature has been measured in simulation experiments (Refs. 20,21), and obstacle avoidance behavior has been modeled from measurements obtained in both simulator and field test experiments (Ref. 22). Jaksch (Ref. 8) has demonstrated with a computer simulation that setting driver

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Figure 4. Stability Factor (K) and Speed Normalized Inverse Yaw Rate Time Constant ($U_0/T_r$) for Two Vehicles Over a Range of Maneuvering Conditions
steering wheel velocity proportional to curvature error (i.e. the difference between road curvature and vehicle path curvature) gives comparable results to actual driving task measurements.

Recently a simple rationale has been developed for the driver's perception of path curvature error, and the resulting model has been submitted to a linear stability analysis (Ref. 23). This analysis subdivided the dynamics of the driver/vehicle system into the three components defined in Figure 1. The kinematic vehicle/road component, which derives curvature error at an equivalent look ahead point down the road, consists of slow, low frequency dynamics due to integration of the vehicle motion variables (e.g. yaw rate and side slip velocity). The high frequency dynamics which restrict the maneuvering bandwidth of the driver/vehicle system come from the vehicle's lateral/directional characteristics and the driver's psychomotor time delay and neuromuscular dynamics. As discussed in Ref. 23 the low and high frequency dynamics provide constraints on feedback gains the driver adjusts to optimize performance. Motion feedback can be used to compensate for the vehicle's high frequency bandwidth (i.e. resulting in anticipation or lead in driver steering actions), and the driver's overall feedback gain is adjusted to optimize the closed loop dynamic properties of the driver/vehicle system.

Recent computer simulation efforts have successfully modeled closed loop driver/vehicle lateral/directional control tasks (e.g. Refs. 8,22,24). As noted in the discussion surrounding Figures 3 and 4, however, combined steering and braking (i.e. braking-in-a-turn) seems to provide the most serious stability problem for the driver and is certainly a common crash avoidance maneuver. The crash avoidance simulation described in Refs. 9 and 23 was designed with scenarios requiring both steering and braking, and a driver longitudinal control model that would respond to braking commands. The vehicle model for this nonlinear time domain simulation includes both lateral/directional and longitudinal dynamics, load transfer due to maneuvering accelerations and the interactive tire force model discussed above.

An example run from the above crash avoidance simulation is included in Figure 5 for a braking-in-a-turn scenario. In this scenario the driver enters a curve at excessive speed and a detection algorithm commands driver braking when lateral acceleration exceeds a threshold, and continues braking at a specified deceleration level until lateral acceleration recedes below a second threshold. The Figure 5 scenario involves a subcompact front wheel drive car entering a curve at a speed that would result in a lateral acceleration of .7 g's without braking. When the lateral acceleration exceeds .4 g's the driver begins braking and the deceleration is brought up to the commanded level of .4 g's. At this point the vehicle goes into extreme oversteer as evidenced by the rear axle side force coefficient which goes to zero for a short period of time and the vehicle side slip angle which peaks in excess of 20 degrees (i.e. .39 radians).
Figure 5. Driver/Vehicle Response for a Braking-in-a-turn Scenario
In the above simulation run the driver steering model manages to maintain control of the vehicle, albeit with large lane deviations, until the tire side force coefficients return to moderate maneuvering levels. This example illustrates how the driver can stabilize a vehicle with directionally unstable dynamics, and thus avoid loss of control. This driver ability is consistent with previous analysis of driver control under rear brake lockup conditions which indicated a marginal ability to maintain stable control (Ref.16). The lane deviations are such, however, that the driver might still have encountered a shoulder encroachment or interfered with traffic in adjacent lanes which could have induced an accident.

**OVERTURNING**

The above crash avoidance scenario concerns a driver induced maneuver that drives the vehicle into directional instability. Another scenario involves maneuvering induced rollover. In this case, lateral maneuvering, for example cornering too fast as above or extreme steering to avoid an obstacle, result in lateral inertial forces that are sufficient to overturn the vehicle. At this point two scenarios are possible; tripped and untripped rollover. As indicated in Figure 6a tripped rollover results when a vehicle slides into a curb or other terrain feature (e.g., shoulder berm) with sufficient velocity. This scenario was analyzed in The United Kingdom in order to assess vehicle proneness to overturning as represented in an accident data base (Ref. 25). The conditions for tripped rollover were analyzed assuming that sliding translational momentum is transformed into rotational momentum. The tripping condition stated in Figure 6a is achieved when the angular momentum is sufficient to raise the vehicle center of gravity beyond the point of rollover. The critical vehicle parameter is the center of gravity height to track width ratio, with higher values being more prone to rollover.

A computer simulation with complete suspension dynamics has been prepared for analyzing the tripped rollover problem (Ref. 26). An example run is shown in Figure 7, where the run starts with the vehicle sliding at 23 ft/sec towards a curb 10 feet away. The sliding velocity decays due to tire friction to a value of 13.4 ft/sec upon curb impact, which is just sufficient enough to cause an overturning moment. The Ref. 26 simulation uses a binary search routine to iteratively determine tripped rollover critical speed for a given case. The critical speed was also calculated from the Figure 6a formula as indicated in Table 3 which gives a comparable critical sliding velocity of 13.2 ft/sec.

The second rollover scenario involves only maneuvering forces as indicated in Figure 6b. In order to roll over under steady state lateral acceleration the road surface friction must be sufficient to produce adequate tire side force. Rollover occurs under these conditions when the overturning moment due to lateral acceleration exceeds the restoring moment due to the vehicle weight. Chassis and tire effects also enter into the equation. The center of gravity plays a crucial role in determining the vehicle's stability. The critical condition is reached when the angular momentum is sufficient to raise the vehicle center of gravity beyond the point of rollover. The critical parameter is the center of gravity height to track width ratio, with higher values being more prone to rollover.

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Rollover Condition:

\[ \dot{y}_c^2 \geq \frac{2gI_x}{m_T h'} \left[ \sqrt{1 + \left( \frac{y_{c.g.}}{h'} \right)^2} - 1 \right] \]

\[ y_{c.g.} \]
\[ h_{c.g.} \]
\[ h_{curb} \]

\[ h' \]

\[ y \]

\[ \dot{y} \]

\[ m_T \]

\[ g \]

\[ I_x \]

\[ y_{c.g.} \]

\[ h' \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{curb} \]

\[ y_{c.g.} \]

\[ h_{c.g.} \]

\[ \sum \text{Moments} = \text{may} h_{c.g.} - mg y_{c.g.} > 0 \]

\[ \text{or} \]

\[ \frac{y_{c.g.}}{h_{c.g.}} < \frac{\text{may}}{mg} \]

\[ \text{Body Roll Axis} \]

\[ m_g \]

\[ mg \]

\[ \text{may} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{curb} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ \sum \text{Moments} = \text{may} h_{c.g.} - mg y_{c.g.} > 0 \]

\[ \text{or} \]

\[ \frac{y_{c.g.}}{h_{c.g.}} < \frac{\text{may}}{mg} \]

\[ \text{Body Roll Axis} \]

\[ m_g \]

\[ mg \]

\[ \text{may} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{curb} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ \sum \text{Moments} = \text{may} h_{c.g.} - mg y_{c.g.} > 0 \]

\[ \text{or} \]

\[ \frac{y_{c.g.}}{h_{c.g.}} < \frac{\text{may}}{mg} \]

\[ \text{Body Roll Axis} \]

\[ m_g \]

\[ mg \]

\[ \text{may} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

\[ h_{curb} \]

\[ h_{c.g.} \]

\[ y_{c.g.} \]

Figure 6. Overturning Scenarios and Conditions for Rollover
Figure 7. Tripped Rollover Simulation Run for an Intermediate Sized Passenger Car; Critical (Rollover) Speed = 13.2 ft/sec
(Adapted from Ref. 26)

TABLE 3. COMPUTED CRITICAL (ROLLOVER) SPEED FOR THE FIGURE 7 SIMULATION RUN

<table>
<thead>
<tr>
<th>Total Mass</th>
<th>Roll Moment of Inertia</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_T = 122 \text{ lb}-\text{sec}^2/\text{ft}$</td>
<td>$I_X = 330 \text{ ft}-\text{lb}-\text{sec}^2$</td>
</tr>
<tr>
<td>Height of c.g.</td>
<td>Curb Height</td>
</tr>
<tr>
<td>$h_{c.g.} = 1.73 \text{ ft}$</td>
<td>$h_{\text{curb}} = 0.5 \text{ ft}$</td>
</tr>
<tr>
<td>Effective Track Width</td>
<td>Critical Speed</td>
</tr>
<tr>
<td>$y_{c.g.} = 2.5 \text{ ft}$</td>
<td>$\dot{y}_c = 13.4 \text{ ft/sec}$</td>
</tr>
</tbody>
</table>
gravity height provides the moment arm for lateral acceleration. Depending on suspension design the c.g. height might lift or squat as the vehicle initially rolls. Tire lateral compliance also acts to reduce the effective track width which provides the moment arm for the restoring moment. The combination of tire compliance and a c.g. height that raises with body roll can significantly increase the roll over propensity of a vehicle over its static c.g. height to track width ratio.

Vehicles with low c.g. height to track width ratio that would not ordinarily roll over under steady state conditions can be induced to roll over under dynamic maneuvering conditions involving transient braking under hard cornering conditions. This rollover maneuver was demonstrated some years ago in a field test program (Ref. 27), and has recently been analyzed with a computer simulation (Ref. 23). An example run taken from Ref. 23 which involves a light utility vehicle is given in Figure 8. The illustrated rollover maneuvering sequence starts with hard cornering perhaps to avoid an obstacle. When the vehicle has reached a maximum roll angle the driver initiates a transient brake application which excites the roll mode near its resonant frequency which is sufficient to create a dynamic overturning moment. This scenario was contrived to create a known rollover maneuver (Ref. 27), but can be rationalized as an obstacle avoidance situation where a confused driver hesitantly applies transient braking.

**CONCLUDING REMARKS**

Based on a substantial background developed over the past three decades recent analyses and computer simulations have given significant insight into driver/vehicle behavior during crash avoidance maneuvering. Driver/vehicle maneuvering capability in terms of cornering and braking characteristics determine initial crash avoidance success. However, vehicle directional and roll instability characteristics may ultimately determine the outcome of crash avoidance maneuvering encounters. The most significant vehicle handling characteristics encountered in crash avoidance maneuvering include oversteer and directional instability under combined braking and cornering, and rollover propensity due to the ratio of center of gravity height to track width.

In terms of driver/vehicle interaction in crash avoidance situations, the driver's contribution seems to be primarily one of inducing steering and braking maneuvers, and system performance can be improved to the extent that maneuvering induced changes in vehicle handling can be minimized. Drivers have trouble with wheel lockup during hard braking, particularly under low coefficient conditions (Ref. 16), and wheel lock up leads to severe control problems. Antilock brake systems can prevent wheel lockup and improve handling under pure braking situations. Under severe combined cornering and braking conditions vehicles will still exhibit significant oversteer characteristics, which can only be avoided by controlling front to rear brake balance as a function of lateral acceleration or load transfer. Combinations of steering
and braking can also induce vehicle roll over, and over turning propensity is directly related to the ratio of center of gravity height to track width. Attention to basic vehicle layout and suspension squat/lift characteristics can help to reduce roll over propensity.

ACKNOWLEDGEMENT

This work was sponsored by the Office of Crash Avoidance, National Highway Traffic Safety Administration (NHTSA), with Dr. H. K. Brewer serving as the contract technical monitor. The opinions expressed are solely those of the author and are not necessarily supported by NHTSA.

**LATERAL / DIRECTIONAL VARIABLES:**

**LONGITUDINAL VARIABLES:**

![Graphs showing lateral and longitudinal variables](image)

Figure 8. Driver/Vehicle Computer Simulation Run Illustrating Maneuver Induced Rollover (Adapted from Ref. 23)
REFERENCES


DRIVER RISK-PERCEPTION IN SPAIN AND THE U.S.A.

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ABSTRACT

This study investigated differences in risk-perception between Spanish and U.S. drivers. Subjects estimated the risk involved in slides of traffic scenes. The subject groups in each country included younger, middle-aged, and older non-professional drivers, as well as middle-aged professional (bus, taxi, or truck) drivers. The data were analyzed by multiple regressions. The independent variables were culture, subject group, sex, 23 dichotomously coded characteristics of the traffic scenes, and the respective first-order interactions. The following are the main findings: (1) U.S. drivers reported lower levels of risk than did Spanish drivers for the same traffic scenes. (2) Younger drivers tended to report lower risk than did middle-aged drivers. (3) Professional drivers, especially in the U.S.A., tended to report more risk than did non-professional drivers of the same age. (4) Culture, subject group, and sex accounted for 34.4% of the variance in risk-ratings. (5) The characteristics of traffic scenes (such as uncertainty, lane intrusion, and preview distance) accounted for an additional 15.2% of the variance. (6) Interactions of culture, subject group, and sex with the characteristics of traffic scenes accounted for an additional 4.1% of the variance. (7) Among the interactions with the characteristics of the scenes, U.S. drivers rated potential need for quick action as resulting in greater risk, while Spanish drivers were unaffected by this factor. Conversely, Spanish drivers rated higher speed as being more risky than lower speed, while the risk estimates of U.S. drivers were unaffected by speed. (8) A total of 53.7% of the variance in risk-ratings can be accounted for by the studied independent variables and their first-order interactions.

INTRODUCTION

This study investigated perception of risk in slides of traffic scenes. The primary objectives were to study (a) cross-cultural and age differences in the absolute level of perceived risk, and (b) cross-cultural and age differences in factors affecting perceived risk. The underlying rationale for this study was an attempt to identify risk-perception factors that differentially affect accident etiology in the two countries.

METHOD

Stimuli

One hundred color slides of traffic scenes were used. Fifty were taken in the U.S.A. from the driver’s viewpoint. Fifty were taken in Spain and most of them were overviews of traffic scenes and were taken from sidewalks, bridges, etc. These slides were selected from a larger set of approximately 500 slides to represent a variety of driving situations under a range of conditions. An attempt was made to avoid slides containing traffic signs unique to one of the two countries. Copies of the same slides were used both in Spain and the U.S.A.
Each slide was coded on 23 dichotomous characteristics (Table 1). (For the U.S. slides, subjects were given explicit information about one of these characteristics—speed [see Procedure], while for the Spanish slides the coding of speed was based on presumed traffic speed given the depicted situation.) The intercorrelations among these 23 variables were generally low. The distribution of these correlations is shown in Table 2.

Subjects

A total of 160 subjects participated in this study. Eighty were tested in Spain and eighty in the U.S.A. There were 20 subjects (10 males and 10 females) in both Spain and the U.S.A. in each of the following four groups: 18-21 year olds, 35-45 year olds, 65-75 year olds, and 35-45 year old professional (bus, taxi, or truck) drivers. The actual ages of subjects in each group are shown in Table 3. The U.S. subjects, who were paid for their participation, came primarily from Ann Arbor, a city with a population of approximately 120,000. The Spanish subjects, who were unpaid volunteers, came primarily from Valencia, a city with a population of approximately 800,000.

Procedure

Each slide was presented for about 20 seconds. The subjects were asked to evaluate the risk involved in the slides by using a seven-point scale. The scale had two anchor points (1 = minimum risk, 7 = high likelihood of an accident). The remaining points (2 through 6) were unlabelled.

For the U.S. slides (which were taken from the driver’s viewpoint), the subjects were given information about their speed (25, 40, or 55 mph [40, 65, or 90 km/h]). Thus, if the speed was given as 55 mph [90 km/h], they were asked to assume that they are driving at 55 mph [90 km/h], and that the traffic situation ahead is as shown in the slide. For the Spanish slides (which generally were not taken from the driver’s viewpoint but were overviews of a situation), no speed information was given.

The slides were shown always in the same order, with the 50 U.S. slides first, followed by the 50 Spanish slides. No practice slides were given. The wording of the subject’s instructions was the same in both countries.

Statistical Considerations

The data were analyzed by the use of multiple regressions. The basic units for the analyses were the mean risk-ratings for each combination of slide, culture, subject group, and sex of the subject. Of interest, therefore, were the mean risk-ratings of groups of (ten) subjects and not the risk-ratings of the individual subjects. Consequently, the tests of significance in the regression analyses should be taken with caution, since the mean ratings were treated as individual data points. An additional reason for caution in the interpretation of statistically significant results is the fact that the risk-ratings for the 100 slides were not independent (as assumed by the regression analysis), but correlated since they came from the same subjects. Because of these considerations, the percent of variance accounted for (\(r^2\)) is a more meaningful measure of the predictive power of the variables (and interactions) under investigation.
### TABLE 1
CHARACTERISTICS CODED FOR EACH INDIVIDUAL SLIDE

<table>
<thead>
<tr>
<th>Variable</th>
<th>Binary Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Ambient Illumination</td>
<td>Day</td>
</tr>
<tr>
<td>Preview Distance</td>
<td>Sufficient</td>
</tr>
<tr>
<td>Following Distance</td>
<td>Sufficient</td>
</tr>
<tr>
<td>Lane Intrusion</td>
<td>No</td>
</tr>
<tr>
<td>Straight Roadway</td>
<td>Yes</td>
</tr>
<tr>
<td>Level Roadway</td>
<td>Yes</td>
</tr>
<tr>
<td>Environment</td>
<td>Rural</td>
</tr>
<tr>
<td>Limited Access Roadway</td>
<td>Yes</td>
</tr>
<tr>
<td>Weather</td>
<td>Good</td>
</tr>
<tr>
<td>Stopped Vehicle in the Lane</td>
<td>No</td>
</tr>
<tr>
<td>Traffic Density</td>
<td>Low</td>
</tr>
<tr>
<td>Road Delineation</td>
<td>Good</td>
</tr>
<tr>
<td>Animals</td>
<td>Absent</td>
</tr>
<tr>
<td>Pedestrians or Bicyclists</td>
<td>Absent</td>
</tr>
<tr>
<td>Speed</td>
<td>Under 90 km/hr</td>
</tr>
<tr>
<td>Road Surface Friction</td>
<td>High</td>
</tr>
<tr>
<td>Bridge or Tunnel</td>
<td>No</td>
</tr>
<tr>
<td>Country of the Slide</td>
<td>U.S.A.</td>
</tr>
<tr>
<td>Complexity</td>
<td>Low</td>
</tr>
<tr>
<td>Overtaking</td>
<td>No</td>
</tr>
<tr>
<td>Intersection</td>
<td>No</td>
</tr>
<tr>
<td>Quick Action</td>
<td>No Need</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>Low</td>
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</table>

### TABLE 2
DISTRIBUTION OF THE ABSOLUTE VALUES OF THE INTERCORRELATIONS AMONG THE 23 SLIDE CHARACTERISTICS

<table>
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<tr>
<th>Range</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
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<td>Maximum</td>
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<td>0.099</td>
</tr>
<tr>
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<tr>
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<tr>
<td>0.500</td>
<td>0.599</td>
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</tbody>
</table>
# TABLE 3
## AGES OF SUBJECTS

<table>
<thead>
<tr>
<th>Group</th>
<th>Culture</th>
<th>Sex</th>
<th>N</th>
<th>Min Age</th>
<th>Max Age</th>
<th>Mean Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Younger</td>
<td>Spain</td>
<td>Males</td>
<td>10</td>
<td>19</td>
<td>21</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>10</td>
<td>19</td>
<td>21</td>
<td>20.4</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>Males</td>
<td>10</td>
<td>18</td>
<td>21</td>
<td>19.9</td>
</tr>
<tr>
<td></td>
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<td>Females</td>
<td>10</td>
<td>18</td>
<td>21</td>
<td>19.0</td>
</tr>
<tr>
<td>Middle-Aged</td>
<td>Spain</td>
<td>Males</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>40.4</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>Males</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>40.0</td>
</tr>
<tr>
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<td></td>
<td>Females</td>
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<td>35</td>
<td>44</td>
<td>38.9</td>
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<td>Males</td>
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<td>66</td>
<td>75</td>
<td>70.1</td>
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<tr>
<td></td>
<td></td>
<td>Females</td>
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<td>65</td>
<td>75</td>
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</tr>
<tr>
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<td>U.S.A.</td>
<td>Males</td>
<td>10</td>
<td>66</td>
<td>75</td>
<td>70.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>10</td>
<td>68</td>
<td>75</td>
<td>71.4</td>
</tr>
<tr>
<td>Middle-Aged Professional</td>
<td>Spain</td>
<td>Males</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>39.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>39.7</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>Males</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>38.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Females</td>
<td>10</td>
<td>35</td>
<td>45</td>
<td>38.1</td>
</tr>
</tbody>
</table>
RESULTS

The mean ratings across all 100 slides are shown in Table 4. These results indicate that Spanish drivers tended to rate the traffic scenes as more risky than did U.S. drivers. Furthermore, older and professional drivers tended to rate the traffic scenes as more risky than did younger drivers. The distribution of the cultural differences in the mean ratings of the individual slides is shown in Table 5.

To study the potential differential effects of the slide variables on driver risk-perception in Spain and the U.S.A., three multiple regression analyses were performed. In these three analyses, the dependent variable was the mean risk-rating of each slide for the ten subjects in each combination of culture x subject group x sex. (These three analyses were based on 98 slides; two slides [involving alcohol and sleep] could not be coded according to the characteristics in Table 1.)

The first multiple regression used culture, subject group, and sex as independent variables. (The group variable was entered in the form of three dummy variables [younger, middle-aged professional, and older], with the remaining group [middle-aged] forming the baseline.) The results for the standardized variables are shown in Table 6. (The entries are in the decreasing order of absolute values of beta weights.) These results indicate that 34.4% of the variance in the risk-ratings can be accounted for by culture, subject group, and sex. The directions of the significant effects are shown in Table 7.

The second multiple regression used all slide variables as “free” independent variables, and culture, (dummy) subject groups, and sex as “fixed” independent variables. The results for the standardized variables are shown in Table 8. (Again, the entries are in the decreasing order of absolute values of beta weights.) These results indicate that 49.6% of the variance in the risk-ratings of the slides can be accounted for by the slide variables, culture, subject group, and sex. (Culture, subject group, and sex accounted for 34.4% of the variance [Table 6].) Consequently, the slide variables accounted for an additional 15.2% of the variance.) The directions of the significant effects are listed in Table 9. All significant effects were in the expected direction, except for complexity, animals, pedestrians/bicyclists, and tunnel/bridge. (The effects of complexity and animals in the unexpected directions were evident only in a multivariate analysis: When bivariate relationships were examined, these effects were in the expected directions. Furthermore, the effect of animals in the multiple regression turned out to be the result of an interaction; see below.)

The third multiple regression used culture, subject group, sex, and all slide characteristics as “fixed” independent variables, and interaction terms as “free” independent variables. The interaction terms were formed by multiplying all slide variables by culture, sex, and (dummy) group variables, respectively. The results for the standardized variables are shown in Table 10. (The first entries are the significant interactions in the decreasing order of absolute values of beta weights, followed by main effects in the decreasing order of absolute values of beta weights.) These results indicate that out of the total set of 122 interactions (23 slide variables x culture, sex, and three [dummy] group variables; culture x sex; culture x group; and sex x group), 11 proved to be significant at the 0.05 level. (Based on chance alone, six interactions [5% of 122] would be expected to be significant at the 0.05 level.) The total variance accounted for by the significant interactions and by the main effects of all slide variables, culture, sex, and group amounted to 53.7%. (The main effects accounted for 49.6% [Table 8]. Consequently, the interactions accounted for an additional 4.1% of the variance.) The interpretations of the significant interactions are listed in Table 11.
### Table 4
**Mean ratings for all 100 slides by culture, subject group, and sex**

(1 = minimum risk; 7 = high likelihood of an accident; standard deviations are in parentheses)

<table>
<thead>
<tr>
<th>Group</th>
<th>Culture</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>Younger</td>
<td>Spain</td>
<td>4.8 (1.5)</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>3.4 (1.0)</td>
</tr>
<tr>
<td>Middle-Aged</td>
<td>Spain</td>
<td>4.9 (1.4)</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>4.1 (1.2)</td>
</tr>
<tr>
<td>Older</td>
<td>Spain</td>
<td>4.8 (1.4)</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>4.0 (1.1)</td>
</tr>
<tr>
<td>Middle-Aged Professional</td>
<td>Spain</td>
<td>5.1 (1.2)</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>4.5 (1.2)</td>
</tr>
<tr>
<td>Mean</td>
<td>Spain</td>
<td>4.9 (1.3)</td>
</tr>
<tr>
<td></td>
<td>U.S.A.</td>
<td>4.0 (1.1)</td>
</tr>
</tbody>
</table>

### Table 5
**Cultural differences in the mean risk ratings of the individual slides**

(negative difference: the slide was rated more risky in Spain; positive difference: the slide was rated more risky in the U.S.A.)

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-3.500</td>
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</tr>
<tr>
<td></td>
<td>-3.000</td>
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<td>-1.000</td>
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<td>-0.001</td>
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<td>0</td>
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<tr>
<td></td>
<td>0.001</td>
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</table>
TABLE 6
LEAST SQUARES REGRESSION USING A SUBSET OF THE MAIN EFFECTS

<table>
<thead>
<tr>
<th>Slide Variable</th>
<th>Beta Weight</th>
<th>Standard Error</th>
<th>T-stat</th>
<th>Signif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture</td>
<td>.291</td>
<td>.024</td>
<td>12.233</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Younger Drivers</td>
<td>-.115</td>
<td>.029</td>
<td>-3.951</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Professional Drivers</td>
<td>.092</td>
<td>.029</td>
<td>3.170</td>
<td>.002</td>
</tr>
<tr>
<td>Older Drivers</td>
<td>.065</td>
<td>.029</td>
<td>2.240</td>
<td>.025</td>
</tr>
<tr>
<td>Sex</td>
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<td>.024</td>
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</table>

$r^2 = .344$

TABLE 7
DIRECTIONS OF THE SIGNIFICANT MAIN EFFECTS FROM TABLE 6

<table>
<thead>
<tr>
<th>Variable</th>
<th>Code Resulting in Increased Risk Rating</th>
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</thead>
<tbody>
<tr>
<td>Culture</td>
<td>Spain</td>
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<tr>
<td>Younger Drivers *</td>
<td>No</td>
</tr>
<tr>
<td>Professional Drivers *</td>
<td>Yes</td>
</tr>
<tr>
<td>Older Drivers *</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Middle-Aged Drivers Being the Baseline
### TABLE 8
LEAST SQUARES REGRESSION USING ALL MAIN EFFECTS ONLY

<table>
<thead>
<tr>
<th>Slide Variable</th>
<th>Beta Weight</th>
<th>Standard Error</th>
<th>T-stat</th>
<th>Signif</th>
</tr>
</thead>
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<td>.026</td>
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<td>&lt;.001</td>
</tr>
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<td>Complexity</td>
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<td>.028</td>
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<td>&lt;.001</td>
</tr>
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<td>.022</td>
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<td>&lt;.001</td>
</tr>
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<td>Preview Distance</td>
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<td>.027</td>
<td>-5.557</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Limited Access</td>
<td>-.148</td>
<td>.021</td>
<td>-6.983</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Environment</td>
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<td>.028</td>
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<td>&lt;.001</td>
</tr>
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<td>Intersection</td>
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<td>.025</td>
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<td>&lt;.001</td>
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<td>Animals</td>
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<td>Weather</td>
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<td>&lt;.001</td>
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<td>Tunnel or Bridge</td>
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<td>Level Roadway</td>
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<tr>
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<td>.001</td>
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<td>Country of Slide</td>
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<td>-3.145</td>
<td>.002</td>
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<tr>
<td>Older Drivers</td>
<td>.065</td>
<td>.022</td>
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<td>.003</td>
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<td>Straight Roadway</td>
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<td>.024</td>
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<td>Overtaking</td>
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<td>Sex</td>
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<td>.018</td>
<td>-.400</td>
<td>.690</td>
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<td>Ambient Illumination</td>
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<td>.025</td>
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<td>.929</td>
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\[ r^2 = .496 \]
TABLE 9
DIRECTIONS OF THE SIGNIFICANT MAIN EFFECTS FROM TABLE 8

<table>
<thead>
<tr>
<th>Variable</th>
<th>Code Resulting in Increased Risk Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture</td>
<td>Spain</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>High</td>
</tr>
<tr>
<td>Lane Intrusion</td>
<td>Yes</td>
</tr>
<tr>
<td>Complexity</td>
<td>Low</td>
</tr>
<tr>
<td>Following Distance</td>
<td>Insufficient</td>
</tr>
<tr>
<td>Preview Distance</td>
<td>Insufficient</td>
</tr>
<tr>
<td>Limited Access</td>
<td>No</td>
</tr>
<tr>
<td>Environment</td>
<td>Urban</td>
</tr>
<tr>
<td>Intersection</td>
<td>Yes</td>
</tr>
<tr>
<td>Animals</td>
<td>Absent</td>
</tr>
<tr>
<td>Young Drivers *</td>
<td>No</td>
</tr>
<tr>
<td>Weather</td>
<td>Poor</td>
</tr>
<tr>
<td>Pedestrians or Bicyclists</td>
<td>Absent</td>
</tr>
<tr>
<td>Quick Action</td>
<td>Potential Need</td>
</tr>
<tr>
<td>Road Surface Friction</td>
<td>Low</td>
</tr>
<tr>
<td>Tunnel or Bridge</td>
<td>No</td>
</tr>
<tr>
<td>Professional Drivers *</td>
<td>Yes</td>
</tr>
<tr>
<td>Level Roadway</td>
<td>No</td>
</tr>
<tr>
<td>Speed</td>
<td>90 km/hr or over</td>
</tr>
<tr>
<td>Country of Slide</td>
<td>Spain</td>
</tr>
<tr>
<td>Older Drivers *</td>
<td>Yes</td>
</tr>
<tr>
<td>Straight Roadway</td>
<td>No</td>
</tr>
</tbody>
</table>

* Middle-Aged Drivers Being the Baseline
TABLE 10
LEAST SQUARES REGRESSION USING MAIN EFFECTS AND INTERACTIONS
(only interactions that proved to be significant at the 0.05 level are listed)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beta Weight</th>
<th>Standard Error</th>
<th>T-Stat</th>
<th>Signif</th>
</tr>
</thead>
<tbody>
<tr>
<td>Culture x Animals</td>
<td>-.226</td>
<td>.084</td>
<td>-2.696</td>
<td>.007</td>
</tr>
<tr>
<td>Culture x Speed</td>
<td>-.198</td>
<td>.038</td>
<td>-5.218</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Culture x Quick Action</td>
<td>.198</td>
<td>.046</td>
<td>4.277</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Culture x Overtaking</td>
<td>.161</td>
<td>.051</td>
<td>3.172</td>
<td>.002</td>
</tr>
<tr>
<td>Culture x Country of Slide</td>
<td>-.143</td>
<td>.033</td>
<td>-4.370</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Sex x Older Drivers</td>
<td>.140</td>
<td>.027</td>
<td>5.255</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Culture x Professional Drivers</td>
<td>-.098</td>
<td>.027</td>
<td>-3.681</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Culture x Limited Access</td>
<td>-.094</td>
<td>.026</td>
<td>-3.634</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Older Driver x Quick Action</td>
<td>.084</td>
<td>.041</td>
<td>2.060</td>
<td>.011</td>
</tr>
<tr>
<td>Sex x Culture</td>
<td>-.077</td>
<td>.030</td>
<td>-2.544</td>
<td>.002</td>
</tr>
<tr>
<td>Sex x Culture x Quick Action</td>
<td>-.063</td>
<td>.031</td>
<td>2.077</td>
<td>.038</td>
</tr>
<tr>
<td>Culture</td>
<td>.528</td>
<td>.098</td>
<td>5.367</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Uncertainty</td>
<td>-.223</td>
<td>.026</td>
<td>-8.552</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Quick Action</td>
<td>-.211</td>
<td>.032</td>
<td>-6.508</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Lane Intrusion</td>
<td>-.196</td>
<td>.025</td>
<td>-7.830</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Complexity</td>
<td>.183</td>
<td>.027</td>
<td>6.803</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Animals</td>
<td>.169</td>
<td>.028</td>
<td>5.961</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Following Distance</td>
<td>-.162</td>
<td>.022</td>
<td>-7.515</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Professional Drivers</td>
<td>.156</td>
<td>.028</td>
<td>5.678</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Preview Distance</td>
<td>-.149</td>
<td>.026</td>
<td>-5.777</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Environment</td>
<td>-.142</td>
<td>.027</td>
<td>-5.328</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Intersection</td>
<td>-.126</td>
<td>.024</td>
<td>-5.210</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Younger Drivers</td>
<td>-.115</td>
<td>.021</td>
<td>-5.391</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Weather</td>
<td>-.114</td>
<td>.024</td>
<td>-4.781</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Pedestrians or Bicyclists</td>
<td>.111</td>
<td>.023</td>
<td>4.826</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Older Drivers</td>
<td>-.099</td>
<td>.045</td>
<td>-2.214</td>
<td>.027</td>
</tr>
<tr>
<td>Road Surface Friction</td>
<td>-.097</td>
<td>.022</td>
<td>-4.439</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Tunnel or Bridge</td>
<td>.095</td>
<td>.019</td>
<td>4.909</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Limited Access</td>
<td>-.083</td>
<td>.027</td>
<td>-3.057</td>
<td>.002</td>
</tr>
<tr>
<td>Level Roadway</td>
<td>-.080</td>
<td>.021</td>
<td>-3.798</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Straight Roadway</td>
<td>-.055</td>
<td>.024</td>
<td>-2.343</td>
<td>.019</td>
</tr>
<tr>
<td>Road Delineation</td>
<td>-.054</td>
<td>.032</td>
<td>-1.674</td>
<td>.094</td>
</tr>
<tr>
<td>Overtaking</td>
<td>-.043</td>
<td>.028</td>
<td>-1.504</td>
<td>.133</td>
</tr>
<tr>
<td>Country of Slide</td>
<td>.043</td>
<td>.034</td>
<td>1.247</td>
<td>.213</td>
</tr>
<tr>
<td>Traffic Density</td>
<td>-.037</td>
<td>.021</td>
<td>-1.708</td>
<td>.088</td>
</tr>
<tr>
<td>Stopped Vehicle in the Lane</td>
<td>-.024</td>
<td>.020</td>
<td>-1.188</td>
<td>.235</td>
</tr>
<tr>
<td>Speed</td>
<td>.022</td>
<td>.030</td>
<td>.721</td>
<td>.471</td>
</tr>
<tr>
<td>Sex</td>
<td>.021</td>
<td>.032</td>
<td>.661</td>
<td>.509</td>
</tr>
<tr>
<td>Ambient Illumination</td>
<td>-.002</td>
<td>.024</td>
<td>-0.92</td>
<td>.326</td>
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</table>

r^2 = .537
### TABLE 11
INTERPRETATION OF THE SIGNIFICANT INTERACTIONS

<table>
<thead>
<tr>
<th>Interactions with Culture</th>
<th>Culture</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U.S.A.</td>
<td>Spain</td>
<td></td>
</tr>
<tr>
<td>Animals</td>
<td>Decreased risk</td>
<td>Either no</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>for the</td>
<td>effect or</td>
<td>risk for</td>
</tr>
<tr>
<td></td>
<td>presence of</td>
<td>increased</td>
<td>the</td>
</tr>
<tr>
<td></td>
<td>animals</td>
<td>risk for</td>
<td>presence</td>
</tr>
<tr>
<td></td>
<td></td>
<td>of animals</td>
<td>of animals</td>
</tr>
<tr>
<td>Speed</td>
<td>No effect of</td>
<td>Increased</td>
<td></td>
</tr>
<tr>
<td></td>
<td>speed</td>
<td>risk for</td>
<td></td>
</tr>
<tr>
<td>Quick Action</td>
<td>Increased risk</td>
<td>No effect</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for quick action</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overtaking</td>
<td>No effect for</td>
<td>Decreased</td>
<td></td>
</tr>
<tr>
<td></td>
<td>overtaking</td>
<td>risk for</td>
<td></td>
</tr>
<tr>
<td>Country of Slide</td>
<td>No effect for</td>
<td>Decreased</td>
<td></td>
</tr>
<tr>
<td></td>
<td>country of slide</td>
<td>risk for</td>
<td></td>
</tr>
<tr>
<td>Limited Access</td>
<td>Decreased risk</td>
<td>Decreased</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for limited</td>
<td>risk for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>access roadway</td>
<td>U.S. slides</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(shallower slope</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>than for Spain)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional Drivers</td>
<td>Increased risk</td>
<td>Increased</td>
<td></td>
</tr>
<tr>
<td></td>
<td>for professional</td>
<td>risk for</td>
<td></td>
</tr>
<tr>
<td></td>
<td>drivers</td>
<td>professional</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(steeper slope</td>
<td>drivers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>than for Spain)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interaction with Sex</th>
<th>Sex</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Culture</td>
<td>Increased risk</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>for Spanish</td>
<td>risk for</td>
</tr>
<tr>
<td></td>
<td>subjects (steeper</td>
<td>Spanish</td>
</tr>
<tr>
<td></td>
<td>slope than for</td>
<td>subject</td>
</tr>
<tr>
<td></td>
<td>females)</td>
<td>(shallower</td>
</tr>
<tr>
<td></td>
<td></td>
<td>slope than</td>
</tr>
<tr>
<td>Older Drivers</td>
<td>Decreased risk</td>
<td>No effect</td>
</tr>
<tr>
<td></td>
<td>for older drivers</td>
<td>or increased</td>
</tr>
<tr>
<td>Country of Slide</td>
<td>No effect for</td>
<td>No effect or</td>
</tr>
<tr>
<td></td>
<td>country of slide</td>
<td>decreased</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interaction with Older Driver</th>
<th>Subject Group</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Middle-Aged</td>
<td>Older</td>
</tr>
<tr>
<td>Quick Action</td>
<td>Increased risk</td>
<td>Increased</td>
</tr>
<tr>
<td></td>
<td>for potential for</td>
<td>risk for</td>
</tr>
<tr>
<td></td>
<td>a quick action</td>
<td>a quick</td>
</tr>
<tr>
<td></td>
<td>(steeper slope</td>
<td>action (shallower</td>
</tr>
<tr>
<td></td>
<td>than for older</td>
<td>slope than</td>
</tr>
<tr>
<td></td>
<td>subjects)</td>
<td>for middle-aged</td>
</tr>
</tbody>
</table>

VTI RAPPORT 331 A
DISCUSSION

The main findings of this study are as follows:

(1) Spanish drivers gave higher risk-ratings to the same slides of traffic scenes than did U.S. drivers, with the effect being stronger for males than for females.

(2) Younger drivers in both countries tended to report lower risk than did middle-age drivers. This result supports the hypothesis that lower perceived risk might be one factor in young drivers’s overrepresentation in road accidents (Williams, 1985). However, it is apparent (see Table 4) that the age effect was not uniform for all combinations of culture and sex of the subject: While the effect was strong for Spanish females and U.S. males, it was weak for Spanish males and absent for U.S. females. (This study did not formally test for higher than first-order interactions.) Consequently, this study provides expansion and qualification of previous findings on young subjects’ lower level of perceived risk (e.g., Cairney, 1982; Finn and Bragg, 1986; Matthews and Moran, 1986).

(3) While professional drivers tended to report higher risk than did non-professional drivers of the same age, this effect was primarily due to U.S. drivers.

(4) Culture, subject group, and sex accounted for 34.4% of the variance in risk-ratings.

(5) The main effects of the characteristics of the traffic scenes accounted for an additional 15.2% of the variance.

(6) The most powerful factors (that did not figure in the significant first-order interactions) were uncertainty in the traffic situation, intrusion in the lane of travel, complexity of the traffic situation, following distance, preview distance, and environment (day/night). All of these effects were in the expected directions, with the exception of complexity. (When bivariate, as opposed to multivariate, relationships were examined, the effect of complexity was in the expected direction.)

(7) The interactions of slide characteristics with culture, group, and age accounted for an additional 4.1% of the variance.

(8) Among the interactions with the characteristics of the slides, the following two are of potential practical interest. First, while the U.S. subjects rated potential need for quick action as resulting in greater risk, the Spanish subjects were unaffected by this parameter. Second, while the Spanish drivers rated higher speeds as more risky, the risk estimates of the U.S. drivers were unaffected by speed.

(9) A total of 53.7% of the variance in risk-ratings can be accounted for by the studied independent variables and their first-order interactions.

(10) The current fatality rate per 100,000 vehicle kilometers in Spain is about twice the rate in the U.S. For example, in 1984 the rate in Spain was 5.1 (Direccion General de Trafico, 1985) and 2.5 in the U.S. (National Safety Council, 1985). (The rates are for rural roads only, since the urban [and total] rates for Spain were unavailable.) The present findings suggest that
the difference in accident rates is unlikely to be the result of a decreased level of perceived risk in Spain. (The obtained main effect was in the other direction.) However, the perceived risk was inferred from the reported risk, and it is possible that subjects in the two countries utilized the scale differently, without any differences in perceived risk. On the other hand, the obtained interactions are not subject to this potential criticism. The differential effect of potential need for quick action on the reported risk in the two countries is especially intriguing and it may contribute to the differential accident rates (along with factors that were not evaluated in the present study, such as differences in roadways, vehicles, seat-belt use, etc.).

REFERENCES


THEORETICAL REQUIREMENTS FOR DRIVERS LICENSE
IN AUSTRIA

In 1987 a new driver examination system will be established in Austria. It has been developed in several years of joint efforts by psychologists, pedagogues, and driving instructors. The basic concept of this examination system is not to examine theoretical knowledge - which is a necessary prerequisite - but to examine its practical application. Therefore it is rather an examination of the ability to understand and handle the theoretical knowledge than a mere examination of the knowledge of rules and regulations.

For this purpose a special kind of picture material has been developed.

The theoretical part of the examination consists of an oral examination which is largely standardized. The driving aspirant is allowed to draw his questions himself. This procedure is intended to combine the advantages both of paper-pencil questionnaires (objectivity) and of an oral examination (understanding).
THEORETICAL REQUIREMENTS FOR DRIVERS LICENSE IN AUSTRIA
Christa MICHALIK
Ph.D., Head of the Institute of Traffic Psychology and Education
AUSTRIAN ROAD SAFETY BOARD

During the past years the driver licensing test has more and more been considered not only as an instrument to examine theoretical knowledge and handling of a certain motor vehicle but also as an instrument which allows to reduce the accident risk of the mostly young driving beginners. The following considerations were responsible for a reorganization particularly of the theoretical driver examination system and therefore also for a reorganization of the theoretical training system:

- Any kind of training is absolved with respect to the examination by the trainee - that means that he concentrates mainly on those topics which he will probably need in the examination. This interaction is a general problem which cannot be observed only in connexion with driver training and driver examination.

- Attending a driving school is rather considered as a necessary annoyance. In the opinion of the mostly juvenile applicants for a drivers license the expected task of the driving school is to provide the trainee as quickly as possible with the knowledge which is necessary to pass the driver examination. Unfortunately there is no demand for a good practical education because the attitude that "real driving" is not learned in the driving school but afterwards through experience is very common.

- There is no doubt about the high motivation of juveniles to receive a driver license. This fact could and should be used much better.

In Austria the theoretical driver examination is an oral examination and consists of two parts namely technical knowledge of vehicles and knowledge of traffic regulations - a fact which is quite unlogical for driving a vehicle is one activity and in reality cannot be split-up into behavior according to 'technical' and 'legal' norms. However, the prerequisite for a reorganization of the driver licensing test was to keep this kind of system.

With the perfect - but utopic - goal in mind to replace the theoretical examination by an extensive road test which allows to examine the candidate's
application of the theoretical knowledge in practice, the following fundamental considerations regarding a reorganization of the theoretical driver examination were defined:

1. The driver examination should not only refer to the knowledge of traffic rules and regulations. It should take behavior much more into account, i.e. the ability to cope with traffic reality and thus be more oriented at traffic safety. Therefore driver examination should be an instrument to find out whether a candidate is able to participate in motorized road traffic without danger for himself or others.

2. As the driver examination considerably influences driver training, an optimum driver examination system should contribute to reduce the overproportionally high accident risk of driving beginners also through its effects upon the training system. That means that the driver training has to be adjusted to the driver examination - an effect which is fully intended. If the candidate has to transfer abstract rules and regulations into concrete and adjusted behavior during the driver examination this requires a better training.

3. The driver examination should not be an instrument to test the candidate’s ability to acquire knowledge, his memory, whether he has strong nerves, or how he handles the examination situation itself, but it should be an instrument to examine his ability to understand and handle the theoretical knowledge in concrete situations. Therefore the tasks and questions should be as near to traffic reality as possible.

4. A modification of the examination system should bring about more objectivity and transparency on the one hand and fairer and more equal treatment of the candidates on the other hand. It is a fact that any oral examination highly depends on the subjectivity of the examiner. This subjectivity can be reduced to a minimum by using a standardized catalogue of questions. Another advantage of using such a catalogue is that the candidate can draw his individual set of questions which increases objectivity even more on the one hand and, on the other hand, the examiner can ask additional questions if necessary.

5. The questions of the catalogue should refer to practical requirements and concrete traffic situations and should cover all subjects of the curriculum determined by law. The degree of difficulty of individual questions should be empirically investigated and should not
be determined by experts' opinions. Questions which can be checked during the practical part of the driver examination should not be included in the theoretical part.

Methods:
1. With the intention to combine the advantages both of paper-pencil questionnaire and of oral examinations, the examiner should ask standardized questions and the candidate should give oral answers. This method allows the examiner to find out by means of asking additional questions whether the candidate has understood the subject or only learned it by heart. The driving schools are forced to teach the candidates with respect to understanding and handling of the theoretical knowledge instead of teaching the answers to certain questions.

2. Verbal questions often require a high faculty of visualization from the candidate and therefore often result in stereotype answers to stereotype questions which hardly allows to examine the understanding of theoretical knowledge. A much better method is to use visual material which allows to examine the practical application and handling of the theoretical knowledge - which of course is a necessary prerequisite - in concrete situations. Whenever more than 3 informations are necessary to describe a situation clearly in words, picture or figure material should be used.

3. When using picture material the following procedure should be observed: the candidate is in his vehicle and is part of the traffic situation presented on the picture, sometimes the driving speed has to be indicated. The candidate shall give a short description and assessment of the traffic situation and afterwards say what he would do in this situation and why he would behave in a certain way. Fundamentally, the questions have to be put from the view of the driver and not from a 'helicopter view'. If necessary for an unequivocal definition of a situation, additional information e.g. regarding distance or speed can be given. A reasonable licensing test should also include questions regarding the possible further development of a critical situation for which picture material should be used, too (avoidance of risks).

4. Fundamentally, definitions of regulations and terms should only be demanded if it is indispensable for explaining or differentiating between various types of behavior e.g. when explaining the difference between stopping and
parking.
Questions to which the answers consist of enumerating certain things should only by permitted in case of series of behavior (e.g. what to do after a traffic accident) whereas questions requiring an enumeration of e.g. required or prohibited behavior when overtaking other vehicles should not be allowed. Questions regarding legal regulations shall only be allowed if their knowledge is necessary for understanding a regulation or is relevant for the behavior in a certain situation like e.g. 'is it allowed to pass on a company car or a rented car to others without knowledge of the owner?'

Contents:
1. As far as traffic signs and traffic guidance installations are concerned, the license applicant first has to understand these symbols before he is able to handle and apply his knowledge in practice. In this case, too, the practical application should be examined and not the knowledge - which only is a necessary prerequisite. In this connexion picture material should only be used for questions referring to specific behavior in a certain situation but not when asking for the meaning of a special traffic sign.

2. Picture material representing right-of-way situations should not be presented from a "helicopter view" but from the view of the driver. Nevertheless, the knowledge of the right-of-way regulations and their practical application immediately before entering the intersection still is not sufficient. In real road traffic the driver has to know already when approaching an intersection what he has to observe and accordingly decide what to do: to stop or to drive on.
As far as the observation of other road users is concerned, not only other vehicles but also pedestrians have to be included who are missing in most theoretical material dealing with this subject.
Also questions regarding technical knowledge should be as close to reality as possible: e.g. "What do you do when the red control lamp at the instrument board lights up?" instead of "How does the hand-brake work?"

3. As far as the examination of the knowledge of 'traffic safety' and 'avoidance of danger' is concerned, the understanding and handling of the theoretical knowledge has to include not only the understanding of legal regulations but also
behavior which is relevant for one's own safety and the safety of others. An important effect of the new driver examination system in this field is the influence upon the training in the driving schools like e.g. providing the candidates with information concerning results of research into the causes of accidents in connexion with the most frequent types of accidents involving beginners which is a considerable contribution to road safety.

According to these requirements approx. 700 questions covering the entire curriculum were worked out and provided with the necessary picture material. Based on these 700 questions approx. 90 examination sheets were compiled which shall be used in Austria starting on the 1st of October, 1987, due to a regulation of the Ministry of Transport.

So far the considerations and the actual state of development regarding the theoretical driver license test in Austria.

Of course there are also considerations regarding a reorganization of the practical part of the driver license test and according to our proposals it should consist of 2 parts:

1. Basic driving exercises in a low traffic zone:
   In this first part of the practical driver license test the ability to handle the vehicle properly shall be examined by means of some basic driving tasks. For this purpose the candidate has to absolve certain standard tasks. Performing these tasks properly is the prerequisite for the actual driving test in traffic.

2. Driving test in traffic:
   The route where the driving test takes place has to fulfill certain standard requirements regarding the complexity of the traffic situations that may occur as well as regarding regulations and signs. The driving test should at least take half an hour which seems to be the minimum time that allows to get - at least a rough - impression of the candidate's driving ability. For more objective assessment a standardized evaluation scheme should be used.

However, up to now it cannot be predicted when these requirements regarding a reorganization of the practical driving test will be realized in Austria.
Apart from the above described new driver examination system in Austria which of course is a compromise for we had to take account of the local conditions in many respects I would like to present a few considerations in connexion with a European or at least an EEC-driver license which I think would be worth to be discussed:

Of great advantage would be the installation of a data bank or item bank which should include all questions of driver license tests of all EEC-countries. The theoretical driver examination should not only refer to regulations of one’s own country but also include questions regarding different regulations at least in the neighbouring countries. Lack of knowledge of traffic regulations or results in hesitant behavior and thus in an inhomogeneous traffic flow—especially in a transit country like Austria.

In addition, the elaboration of international assessment criteria regarding the practical examination as well as of a requirement profile regarding examiners—upon whom the reliability of the result of the practical examination depends—would be very desirable. Both the assessment criteria as well as the requirement profile should be homogeneous at least for Western Europe.

Also the question whether the theoretical driver examination should take place subsequent to the practical examination—which is quite opposite to the present practice—would be worth a few considerations.

When thinking of the often very severe consequences caused by only one error made while driving a vehicle, the question seems to be justified whether one training and passing one examination is sufficient. Of course driver examination should be a solid instrument which allows to decide validly whether a candidate is able to participate in motorized road traffic. But also the best examination system can never be a hundred percent reliable instrument as far as the prognosis of future driving behavior is concerned. Therefore, some countries like e.g. Norway or lately also Western Germany have adopted psychological—educational measures with the intention to allow the—mainly young—driving beginners to gather experiences in normal road traffic under some supervision.

One of the most fundamental realizations of psychology is that learning processes can only be effective when they are based on own experiences in
real-life situations, like e.g. in our case to experience difficulties in real road traffic. Only in connexion with his own driving experience the driving beginner is able to realize that he has still deficits in coping with difficult driving tasks. This insight cannot be reached through any training however good it might be.

But how could this problem be solved? Based on these considerations two models of "Driver License on Probation" were developed:

- The General Preventive Model:
  This model includes an obligatory second training phase for all driving beginners. Within a certain period of time (e.g. 2 years) certain additional training courses have to be absolved. The theoretical part of this training includes correct attitudes towards road traffic, avoidance of risks, communication with other road users, and defensive driving. The practical part should give the trainees the opportunity to practice special driving tasks like e.g. night drives, driving on highways and mountain roads or driving under adverse weather conditions, etc.

  One of the advantages of this second training phase - which is carried out by driving trainers who had to absolve a special training and examination - is that it starts right at a time when the driving beginner shows the highest accident risk. It allows to correct erroneous behavior which has already been acquired but is not yet automated.

  This model has already been applied with great success in Norway for several years.

- The Individual Preventive Model:
  The overproportionally high percentage of young drivers being involved in accidents is one of the most important problems of road safety both on a national as well as on an international level. The reasons can be found in two fundamental factors namely in a lack of driving experience on the one hand and, on the other hand, in the typical juvenile personality attitudes which cause the young driver not only to underestimate the risks of road traffic but also to accept them intentionally. A calculation of the risk of young driving beginners to be involved in an accident showed that their risk is at least 6 times higher than that of persons who own the driver license for longer than 10 years.
An approach to this problem was made by means of the individual preventive model. In case of unadjusted driving behavior during the first years after acquiring a driver license the driver has to solve an additional specific training. These driver improvement courses take into account the candidate's specific problems like e.g. driving while being under the influence of alcohol, general attitudes towards road traffic, or handling of the vehicle.

Based on practical experiences the following subjects seem to be relevant for such courses:
- Discussion of typical problems and accidents of driving beginners like e.g. selection of an appropriate speed adjusted to the traffic situation or selection of the appropriate distance to the preceding car, etc.
- Explanation of the relationship between subjective and objective risk - an important subject for young drivers.
- Discussion of the social components in the traffic system, i.e. the interactions between one's own behavior, the behavior of other road users and the requirements of the road traffic system.
- In addition, the discrepancy between the actual and the desirable situation on our roads should be treated.

Nearly one year ago such an individual preventive model has been adopted by Western Germany. Of course accident statistics are not yet available but it seem to have positive effects - at least in an educational preventive sense - because entries of violations in the central data bank in Flensburg decreased significantly in cases where a driver was informed that he would have to absolve a course if he would once again commit a specific traffic offence.

To conclude I want to mention one observation which seems quite important to me: The expectations connected with an appropriate driver training, driver examination system and driver improvement training and the necessity to influence the behavior of road users by means of such measures does not have the same importance for all countries. It seems to be connected closely with the national road system, with the psychological attitude towards the driver license, and with its social importance. This might be the reason why these considerations and the measures resulting from them have high priority in
Europe and in Japan whereas in the USA this subject is not discussed at all.
In Austria every year approximately 9,000 applicants for a driver license have to absolve a psychological driver aptitude test. That is nearly 7 percent of the total number of applications per year (at the moment approx. 130,000).

The persons who have to absolve such a test can roughly be divided into two groups: those who have to show certain minimum requirements as far as performance capacity and personality traits are concerned and those who have to show performance and personality qualities above average due to increased responsibility and demands (e.g. bus drivers).

What are the requirements regarding performance capacity and personality which are essential for driving a vehicle safely from the psychological point of view?

- Most information in road traffic (approx. 80-90%) are taken in visually. Therefore a sufficient processing capacity of visual information is absolutely necessary. A driver has to be able to differentiate between relevant and irrelevant information. A necessary prerequisite is the ability to perceive each traffic situation - also more complex ones - quickly and accurately, to survey moving objects continuously, and to perceive possible dangers in the periphery of the visual field.

- Another requirement is a sufficient reactive capacity also under conditions of stress. Especially the ability to adjust to changing conditions as well as stability of performance capacity under varying load over a longer period of time are important.

- Of course a driver has to show an adequate level of attention and concentration. Constancy in attention and the ability to increase the level of attention to a maximum for a short period of time are required.
Adequate sensorimotor coordination, i.e. the ability to translate sensory information into adequate and coordinated movements when steering a vehicle, is required, too.

Driving a vehicle also requires a certain intellectual capacity: understanding of rules, comprehension of visual information as well as a certain level of practical intelligence are necessary.

Last not least a driver has to show certain personality traits and attitudes. Of great importance are emotional stability, social responsibility, adequate assessment of one's own performance capacity, low readiness to take risks, little tendency towards aggressive behavior, as well as a realistic relationship to vehicles.

Based on years of practical experience as well as on scientific research the experts of the Institute of Traffic Psychology of the Austrian Road Safety Board developed a number of psychological tests which allow to examine all the above mentioned aspects of performance and personality and thus also allow a prognosis regarding future driving behavior.

In the course of the reorganization of driver aptitude diagnosis a test device called Act & React Test System was developed for the presentation of the different tests. This development resulted in a further improvement of the quality of psychological driver aptitude diagnosis.

Slide 1: ART-90

This test unit - which was named ART-90 - combines modern computer technology with the latest traffic psychological findings. The whole testing period - beginning with input of the subject's data and continuing with instruction, test, evaluation, and data storage is automated which considerably reduces the organizational and administrative work connected with psychological driver aptitude diagnosis.

However, presenting the tests at a microprocessor-controlled test unit also entails considerable advantages for the subject: During the whole testing period he works independently at 'his own test unit'. The instructions to all tests are presented via the monitor of the test unit. By means of a so-called light pen the subject can communicate with the test unit and can repeat and practice each
step of the instruction until he has understood the
task. This concept allows for the subject's
individual speed of learning.

The advantage for the traffic psychologist is that
immediately after the subject has performed the
tests the evaluated data are available. In the
personal interview subsequent to the testing the
psychologist can refer to characteristic or
inadequate test results and can discuss them with
the subject.

Last not least it is worth mentioning that the
automated data storage allows a continuous and
economic collection of data free of errors. Thus an
extensive pool of norm values which is constantly
updated is available.

I would like to give you a brief survey of the
individual tests which are used in the ART-90 to
examine the aspects of performance and personality
necessary for driving a vehicle safely.

- For the examination of the visual processing of
  information several tests are presented:

  Slide 2: Labyrinth of Lines

  - The Line Labyrinth Test has been designed to
    examine visual structuring ability: The
    subject has to follow one line after the other
    from its beginning to its end. The lines are
    presented on the screen of the ART-90, the
    answers are given by means of the light pen on
    the monitor.

  Slide 3: Tachistoscope

  - The Tachistoscope Test is used to examine the
    ability to take in and process important
details of the traffic scene and the traffic
    environment quickly. For this purpose traffic
    situations are presented on the screen of the
    ART-90 for slightly less than a second.
    Subsequently the subject has to answer
    questions referring to details shown on the
    pictures via the monitor.

  Slide 4: Peripheral Perception

  - The Peripheral Perception Test is used to
    examine the perception of moving objects
    especially in the periphery of the visual
    field. The subject has to react correctly and
in time to certain peripheral light stimuli presented by means of the light-emitting diodes on the peripheral display of the ART-90. At the same time the subject has to perform a central task on the monitor which consists of steering a small bar by means of the rotary knob below the monitor through a track.

The purpose of this tracking task is not only to engage the subject's attention in the center of the visual field but also allows to examine his sensorimotor coordination.

Slide 5: Cognitrone

- The Cognitrone - which also is an integrated part of the ART-90 - has been designed to examine attention capacity. For this purpose two rather similar tests have been developed: Geometrical figures different in their number and complexity are presented at the upper display of the Cognitrone while only one figure is presented at the lower display. The subject has to decide whether the figure below is identical with one of the upper figures or not. This task requires a constantly high level of attention.

- The subjects' reactive behavior is examined at two peripheries of the ART-90:

Slide 6: Viennese Reaction Device II

- The Viennese Reaction Device II is used to examine reaction time and accuracy of reaction. The subject has to react to one out of several combinations of stimuli (acoustic, visual, or combined) by means of moving his finger from the lower button (which we call 'resting button') to the upper button (called 'reaction button') as quickly as possible. This design allows to differentiate between central nervous decision time and motor reaction time.

Slide 7: Viennese Determination Device II

- To examine reactive behavior under changing and more complex conditions a Reactive Stress Tolerance Test is presented at the Viennese Determination Device II. The subject has to react to various visual and acoustic signals (different color and acoustic signals) which are presented at 3 different speeds (slow,
very quick, quick) by means of pressing the corresponding buttons, keys, and foot pedals.

Slide 8: Matrices Test

The Matrices Test - which is presented via the monitor - is used to examine the subjects’ intellectual performance capacity. A matrix consists of 8 geometric figures which are constructed following certain logical rules and have to be completed. The subject has to find out the rule and select the missing figure out of a number of possible solutions.

The personality traits relevant for driving a vehicle are examined by means of 3 questionnaires which are presented via the monitor and answered by means of the light pen. One of the questionnaires examines general aspects of personality such as emotional stability, social responsibility, anxiety, and self-control. Another questionnaire examines the acceptance of risk and the third one attitudes towards road traffic.

The relevance of this test battery for the prognosis of driver behavior was investigated by means of two validation studies. The first one was carried out with volunteers and the second one with subjects from our routine driver aptitude tests. In addition to the examination at the ART-90 where all tests were presented the subjects’ driving behavior was observed on a standardized route and information regarding offenses against the traffic code and traffic accidents were gathered.

For the examination of the validity the correlations between individual test variables and variables of driving behavior were computed. Especially our subjects from routine driver aptitude testing showed highly significant correlations (between 0.40 and 0.60). In addition, the test battery as a whole was examined regarding the prognosis of driving behavior. For this purpose the subjects were classified into several types of drivers by means of a cluster analysis. Each group showed a characteristic way of driving (e.g. the aggressive, risk-accepting type of driver, or the rather unexperienced, hesitating type of driver, etc.). A discriminant analysis showed that between 70 and 80 % of the subjects could be classified correctly into one of these groups also when using their test results only. These results justify the application of our tests.
at the computerized test unit ART-90 for the examination of traffic relevant dimensions of performance and personality.

To demonstrate the application of the ART-90 in the routine driver aptitude diagnosis at the Austrian Road Safety Board a video film is presented in the hall.
"WHY CAN WE EXPECT NEW SCANDINAVIAN DRIVER EDUCATION PROGRAMMES TO SET INTERNATIONAL STANDARDS AND IMPROVE FUTURE SKILLS OF NEW DRIVERS?"

by Dr Birger Nygaard, VTI, Sweden

The relatively higher involvement in traffic accidents by young and new drivers is often referred to as being caused by their lack of skill and experience to cope with the demands of traffic and influenced by a certain immaturity as a normal trait seen with youngsters. Much effort has been invested in driver training programmes and driver licensing schemes to improve this condition. It is often seen, however, that the most efficient training and accident avoiding driving behaviour is obtained, not during the driving school and the follow-up passing of the driving test, but as a result of the free driving after the licensing. Learning by doing is in this context presumably most efficient when obtained as a normal driver in normal traffic. However, we should not forget that accident involvement is a most potential teacher.

In-depth studies of traffic accidents involving new drivers indicate at the least the main contributing factors:

1. Lacking ability to correctly anticipate and imagine the risk of own behaviour when alone or interacting with other road users.

2. Lacking ability to adequately control the vehicle both in ordinary, normal manoeuvres and when an emergency occurs.

To meet these problems the new Scandinavian driver education programmes, recently also adopted by the OECD Road Programme, conceptually base the training on three topics:

A. Initial training in car controlling, outside normal traffic according to evaluative schemes set by the driver himself, adapted to his skills and progress followed by stepwise training in real traffic of increasing difficulty.

B. Classroom and in-traffic training of risk anticipation based on typical errors and accident causes seen with new drivers.

C. Elongation of the training period and incorporation of special courses in night-time driving, skid driving and strategies for steering and braking in emergency situations as a conclusive part of the driver training.

The paper discusses the single blocks of the education more deeply and presents some recent results.
EFFECTS OF MINIMUM DRINKING AGE ON HIGHWAY FATALITIES IN THE UNITED STATES

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ABSTRACT:

Between 1975 and 1984 somewhat less than 20 percent of the highway fatalities in the United States involved at least one 18 to 20 year old driver. Since many of these accidents also involved alcohol, raising the minimum drinking age (MDA) holds the promise of reducing this death toll. In this paper, the effects of changes in the minimum drinking age on state fatalities involving 18 to 20 year old drivers were estimated using a pooled, time-series, cross-sectional statistical approach. The analysis indicated that approximately 11 percent of the fatalities which involve drivers in the age groups affected by the law change would be avoided. If all states had MDA's of 21 in 1984 rather than 18, approximately 860 lives would be saved. Since many states already have MDA's above 18, about 60 percent of this saving is already being realized.
EFFECTS OF MINIMUM DRINKING AGE ON HIGHWAY FATALITIES IN THE UNITED STATES

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ABSTRACT:
Between 1975 and 1984 almost 20 percent of the highway fatalities in the United States involved at least one 18 to 20 year old driver. Since many of these accidents also involved alcohol, raising the minimum drinking age (MDA) holds the promise of reducing this death toll. In this paper, the effects of changes in the minimum drinking age on fatalities by state involving 18 to 20 year old drivers were estimated using a pooled, time-series, cross-sectional statistical approach. The analysis indicated that an increase in the MDA reduces fatalities involving affected drivers by approximately 11 percent. If all states had had MDA’s of 21 in 1984 rather than 18, approximately 860 lives would have been saved. Since many states already have MDA’s above 18, about 60 percent of this saving has already been realized.

In 1984, 7,797 people died in the United States in accidents involving at least one 18 to 20 year old driver. Overall, 50 percent of the fatal accidents in the United States are thought to involve alcohol. In the hope of avoiding many of these fatalities, Congress passed the National Minimum Drinking Age Law which authorizes the Secretary of Transportation to withhold a portion of a state’s Highway Trust Funds if the state’s laws allow persons under 21 years old to purchase or publicly possess any alcoholic beverage.

This paper examines the effect of state Minimum Drinking Age (MDA) laws on highway fatalities. In 1984 when the National Minimum Drinking Age Law was passed, 21 states had a MDA of 21 years old. In the ten years prior to this law, many states had increased the MDA, some all the way to 21 years old. It is the experiences of the states in these ten years, 1975-1984 that are used to estimate the effect of MDA on highway fatalities.

Possible Influences of the MDA Changes:
A MDA law change will not eliminate drunk driving among the affected young drivers because there are many illegal means of obtaining alcoholic beverages. Increasing the MDA should make it more difficult to obtain alcoholic beverages for those directly affected by the law change. Making it more difficult to obtain alcoholic beverages ought to reduce drinking and reduced drinking should result in less drunk driving. So, fatalities involving
alcohol and drivers in the affected age group should be reduced. While many people have provided empirical support for these arguments\textsuperscript{1}, other arguments and data have been advanced which would suggest otherwise.

Some people\textsuperscript{2} have argued that increasing the MDA does not reduce drinking but it does affect the physical location where drinking by the young occurs. It substitutes drinking in cars for supervised drinking in bars and taverns.

Others\textsuperscript{3} have argued that while the fatalities involving alcohol and young drivers should decline immediately after an increase in the minimum drinking age, fatalities involving drivers just over the MDA will increase when this age group learns how to drive while drinking. This argument suggests that MDA laws simply shift fatalities from one age group to another.

It is difficult to predict the relative importance of the possible effects of increases in MDAs by reason alone. They all may have some truth. Only measuring the net effect on highway fatalities of changes in MDAs will indicate whether the changes are beneficial with respect to lives saved. Other considerations including alcohol related traffic injuries, other alcohol related injuries and fatalities, and abridgment of choice are relevant in deciding whether to increase the MDA.

**Measuring the Effect:**
Fatalities involving 18 to 20 year old drivers who had been drinking would be the ideal measure of the effect of changes in MDA. This measure would be sensitive to the change because it includes the population affected by the law change but no one else. The National Highway Traffic Administration's (NHTSA) Fatal Accident Reporting System (FARS) includes information on both the driver age and on the blood alcohol concentration of the driver. Unfortunately, blood alcohol concentration information is not available for all 18 to 20 year old drivers involved in fatal accidents, and testing for blood alcohol is likely to increase after state law changes because of the increased awareness of alcohol particularly for younger drivers. So, what is potentially the best measure of the effect of MDA changes, fatalities involving a drinking 18-20 year old driver, is compromised by incomplete and probably biased reporting on alcohol involvement.

\textsuperscript{1} Wagenaar (1983); Williams et al (1983); Arnold (1985) among others and the survey by the U.S. General Accounting Office (1987).
\textsuperscript{2} Notably Mr. Birkley of the National Licensed Beverage Association in testimony on the National Minimum Drinking Age Law in a hearing before the Subcommittee on Investigations and Oversight of the Committee on Public Works and Transportation of the House of Representatives, September 18, 1986.
\textsuperscript{3} Bolotin and DeSario (1985) and Males (1986) have made this argument.
Fatalities involving any 18 to 20 year old driver is the best available measure and the one selected in this study. It is an unambiguous measure which is reliably reported and which can easily be used to develop a national estimate of the effect of MDA changes on highway fatalities and it is as close to the target population as the data reliability permit.

Figure 1 presents the trend in fatalities involving 18 to 20 year old drivers along with a measure of the proportion of states where 18 to 20 year old drivers cannot drink. This proportion would equal 1 if all states had MDA's of 21 years old. Each state's contribution to the measure is prorated based on the MDA. So, a state with a MDA of 19 would count one third as much as a state with a MDA of 21 years old. The measure counts small states the same as large states. Figure 1 shows fatalities involving 18 to 20 year old drivers declining as the proportion of states with a MDA of 21 increases.

Before concluding that MDAs have caused this drop in fatalities, consider the behavior of other fatality series presented in Figure 2. These other series exhibit very similar patterns. Since the other series are not likely to be affected by the MDA changes, influences other than MDA changes must be responsible for the overall pattern. This illustrates the problem of measuring the effect of MDA law changes: In order to associate the measured fatality change with a MDA law change, the effects of other influences must be understood and controlled.

**Methods:**
To control for the many influences on highway fatalities and to make the most complete use of the available data, a pooled time-series, cross-section model was developed of annual, state, per capita fatalities involving 18 to 20 year old drivers. Fatalities divided by 18 to 20 year old population was selected as the dependent variable rather than fatalities because states differ substantially in their size, making it more likely that an extraneous, size related factor would be associated with fatalities than with fatalities normalized by population. The specification gives further protection against this type of spurious association. The model is described in Table 1. Important variables are discussed below.

A variable which identifies the period after a change in MDA is used to estimate the effect of the change in MDA. This MDA intervention variable, AGE, is zero until a change in MDA. Then the variable is one if the state changes from a MDA of 18 to an MDA of 21. The value of AGE is reduced for smaller age changes, for partial year effects, and to reflect "grandfather" clauses in the state laws. "Grandfather" clauses allow those people who can legally drink just before the law is enforced to continue to drink after the law is in force even if they are underage. So, if a state passes a MDA law which changes the age to 19 from 18 on July 1 but includes a "grandfather" clause, the value of the AGE variable in the first (partial) year of enforcement would be: one third, to reflect the one year change;
Fig 1: STATE MDAs & 18-20 DRIVER-INV. FATS.
NUMBER & PROPORTION OF STATES WITH MDA=21

- STATES AT MDA 21 (/51)
- FATALITIES (*10,000)
Figure 2: Fatality Trends Relative to 1975 (FATS/1975 FATS.)
Table 1: Model to estimate the effects of MDA changes

MODEL:
\[
\log (RATES_Y) = B_0 + B_1 \cdot AGES_Y + \ldots B_N \cdot \log(\text{control variables}_Y) + U_S_Y
\]

Where:
- \( RATES_Y \) = fatalities involving 18-20 year old drivers in state S in year Y divided by the 18-20 year old population in the same state and year.
- \( AGES_Y \) = MDA intervention variable for state S in year Y which reflects the extent and timing of the MDA change if any.
- \( B_N \)'s = regression coefficients
- \( U_S_Y \) = stochastic error term

control variables tested include:
- \( STATES = \) dummy variable which assures that the average error for each state is zero.
- \( YEAR_Y = \) dummy variable which assures that the average error for each year is zero.
- \( OLDRATES_Y = \) fatalities involving drivers 21 years old and over divided by the population 21 years old and over in state S and year Y.
- \( UNEMPL_S = \) unemployment rate for all members of the labor force in year Y and state S.
- \( BEERS_Y = \) per capita consumption of malt beverages in state S and year Y.
- \( \%R.VMT_S = \) rural vehicle miles traveled (VMT) divided by total VMT in state S and year Y.

times one half, to reflect the half year of effect; times one quarter, to reflect the "grandfather" clause adjustment for a half year. In the second year, the value of the AGE variable would be one third minus one twenty-fourth to reflect the "grandfather" clause 18 year olds who can drink for part of the year. The adjustments to the AGE variable assume that 18 year olds, 19 year olds, and 20 year olds are equally likely to be involved in fatal accidents and that all days of the year are equally likely to have fatal accidents. While these assumptions are not completely accurate, they simplify the calculation of the AGE variable and still make important adjustments to the exposure of 18 to 20 year old drivers to the MDA law change.
The STATE and YEAR variables are actually sets of dummy (0 or 1) variables. The 50 STATE variables are included to account for the average fatality rate for each state so that the large state-to-state differences in fatality rate are not falsely attributed to MDA changes which occur in only a subset of the states. The nine YEAR dummy variables are included to account for the average fatality rate for each year so that trends in the national fatality rate are not falsely attributed to the MDA changes which accumulate more quickly in the latter years of the data. Inclusion of the 50 state dummy and nine year dummy variables help protect the model from the omitted variable problem which might result in a spurious or inflated association between MDA and fatality rate.

OLDRATE, the per capita fatality involvement rate of drivers 21 and over, is included to account for many of the factors which could be expected to affect 18 to 20 year olds as well as older drivers. Factors like weather, changes in roads and traffic control, and changes in the availability and efficiency of emergency medical services would be expected to affect the two groups similarly.

The state’s unemployment rate, UNEMPL, is expected to affect the amount of driving, especially the amount of riskier discretionary driving, and this effect has been found by the authors (1985) to be more pronounced among younger drivers. So, increases in the unemployment rate would be expected to cause decreases in the fatality rate.

Increases in apparent per capita beer consumption (actually sales) should increase the fatality rate since more consumption means more opportunities to drive while intoxicated with the associated increase in the risk of a fatal accident. BEER could be influenced by the MDA, however, so the effects of this variable must be interpreted with caution.

Finally, the proportion of driving on rural roads should affect the fatality rate because rural roads have a higher fatality rate per vehicle mile than urban roads. The variable %R.VMT reflects state-to-state differences in the composition of driving.

Results:
Table 2 presents the results of estimating three forms of the model on the state per capita fatalities involving 18 to 20 year old drivers. Data for all states between 1975 and 1984 were used with a weighted least squares estimation procedure. In this procedure, the fatality rate for each state-year is weighted by the fatality count for the state-year. This weighting helps reduce problems which exist because fatalities involving 18 to 20 year old drivers have a higher variance in small states than larger states. Since a measure of fatality reduction is sought, fatalities are an appropriate weighting factor.
Table 2: Model results (coefficients and t-statistics)

<table>
<thead>
<tr>
<th>VARIABLE</th>
<th>MODEL I</th>
<th>MODEL II</th>
<th>MODEL III</th>
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<tr>
<td>AGE</td>
<td>-.19</td>
<td>-.11</td>
<td>-.09</td>
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<tr>
<td></td>
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<tr>
<td>YEAR</td>
<td>OUT</td>
<td>IN</td>
<td>IN</td>
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<tr>
<td></td>
<td>(9 dummy variables)</td>
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<td></td>
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<tr>
<td>OLDRATE</td>
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<tr>
<td></td>
<td>(16.09)</td>
<td>(13.44)</td>
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<td></td>
<td>(-9.11)</td>
<td>(0.25)</td>
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<tr>
<td>BEER</td>
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<tr>
<td></td>
<td>(5.90)</td>
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</table>

Model I shows the results of estimating the model without the OLDRATE or STATE and YEAR dummy variables. All of the variables in the model have the expected signs and are statistically significant at the 95 percent confidence level. This model suggests that raising the MDA reduces fatalities involving law-affected drivers by 19 percent. However, as measured by the adjusted R-squared, this model explains only about 40 percent of the variation in the per capita state fatalities involving 18 to 20 year old drivers.

In Model II, the OLDRATE, STATE and YEAR variables replace UNEMPL, BEER and %R.VMT. This model explains substantially more of the variation in the fatality rate and both OLDRATE and AGE have the expected signs and are statistically significant. This model suggests that increasing the MDA reduces fatalities involving law affected drivers by eleven percent.
All of the variables are included in Model III. Very little overall improvement is shown judging by the slight increase in adjusted R-squared between Model II and Model III. Of the three variables added to Model II, only BEER has a coefficient which is statistically significant. As mentioned earlier, changes in MDA would be expected to affect apparent beer consumption since a part of the population is prohibited from purchase or public possession of alcoholic beverages. So, when the MDA is increased beer consumption should decrease and fewer fatalities would be expected. Because of this relationship, the size of the effect of the MDA change is probably underestimated by Model III. Model II probably provides a better estimate of the size of the reduction in fatalities involving drivers affected by the law change: eleven percent, though this estimate is not exact. At the 95 percent confidence level, the reduction in fatalities involving affected drivers is between 5 percent and 17 percent.

This eleven percent estimate is based on the experience of states which changed their MDA during the 1975 to 1984 period. During this period, 28 states changed their MDA at least once. Fourteen of these states changed the MDA to twenty or below and had at least one year of data where drivers who could never legally drink began drinking at the new, older age. So, if there is an increase in fatal involvements at this older age, it is captured in the data for these fourteen states and it is partially captured in the coefficient estimated in Model II.

An analysis of annual state per capita fatalities involving 14 to 17 year old drivers was performed to see if raising the MDA had an effect on these fatalities by making alcohol more difficult for them to obtain illegally. This analysis did not find an effect which could be statistically distinguished from zero at the 95 percent confidence level.

Finally, to test the specificity of the AGE variable, it was used along with the STATE and YEAR dummy variables to model annual state per capita fatalities involving 21 to 23 year old drivers. The AGE variable was not statistically significant at the 95 percent confidence level, indicating that the AGE variable is very specific in capturing the effects of MDA changes and not other broader effects on highway fatalities.

**Lives Saved:**
Given the best estimate that increases in the MDA reduce fatalities involving drivers affected by the law by eleven percent, how many lives were saved in the United States in 1984 because states had MDAs above 18 years old? How many more lives could have been saved if all states had had MDAs of 21 years old?

Figure 3 shows the proportion of 18 to 20 year old driver involved fatalities in 1984 by the effective MDA in the state where they occurred. Notice that 42 percent of these fatalities occurred in states where the MDA was already 21 years old. These fatalities would not be affected by a change to a
Fig 3: 18–20 YEAR OLD DRIVER–INVOLVED FATS.
BY EFFECTIVE MDA IN 1984

FRACTION OF THE 7,797 18–20 DRIVER INVOLVED FATALITIES BY MDA

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uniform MDA of 21. Of the 399 fatalities in states where the MDA was 20 years old, only about a third would involve 20 year olds. Similar reasoning leads to the numbers in Figure 4 which shows that 59 percent of the fatalities involving 18 to 20 year old drivers in 1984 would not be affected by a uniform MDA of 21 because these fatalities involve drivers who already could not drink legally. Roughly eleven percent of the remaining 3,217 fatalities, 354, would have been prevented if there had been a uniform MDA of 21 years old.

Many lives were saved in 1984 because states had MDAs above 18 years old. Those fatalities not affected by a uniform MDA of 21 would be higher than they actually were in 1984 by eleven percent if the MDA were 18 instead. This represents 504 lives that were saved in 1984 because states did have MDAs above 18.

Conclusions:
An increase in the MDA reduces fatalities involving affected drivers by about eleven percent (between five and 17 percent at the 95 percent confidence level). A uniform Minimum Drinking Age of 21 years old rather than 18 would have saved about 858 lives in 1984. Much of this saving was already being realized because many states had MDAs above 18 years old in 1984. However, 354 of the lives which were lost in 1984 could have been saved if the states where they occurred had MDAs of 21 years old.

Figure 5 compares the lives saved by a uniform MDA of 21, both actual and potential, with the accidental deaths from selected other transportation modes to give perspective on the numbers. In the context of fatalities for other modes, the lives saved by a uniform MDA of 21 years old look very substantial. Only eliminating fatalities in general aviation or recreational boating would save more lives than raising the MDA from 18 to 21. Ultimately, the relative value of the right to consume alcohol must be weighed against the lives lost and injuries sustained from intoxication of 18 to 20 year olds on the highways and in other alcohol related incidents.

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Fig 4: 18–20 DRIVER INVOLVED FATALITIES
AFFECTED AND NOT AFFECTED BY A UNIFORM MDA OF 21

AFFECTED 3,217 (41%)

NOT 4,580 (59%)

PROPORTION OF THE 7,797 FATALITIES IN 1984
Figure 5: TRANSPORT FATALITIES 1984
FOR SELECTED MODES

<table>
<thead>
<tr>
<th>Mode</th>
<th>Fatalities in 1984</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recreational Boating</td>
<td>1063</td>
</tr>
<tr>
<td>General Aviation</td>
<td>1002</td>
</tr>
<tr>
<td>Rail</td>
<td>598</td>
</tr>
<tr>
<td>MDA 21</td>
<td>858</td>
</tr>
<tr>
<td>Commercial Aviation</td>
<td>354</td>
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<tr>
<td>Hazardous Materials</td>
<td>7</td>
</tr>
</tbody>
</table>

Source: Transportation Safety Information Report 1984
References:


License Removal at Time of Arrest for Driving While Intoxicated: An Approach with Promise in the United States

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ABSTRACT:

A relatively recently adopted driving while intoxicated (DWI) sanction in many states in the United States is called administrative per se. This sanction involves an immediate short term license suspension or revocation for persons arrested for DWI whose chemical test results exceed the per se limit (generally 10 in the United States) or who refuse to submit to such a test. The duration of license removal ranges from 10 to 90 days for test failure and generally longer for test refusal. Separate sanctions are applied later if the arrestee is found guilty of the DWI offense. This sanction is intended to help accomplish deterrence through the swift, certain imposition of a relatively severe sanction.

This study will examine how this sanction is actually being implemented in several states in the United States and the extent to which it may be contributing to DWI deterrence.
DRINKING AND DRIVING. INSTITUTIONAL AND SOCIAL ASPECTS OF LAW ENFORCEMENT

by Dr Marie-Chantal Jayet, INRETS-DERA, France

"Per se system", "random checks" and improved technics of detection seem at the present time to constitute the international standard of drunken driving laws enacted in many countries on two continents (Europe, U.S.A.).

This fact may be regarded as a by-product of general tendencies to deal with law enforcement as a pure technical problem. The appropriateness of this approach will be examined with reference to the first findings of a research focused on judicial responses to the drunken driving laws in France.

Legal process (arrests, prosecutions, sentencing) seem to be affected by internal institutional logics and socio-cultural backgrounds of judicial working and practices rather than by formal and uniform legislative provisions. The rationalization assumption intending to regulate and to improve law enforcement is contradicted whether because law is not enforced or because of the law enforcement trends. In fact, the way in which the law is enforced is more relevant to general or local attitudes towards alcohol and driving than to the aim of the law.

These findings demand a shift of emphasis within the law enforcement approach, from technical standpoint to sociological framework, and from legal formal provisions to underlying conditions of legal and judicial practices. Thus, from both the policy and research point of view, and with regard to routine practices, the main conditions of law implementation have to be regarded as being firstly rooted outside of the legal process and secondary inside of it.

A last point would have to take place in that problematic scope but it would need an appropriate comparing research. It rests in the probable impact of criminal law system, justice organisation and working, lawyer status, on the way in which law is more or less enforced. From that standpoint, a comparative study about law enforcement practices within the Common Law and Civil Law countries could show unlighted features in national studies.
DRINKING AND DRIVING: INSTITUTIONAL AND SOCIAL ASPECTS OF LAW ENFORCEMENT
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1. INTRODUCTION

Concern to prevent alcohol-related risk has led in particular to safety research being oriented chiefly towards diagnostic and evaluative approaches, firstly to the alcohol factor and secondly to preventive measures based in the main on criminal law.

The application of drunk-driving laws accordingly is regarded as a sub-theme of the whole question of their effectiveness and as an argument to strengthen a prevention policy based on the theory of deterrence.

This explains why the usual approach to the matter has done little or nothing to highlight the descriptive and analytical aspects of whatever favours or inhibits effective application of laws.

In the field of law and criminal sociology, research on the implantation of law into social principles and its effects on social life has contributed to the development of a number of studies on a criterion of what may be termed "the effectivity of the criminal law". (LASCOUNES P., SERVERIN E., 1986). A reading of those studies leads to the conclusion that this criterion is apparently a socio-legal equivalent of the policy-related and practical conception of "implementation" (BLANKENBURG E., 1986). Indeed it incorporates the idea of implementation in a conception of social operation of criminal law. In this way it takes cognizance of a targeted problematic in the explicative analysis of the relations and "gaps" between criminal law and society, and between the law and its object.

For exploratory purposes this paper proposes to examine from different angles the question of the application of the drunk-driving laws, and in particular the operational value of the approach based on the criterion of "effectivity" and on the limits of the analyses based on the preventive model of deterrence. Some data relating to the application of the drunk-driving laws in France will be presented to this end.

It would appear logical to begin with the very concept of "application of the law" and its subordinate relationship to the conceptual model applied to operation of the law.
2. APPLICATION OF THE LAW: INTERFACE BETWEEN CRIMINAL LAW AND SOCIETY

The question of the application of the law may be understood in different ways, depending on the conceptual model of reasoning used about justice and law. Depending on one's viewpoint, the process involved may vary in content to a considerable extent. Thus, it can answer to different status, from being a more or less complex technology bearing specifically on drunk driving to one embracing the full breadth of operations of the legal order in society (legislative, executive, and normative).

In road safety, as we have already pointed out, the tendency with regard to drunk driving is to examine this matter of the application of the law from the point of view of its effectiveness. As a general rule, it takes an evaluative approach towards the impact of the law or of new legislative measures aimed at increasing its effectiveness.

This terminology is used first and foremost to indicate problems (and disappointments) arising in terms of expectations of reduced accident risk and drunk driving, and which provide the logical basis for the preventive policy of making such driving a criminal offence.

Strictly speaking, the implementation of the law has not been granted the status of a study or research subject which, when analyzed, would explain why the law is ill-applied and not respected.

The application of the law is akin to a technology with functional shortcomings, leading to comment, revisions and even the adoption of legal countermeasures intended to make it more operational (discretionary and inadequacy of control, clemency of sentencing, in particular). Taken all in all, therefore, the question of the application of the law in cases of drunk driving tends to be confused somewhat with a principle of preventive technology and a phase of policy-related thinking as regards prevention programmes.

Such an approach, which is not unconnected with the manner of designing the law itself as a preventive technology - an aspect that we shall discuss below - is not, however, inconsistent with the desire to raise the question of the application of the law to the status of a subject of research on preventive policy.

In the field of criminal law and policy, the application of the law refers essentially to the corpus of rules and procedures governing the exercise of judicial control of law infringements by specialized
agencies (police and justice). The legal procedures that form the practical and operational bases for law enforcement comply with criteria of conformity and legality set down in jurisprudence in line with existing law.

The application of the law in this context corresponds to a legal technology of operation and monitor of the legal process.

These legal provisions, which may vary from one legal system to another and from one state to another, are of genuine interest, and not merely in terms of comparative law; opportunities such as "judicial review" and "plea bargaining", which exist in the USA, could usefully be associated with European procedures in the course of analysis of judicial practices on the basis of law compliance.

In respect of legal sociology, the subject of the application of the law may be geared to overall operation of the legal order in society. Analysis of the subject accordingly takes account as much of the content of the law, its scope theory and rules of operation, as it does of its level of judicial implementation and social impact. The approach may be applied at either of these levels of implementation of the law.

In the axis of this legal sociology, the question of "effectiveness/ineffectiveness" is broached in terms of "gaps" and, as we have already indicated, is analyzed as a problem of "relationship" between criminal law and society and/or the relatively well-equated partnership of the legal and social orders.

Viewed in this light, the approach to application of the law is equivalent to analyzing the "effectivity" or "ineffectivity" of the law as a product of concordance or deviation, or of duplication of, or severance between, the legal and social orders.

Analysis of "effectivity" may therefore be said to convert the application of the law into the "interface" of the relationship between the law and social matters - the interface that shows up any points of resistance, difference and consistency between them.

This type of approach is constructive both in terms of preventive policy and that of applied drunk-driving research, and for two reasons.

Firstly, the approach which views application of the law as an interface highlighting the relationship between social matters and the law provides an explanatory analysis of what is regulating the control by agencies of breaches of the law, whether or not
through the use of procedural rules. It should therefore be seen as a source of information on whatever contributes to, hinders, or otherwise diverts the executive dimension of the law. What is regulating driver behavior may be analyzed in the same way (normative dimension).

Secondly, pinpointing resistance to the proper course of the law and identifying its source, over and above a marginal allowance for potential evolution of judicial practices of legal control, reveals the limits of the law's reach where other preventive problematics may arise, (particularly in relation to the social status of alcohol).

From the point of view of research, in methodological terms, the utilization of the approach based on the criteria of "effectivity" and "interface" opens the way to two further procedures, one focusing on the law's executive dimension and the other on its normative dimension.

Given that the executive dimension of the law involves its implementation by agencies specially constituted to monitor any breaches, the study of its effective application relies on the analysis of the judicial practices of the police and courts of justice. Two types of data may be utilized:

- penal statistics of sentences and sanctions relating to drunk driving (these reveal a certain number of facts regarding the structure and tendencies of the drunk-driving law application);

- practices of detection, legal proceedings, sentencing and penalizing (analysis of legal and non-legal criteria of decision-making compliance with the law).

The normative dimension of the law corresponds to the final reach of the legal norm, in other words to its capacity to perform as an individual norm of behavior. Its effectiveness may be examined by means of ad hoc surveys among social representations, and through socio-anthropological analyses of social practices about mobility patterns and the consumption of alcohol.

This type of approach has an advantage in that it avails of a whole body of explicative theories of social matters, of the social operation of law (theories of "culture", "consensus", "conflict") and studies relating to it under criminal sociology. Such a background unfailingly provides invaluable support and can be of particular use in the case of an explicative analysis of the "effectivity" of the drunk-driving law.
We shall conclude this chapter by pointing out that the two additional steps to be taken with regard to the "effectivity" of drunk-driving laws are at present the subject of research at INRETS (BIECHELER M.B., JAYET M.Ch. and al.).

Since the question of the application of the law is indissociable from that of preventive policy and the theory on which it is based, we shall now turn to the subject of the theory of deterrence and the model of criminal prevention.

3. THEORY OF DETERRENCE AND STANDARD MODEL OF PREVENTION

Use of criminal law in normally the first response of the preventive policy to the risk of drunk-driving. Depending on the country, this criminal policy may (or may not) be employed in unison with other preventive measures in order to control this particular road risk by educative, informational or even therapeutic means.

Whatever the case may be, road safety policies instituted in different countries down the years have led to the development of a type of international standard criminal policy of combat drunk driving. It consists of a trilogy of measures as follows:

- blood-alcohol concentration (BAC);
- random checks;
- chemical screening test of BAC.

According to country, these measures are coupled with more or less stiff penalties combined with administrative and medical techniques for treatment of drivers.

The use of this model standard, however, is linked to policy aims which are identical in the main and are intended to enhance the law's deterrent capability. Moreover, this standard legislative infrastructure is regarded as a rationalization of drunk-driving criminal policy (ROSS L. and al., 1984).

About the principle of these measures, we can say that it consists of considering methods of the application of the law as laws. This standard model in itself therefore is a technique of application of the law.

It can be seen first of all that the content of these measures may vary from country to country and, in the course of time, within a country, undergoing change far more quickly than the main body of laws regulating
social life (1). Secondly, the content of such application measures is not really the fruit of legal logic or of rules of procedure. It corresponds to the results of evaluations of alcohol factor and risk leading to the technical concept of a risk threshold. It also corresponds to a probabilistic logic of optimum effectiveness of legal control (reliability and frequency of detection) that is not proper to legal logic. The latter contends that the stuff of the law consists in indentifying and punishing breaches of the order and rules of society. Just as the law condemns theft (and not just a certain threshold) and the magistrate assesses the seriousness of the crime according to the logic of the law, the legal process would be to condemn drunk driving, estimate its seriousness in terms of BAC level and tailor penalties accordingly.

Apart from the fact that a law of this type would be more consistent not only with the useful, but also the ethical and symbolic functions of law, it would also be vested with a simplicity and stability which would undoubtedly make it more readily applicable and more credible to the public at large than the constant alterations in, and additions to, measures that are such a feature of passing political phases or electoral stakes (at least in France). This would bring the law into line with the proper function of law (protection of values and community well-being) by investing risk with a moral connotation rather than administering a policy compromise (level of legal threshold) on the basis of the statistical results of the risk analysis.

As regards the end-purpose and criterion of rationalization of the three standard legislative measures, the procedure involves adjusting and optimizing application of the law on a technical basis in order to increase its effectiveness: hastening and generalizing the detection process (chemical tests and random checks) so as to increase the impact of control and sanctions and the law’s deterrent function.

This standard of criminal policy applied to drunk driving is a technique for direct implementation of the theory of deterrence.

We do not intend to go into the usual discussion here regarding this theory, since more often than not it is

(1) This aspect moreover is closely linked to the fact that such measures are not laws based on social values, but rather ways and means of itemizing application of the law on drinking and driving; in other words, their amendments constitute an evolution of policy technology rather than a fully-fledged legislative evolution as such.
formulated with a view to confirming (or disproving) the validity of the theory of deterrence with regard to the question of the impact of the law.

We wish rather to tackle the subject from the angle of research, focusing chiefly on what the thinking behind the deterrence theory is missing in the approach to application of the law.

The theory of deterrence places law within a utilitarian model in which the drunk-driving law is purpose-oriented as a form of prevention technology in support of the overall policy of road safety. The role of the law is none other than that of an instrumental function of deterrence relying for its effect on fear of application and/or severity of punishment.

In this particular conception, the legislative principle is, to a certain degree, analogous to that of the stimulus-response system which is specific to the behaviourist theory of training in experimental psychology (utilization of automatic punishment to inculcate conditioned behaviour). It is also analogous to what is known in criminal sociology as the "functionalist model".

The logic of deterrence in fact leads to the approach involving application of the law according to a circular type of reasoning affecting the technical dimension of the problem alone, and which frequently takes the following form:

- law and justice operate as a mechanism and device for the imposition of penalties;
- the application of the law is synonymous with frequency and severity of sentence;
- the law/society or law/social-behaviour relationship may be summarized in the concept of "impact";
- variations in regard to application of the law are dysfunctions of the system.

Examining these different states of the legal process as viewed through the theory of deterrence, it may be observed that the reasoning with regard to the law and its application is induced by a recurrent logic, i.e. the automatic process of sentencing: each level of implementation is defined in terms of the postulate of automaticity (whether implicit or explicit). Furthermore, in line with this logic, the whole grasp of the question of application of the law is confined solely to an estimate of the effect achieved (impact) on:
- the risk and alcoholization of drivers,
- the punitive response.

By thus placing application of the law midway between the postulate of automaticity of penalty and focalization on expected impact, the explicative approach of deterrence takes account of the intrusion of social aspects (cultural and institutional) on the legal process solely in the form of dysfunctioning of the law's rules of operation (automaticity and deterrence).

Thus the logic of deterrence puts the dimension of social aspects in a truly secondary position in relation to implementation of the law. In other words, it does not regard them as conditions and variables inherent in the legislative process: it cannot therefore consider them as being as explicative of the effective capacity of the law as the quantitative (technical) aspects of application of the law (frequency and severity of penalties).

The explicative model of deterrence therefore leaves to one side the question of the effective relationship between criminal law and society, and between the law and alcohol which are the hub of the complex body of problems pertaining to the constitution and interiorization of legal norms as individual driving norms.

In view of the foregoing, this model is quite unsuited to understanding and analyzing the multidimensional process of implementation of the law. Moreover, the dominant character of the criteria of automaticity and impact divert the policy-making approach along an inflationary drift of countermeasures that are fundamentally ill-conceived for the control of social mechanism of which they are ignorant.

The postulate of deterrence, to which the legislative standard (the per se system, random checks, chemical

(2) The logic of deterrence means that these intrusions are regarded as unruly dimensions (condemned or disapproved of) or as dimensions calling for further legislative measures if they are to be kept under control, e.g. measures relating to minimum driving or drinking age.

(3) Were it not for this domination, there is reason to believe that a major part of the discussion concerning the Scandinavian model and "myth" would have had little chance of such a development if the bases of the reasoning had centred on the effectivity of the law as an interface between law and society, in view of the distinctly Scandinavian aspects of this field.
test) is linked, is therefore unsuited to solving the problem of differences and variations between punitive and normative responses that this standard notes between different countries, moreover between regions or social groups.

By oriented research towards the effective application of the law on drunk driving as an "interface" between law and society and law and alcohol, this approach enables us to:

- uncover the dimension overlooked in the technical logic of deterrence;
- plan and develop other approaches for application of the law, and
- consider what relates to legislative technology and what does not, and what relates to the legal and social orders.

We shall round off this presentation with some data relating to the application of the drunk-driving laws in France.

4. APPLICATION OF THE DRUNK-DRIVING LAW IN FRANCE

France's road safety policy launched the operation of the legislative standard in 1970 with the introduction of the law on the legal BAC level as measured by the alcootest and blood analysis. In 1978 the adoption of the principle of random checks, to be carried out independently of any breach of the law or accident, marked the completion, by means of a law, of the standard legislative system. Between 1978 and 1987, four new legal measures were introduced in order to buttress implementation of the law by augmenting the legal gravity of the authorized limit (offence over and above 0.8 g) and the severity of penalties. Their deployment is also indicative of a desire to encourage tighter control (police) and tougher sentences (courts).

The aim of this criminal policy concurs with the option of deterrence and punishment without developing alternative or additional solutions to penal measures specifically intended for cases of drunk driving. In other words, prevention at present relies entirely on the existing law and standard (apart from a few information campaigns).

If we confine ourselves to the approach arising out of the theory of deterrence, in terms of frequency, impact and severity of penalties, the results of the two principal laws (1970, 1978) attaching to this
criminal policy do not fall into line with the logic of deterrence.

According to the criterion of frequency, the application of the law on the legal limit (1970) doubles the frequency of judicial control resulting in condemnations, whereas the random-check law (1978) appears to have no such effect: the annual figure for condemnations rose from 20,000 in 1970 to 40,000 in 1976, and since that time has fluctuated in the region of this last figure. The application of the law would appear to have reached a ceiling in 1976 on the basis of the per se system. When related to the evolution of all sentences pronounced by the courts during those years, the sharp increase between 1970 and 1976 is attributable to drunk driving, yet the apparent stagnation which follows, in point of fact, blankets a certain fall-off in the application of the law (confirmed by factor analysis of the penal statistics).

The criterion of impact, on the other hand, indicated the reverse. The 1978 law has indeed had an impact on risk and alcoholism among drivers, whereas the 1970 law has not (ONSER surveys: 1970, 1977, 1979). The effect of the random-check law (1978) has been felt above all in cases of moderate drinking (0.4 to 0.8 g/l) and the associated risk, although it has been of limited duration (BIECHELER M.B., LASSARRE S., 1984).

Comparison between these two aspects of application of the law in France shows that there is no link between the effective growing of frequency of condemnations and the impact on drivers and risk. Quite the reverse, the only probability of greater frequency has but a very limited impact of short duration.

The principle of improving detection by means of a chemical test shows that the rate of detection by control personnel of alcohol consumption above the legal limit is one driver in every nine (Experiment in Strengthening of Control, an ONSER survey, DUVAL H., 1982).

According to the criterion of severity of penalties, application of the law displays a paradoxical tendency. The severity of penalties is diminishing at the same time as the number of condemnations spirals upwards: prison sentences are falling while suspended sentences and fines in particular are on the upsurge (JAYET M.Ch., 1985).

The two last-mentioned findings may properly be termed dysfunctions. They indicate none the less that the logic of automaticity cannot provide feedback on the phenomenon of implementation of the law and that the latter is partly determined by the institutional logics of the legal control agencies. Studies carried
out on punishment rates in Western countries appear to indicate an empirical generality of levelling-off of the punitive response throughout these societies over a period of time. French magistrates in the years from 1970 to 1976 tended to pronounce as reported in the lastest of these studies:

"Penal response has a tendency to adjust spontaneously according to a homoeostatic process ... severe punishment is accompanied by a fall in the number of condemnations while more frequent punishment leads to less severe penalties" (TREMBLAY P., 1986).

Present research on legal practice has come up with two types of findings which lobby in favour of a sceptical approach to the logic of automaticity in connection with application of the law. These findings are the result of factor analyses applied to statistics of penal sentencing (in one case from 1967 to 1978, and in the other from 1975 to 1982).

With regard to distribution of BAC level by age group in the population of drivers (BIECHELER M.B., 1984), a first level of analysis shows that the law is not applied automatically and falls short of the statistical probability of detecting drivers with illegal BAC's.

HISTOGRAMS BY AGES OF ILLEGAL BAC'S AMONG DRIVERS AND ILLEGAL BAC'S SENTENCED (1978)
When submitted to factor analysis, these data also show that the drunk-driving law (1970) was applied mainly to persons under 25 years of age until 1978 (JAYET M. Ch., 1986), and has been tendentially first applied to persons under 20 years since that time.

In geographical terms, application of the law brings two influences in its wake: on the one hand, it goes some way to standardizing the punitive response in most départements, and, on the other, it accentuates deviations in the gaps of the extremes (the most and least punitive). For these two extremes, the socio-cultural status and historical background of alcohol are very different (yet no differentiation is made here for degree of road risk).

5. CONCLUSION

This paper set out to stress the need to steer the approach to the problem of application of the law away from the obsession with evaluation (impact on risk) and the postulate of the automaticity of penalties. By orienting the approach towards analysis of the concrete returns of implementation of the law, we can unfold its developmental potentialities for prevention, hand in hand with other preventive methods on a more objective footing in regard of the law's true potential.

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THE DRINKING AND DRIVING PROBLEM IN NORWAY

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Since 1936 Norway has had a per se law with a BAC limit of 0.05 percent and imprisonment as the normal punishment. A small number of DUI drivers being caught during the 50's and 60's made the Norwegian authorities consider the DUI problem solved by the country's very severe law. Studies made during the 70's indicated that 40-50 percent of all killed or injured drivers had been drinking. The methods of these studies were far from perfect, but the studies pointed out that the DUI problem was not solved. A national survey of BAC of 75 percent of all killed drivers in 1976-77 showed that approximately 30 percent had a BAC higher than 0.05 percent, indicating that DUI could be a considerable problem in Norway.

A 1981/82 national roadside survey shows that the average incidence of DUI is only 0.27 percent. The risk of being killed is estimated to be 160 times higher for a driver with BAC higher than 0.05 percent than for a driver with BAC less than 0.05 percent. The risk increases rapidly with increasing BAC.

Comparisons of DUI in Norway with other countries are made, showing that the percentage of DUI is considerably smaller in Norway than most other countries, but the percentage of killed drivers with BAC higher than 0.05 percent is only slightly smaller.

These results may indicate that the severe Norwegian per se law has deterred low-risk drivers from DUI, whereas high-risk drivers still drive after drinking. In that case, the Norwegian experience shows that a severe per se law is only one step towards the solution of the very problem of DUI, i.e. the DUI accidents. The next steps should be increased surveillance and treatment of recidivists.
THE DRINKING AND DRIVING PROBLEM IN NORWAY:
The Scandinavian Approach - Success or Failure?

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Research Officers
Institute of Transport Economics
Oslo, Norway

1. INTRODUCTION

The use of per se laws with a low legal BAC limit is discussed internationally as a means to reduce alcohol-related traffic fatalities and injuries. In 1936 Norway was the first country in the world to introduce such a law. What are the results of 50 years' experience with a severe per se law? Is the problem of drinking and driving, i.e. the alcohol-related accidents, solved in a better way in Norway than in other countries?

2. THE NORWEIGAN PER SE LAW

The Norwegian per se law has a legal BAC limit of 0.05 percent. The penalty for DUI is normally unconditional imprisonment. In addition the licence is revoked by the chief of police.

The law has been and still is strictly enforced. A survey of legal documents showed that in the 1970's about 85 percent of convicted drivers were sentenced to 21 days or more of unconditional imprisonment. All convicted drivers had their licences revoked - 93 percent for two years or more (Christensen & Fosser 1980). This situation is what Ross (1982) calls the Scandinavian approach.

The law has been and is widely accepted by the public. Only about 10 percent of the adult population find the legal BAC limit too low, and less than 10 percent find the punishment too severe. A great minority even wants a lower legal limit and more severe punishment (FAKTA 1970). DUI is considered a more serious offence than speeding, driving without a licence, driving against red light (Frøyland 1984), and driving with defect breaks (Norges Markedsdata 1976).
3. NO ALARMING FIGURES IN THE 1950'S AND 1960'S

Until the 1970's the only available data on the drinking and driving problem in Norway were the number of drivers convicted for DUI. During the 1950's and 1960's this number increased steadily, but less than the increase of road traffic. There were no alarming figures, and the authorities considered the DUI problem solved by the strict law and severe punishment.

4. STUDIES ON THE BAC AMONG KILLED DRIVERS

In the 1970's a number of studies appeared on the BAC among killed or injured drivers. These studies indicated that as much as 40-50 percent of these drivers had BAC's of more than 0.05 percent (Glad 1985). The samples were small, covering only limited regions of the country. Some of the studies had defective sampling methods. Hence, the reliability of these studies was uncertain. Nevertheless, these studies led to a growing concern about the DUI problem in Norway.

To obtain more reliable information a national study on the BAC of killed drivers was carried out during the period from June '76 through May '77. Blood samples from 75 percent of all killed drivers were analyzed for alcohol. The results showed that approximately 30 percent had a BAC exceeding 0.05 percent (Glad 1985). This is more than in Sweden, but less than in other countries where such figures are known, as seen in Table 1.

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
<th>BAC&gt;</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway (a)</td>
<td>30</td>
<td>0.05</td>
<td>1976-77</td>
</tr>
<tr>
<td>Sweden (b)</td>
<td>20</td>
<td>0.05</td>
<td>1976-79</td>
</tr>
<tr>
<td>Canada (c)</td>
<td>50</td>
<td>0.05</td>
<td>1984</td>
</tr>
<tr>
<td>USA (d)</td>
<td>52</td>
<td>0.06</td>
<td>1983</td>
</tr>
<tr>
<td>Australia (e)</td>
<td>43</td>
<td>0.05</td>
<td>1977-82</td>
</tr>
</tbody>
</table>

References: (a) Glad 1985; (b) Valverius, Moberg & Linden 1982; (c) Haas et al 1985; (d) Fell 1985; (e) Charlesworth et al 1985.
The percentage of impaired drivers among killed drivers is influenced by measures to reduce alcohol-related traffic fatalities as well as measures to reduce non-alcohol related ones. If the latter measures have been applied successfully, non-alcohol-related fatalities will be rather few. Consequently, the percentage of impaired drivers among killed drivers will be high. To compare the situation of different countries, the number of killed impaired drivers should be related to the total vehicle mileage.

As shown in Table 2, Norway and Sweden have fewer killed impaired drivers in relation to total vehicle mileage than the USA and Canada, even though the BAC limit is higher in the North American studies. This fact indicates that the DUI accident problem is smaller in Norway and Sweden than in the USA and Canada. Whether the per se laws of the former countries are the cause of this situation, is discussed internationally, but authors such as Andenas (1974), Ross (1982) and Snortum (1984) seem to agree that the strict legislation is of some importance.

**TABLE 2 KILLED IMPAIRED DRIVERS RELATED TO TOTAL VEHICLE MILEAGE**

<table>
<thead>
<tr>
<th>Country</th>
<th>100 mill vehicle kms</th>
<th>No of killed impaired drivers</th>
<th>No of impaired drivers</th>
<th>Killed impaired drivers per 100 mill vehicle kms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>169 (a)</td>
<td>147 (a)</td>
<td>44</td>
<td>0.26</td>
</tr>
<tr>
<td>Sweden</td>
<td>463 (b)</td>
<td>478 (c)</td>
<td>96</td>
<td>0.21</td>
</tr>
<tr>
<td>USA</td>
<td>25623 (d)</td>
<td>24690 (e)</td>
<td>12839</td>
<td>0.50</td>
</tr>
<tr>
<td>Canada</td>
<td>1763 (d)</td>
<td>2556 (f)</td>
<td>1128</td>
<td>0.64</td>
</tr>
</tbody>
</table>

* For Norway and Sweden impaired is defined by BAC > 0.05, for USA BAC > 0.06 and Canada BAC > 0.08.

References: (a) Central Bureau of Statistics 1980; (b) AB Bilistatistik 1979; (c) National Central Bureau of Statistics 1978 and 1979; (d) IRF 1984; (e) FARS 1985; (f) Transport Canada 1982

5. A NATIONAL ROAD-SIDE SURVEY

The fact that the rate of killed impaired drivers to total vehicle mileage in Norway is as much as approximately half the North-American rate, may indicate that there is a considerable amount of drinking and driving in Norway. To find the extent of DUI a national roadside survey was carried out from September '81 through September '82. The police arranged more than 8000 road blocks randomly distributed all over the country 7 days...
a week and 24 hours a day. A total of 72,000 randomly selected drivers were tested. The survey showed that 0.27 percent of the drivers had a BAC exceeding 0.05 percent. Despite a fairly high percentage of impaired drivers among killed drivers, the percentage of DUI is very low in Norway, compared to most other countries, as can be seen from Table 3.

### TABLE 3 PERCENTAGE OF DUI ON THE ROAD

<table>
<thead>
<tr>
<th>Country</th>
<th>Percentage</th>
<th>BAC&gt;</th>
<th>Time</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway (a)</td>
<td>0.27</td>
<td>0.05</td>
<td>All times</td>
<td>1981-82</td>
</tr>
<tr>
<td>Sweden (b)</td>
<td>0.15</td>
<td>0.05</td>
<td>All times</td>
<td>1975-77</td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Rapids (c)</td>
<td>3.2</td>
<td>0.05</td>
<td>All times</td>
<td>1964</td>
</tr>
<tr>
<td>Vermont (d)</td>
<td>13.7</td>
<td>0.05</td>
<td>Night</td>
<td>1974</td>
</tr>
<tr>
<td>Vermont (d)</td>
<td>4.6</td>
<td>0.10</td>
<td>Night</td>
<td>1974</td>
</tr>
<tr>
<td>Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ontario (e)</td>
<td>14.0</td>
<td>0.05</td>
<td>Night</td>
<td>1979</td>
</tr>
<tr>
<td>Ontario (e)</td>
<td>7.0</td>
<td>0.08</td>
<td>Night</td>
<td>1979</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adelaide (f)</td>
<td>3.3</td>
<td>0.05</td>
<td>All times</td>
<td>1979</td>
</tr>
<tr>
<td>Netherlands (g)</td>
<td>11.0</td>
<td>0.05</td>
<td>Weekend nights</td>
<td>1977</td>
</tr>
</tbody>
</table>

References: (a) Glad 1985; (b) Jagefors 1981; (c) Borkenstein 1964; (d) Damkot 1982; (e) Mayhew et al 1986; (f) McLean & Holubowycz 1981; (g) Noordzij 1981

### 6. THE RISK OF BEING KILLED WHILE DUI

When the percentage of impaired drivers among killed drivers and the percentage of impaired drivers among all drivers are known, the risk of being killed while driving under the influence of alcohol relative to that of drivers not under the influence can be calculated. As seen in Table 3, this risk is much higher in Norway and Sweden than in the USA and Australia.

### TABLE 4. RELATIVE RISK OF BEING KILLED FOR DRIVERS WITH BAC > 0.05 PERCENT

<table>
<thead>
<tr>
<th>Country</th>
<th>Risk</th>
<th>Type of accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norway</td>
<td>160</td>
<td>Fatal</td>
</tr>
<tr>
<td>Sweden</td>
<td>170</td>
<td>Fatal</td>
</tr>
<tr>
<td>USA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand Rapids</td>
<td>30</td>
<td>Fatal</td>
</tr>
<tr>
<td>Australia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adelaide</td>
<td>20</td>
<td>Fatal and injury</td>
</tr>
</tbody>
</table>

Calculated on the basis of preceding tables
As may be expected, calculations show that the risk of being killed is strongly increasing with increasing BAC level in Norway as well as in other countries where such data are available. Although considerable both in the USA and Canada, the increase is much greater in Norway, as shown in Figure 1.

FIGURE 1. RISK OF ACCIDENT INVOLVEMENT RELATIVE TO BAC
Norway: Killed drivers; Glad 1985.
Canada: Fatal crashes; Adapted from Mayhew et al 1986
USA: Fatal or serious crashes; Borkenstein 1964
7. CONCLUSION

Four basic facts can be summarized from these results:

1. The rates of killed impaired drivers to total vehicle mileage in Norway and Sweden are approximately half the North-American rates.

2. The percentages of DUI in Norway and Sweden are considerably smaller than in most other countries.

3. The risk of a DUI driver relative to other drivers of being killed is much higher in Norway and Sweden than in other countries.

4. The risk of being killed increases much more in Norway than in other countries when the BAC level increases.

What conclusions can be made about per se laws from these facts?

The per se law - or some other factor operating in countries with a long tradition of strict per se laws - seems to limit the amount of DUI radically, which in turn may have contributed to a reduction of DUI fatalities. But the reduction in fatalities are by no means as considerable as the reduction of DUI itself.

On the basis of these findings, we will not conclude that the strict Norwegian per se law has been a failure. It has contributed to reducing the number of DUI accidents, but it is certainly not a complete success.

8. DISCUSSION

What other factors are at work to keep the number of DUI fatal accidents, and thus the risk of being killed, as high as it is in Norway?

Wilson and Jonah (1986) suggest that "not all impaired drivers share the same risk of accident involvement; the unexplained variance in alcohol’s effects on accident risk is due largely to personality, emotional and attitudinal factors. There is a subgroup of impaired drivers who exhibit a high-risk behavioural syndrome."

If so, and if the Scandinavian approach to DUI deters low-risk drivers more than high-risk drivers from driving under the influence of alcohol, the high risks of impaired drivers in Norway and Sweden are at least partly explained. Drinking drivers in Norway and Sweden are a more selected group and therefore differ more from ordinary drivers than drinking drivers in other countries were DUI is more common. The fact that 20
percent of convicted Norwegian drinking drivers are recidivists (Gjerde & Mørland, 1987) and 15 percent have a criminal record (Christensen & Fosser, 1980) supports this explanation. This also indicates a need for special-deterrent measures, e.g. rehabilitation programmes, treatment of drinking problems, confiscating the vehicles of recidivists etc.

In Norway with a strict per se law, further reduction of the number and severity of DUI accidents is not likely to be gained by lowering the legal BAC limit or introducing even more severe punishment. However, there are reasons to believe that increased surveillance may reduce the percentage of DUI to the Swedish level (Assum 1986). To what extent this will also reduce the number of DUI accidents, remains to be seen.
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ENFORCEMENT OF DRUNK-DRIVING LAWS BY USE OF "PER SE" LEGAL ALCOHOL LIMITS: BLOOD AND/OR BREATH CONCENTRATION AS DEFINITION OF IMPAIRMENT

A. W. Jones

Department of Alcohol Toxicology, National Laboratory of Forensic Chemistry, University Hospital, Linköping, Sweden.

Most developed nations have adopted punishable limits of alcohol in the blood of drivers as one approach to improve traffic safety and reduce alcohol-related accidents on the highway. Two broad classes of alcohol-traffic legislation are in effect (1) "per se" laws that define a statutory limit of alcohol in a specimen of blood as the sole deciding factor and (2) presumptive laws whereby the chemical test result merely presumes guilt and other information is admissible in evidence. In medicolegal practice, "per se" laws are more practical and easier to enforce because they offer a clearcut judgement of when an individual is breaking the law. But this legal framework places special demands on the accuracy, precision and specificity of the methods of forensic alcohol analysis used. The illegal "per se" limits of alcohol in blood differ among different countries and this seems to depend on political forces, cultural differences, activity of teetotal organizations and the attitude of news media and the public to social drinking. The Scandinavian countries enjoy a 50 year tradition of punishable limits of blood-alcohol concentration (BAC) in traffic law-enforcement. In Sweden, Norway and Finland the legal BAC limit is 0.5 mg/g in a specimen of venous blood and the method of forensic alcohol analysis used (gas-liquid chromatography) is well established. Recent inter-laboratory proficiency studies indicate a high degree of quality assurance. In USA, drunk-driving laws with statutory alcohol limits were introduced later and in many states 1.0 mg/ml is the lowest punishable limit of BAC. Furthermore, breath-alcohol instruments are widely used for substantive testing to determine the alcohol load in the organism. The analysis of breath offers a noninvasive technique and gives on-the-spot evidence of alcohol involvement. Many European countries, including Sweden, are considering a change in their existing drunk-driving laws to allow for quantitative evidential breath-alcohol analysis. The question of whether BAC and BrAC are equally valid and reliable as measures of impairment has therefore become an important forensic science issue. The concept of tolerance to alcohol, individual differences in impairment after the same dose, pharmacokinetics of alcohol in blood and breath, as well as age and sex differences in alcohol disposition are important to consider by those drafting the new law. Recent experiments show that the concentration of alcohol in blood and breath are highly correlated whereas the BAC and subjective and objective tests of impairment exhibit considerable scatter. Moreover during the absorption phase of the BAC time-profile, when individuals are most affected by alcohol, expired breath-alcohol is a better index of arterial blood concentration and therefore the exposure of the brain to alcohol. Forensic alcohol research aimed at investigating the fate of alcohol in the body and its detrimental effect on psychomotor functions lend support to the notion that BAC and BrAC are equally valid as definitions of impairment for the purpose of traffic law-enforcement. Two parallel scales of measurement can be envisaged with punishable limits of alcohol concentration in blood and/or breath depending on the material analysed. Quality control programs with strict regulations for testing the reliability of the methods and procedures employed with a statistically determined allowance for sampling and analytical error are prerequisites when the analytical results are used for legal purposes.
ENFORCEMENT OF DRINK-DRIVING LAWS BY USE OF "PER SE" LEGAL ALCOHOL LIMITS: BLOOD AND/OR BREATH CONCENTRATION AS THE DEFINITION OF IMPAIRMENT

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1. INTRODUCTION

Most developed nations enforce drinking-and-driving laws that rely on a definition of impairment in terms of the concentration of alcohol in a motorist's blood (BAC). The use of punishable BAC limits has long been considered to be an effective countermeasure to driver behaviour under the influence of alcohol (1). Two basically different drink-driving statutes are in effect: (i) illegal per se limits of alcohol concentration in a specimen of blood, breath, or urine and (ii) presumptive laws whereby the chemical test result if above the prescribed limit merely presumes guilt. Other information about the driving incident may be presented in evidence and can influence the outcome of the trial. An important distinction therefore stems from the fact that presumptive laws are rebuttable whereas per se statutes are not (2). In practice, illegal per se laws are easier to enforce because they offer a clearcut definition of when an individual is breaking the law. The result of the laboratory analysis therefore becomes the sole deciding factor needed as evidence to gain a conviction for driving under the influence of alcohol.

More and more countries and state jurisdictions opt for the enforcement of per se alcohol limits for driving. However, this kind of legal framework places special demands on the methods and procedures used for forensic alcohol analysis. Another consequence of the per se law enforcement is the creation of a razor-sharp difference in penalty for those individuals at or near a critical BAC limit. Special precautions must be taken to ensure the accuracy, the precision and the specificity of the methods of analysis used for legal purposes. The essential elements of analytical quality control must be rigorously enforced (3). Other scientific safeguards should include strict rules and regulations for sampling, labelling, transport and storage of body fluids used for analysis. The analytical result reported to the police must therefore include an allowance for sampling and analytical sources of error. The reduced value should then be used for legal purposes.

The prescribed legal limits of alcohol differ among countries and even within regions of the same country (e.g. VIRAPPORT331A.
states of USA and Australia). This seems to depend on several factors, among others, political forces, cultural norms, activity of teetotal organizations, and the attitude of news media and the general public to social drinking (4,5). The methods of analysis and the choice of biological sample is influenced by the structure and traditions of alcohol research in each country. In Sweden, Finland and Norway the prescribed illegal BAC limit for driving is 0.5 mg/g. The source of blood; venous, capillary or arterial is not specified by law. In Denmark the lower limit of blood-alcohol concentration is 0.8 mg/g and this reflects the more liberal attitude of the Danes towards sale of alcoholic beverages and social drinking.

<table>
<thead>
<tr>
<th>Country</th>
<th>Blood Limit (mg/g)</th>
<th>Breath Limit (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Norway</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Finland</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Denmark</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>Great Britain, France, Austria</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>USA</td>
<td>0.10</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Fig. 1: Two different logarithm scales of measurement for reporting the concentration of alcohol in blood (mg/g) and breath (mg/L) for legal purposes. The present statutory legal limits for driving in various countries are shown.
In North America, the prescribed legal limits of blood-alcohol concentration depend on the particular state jurisdiction and both presumptive and per se laws often exist together but at different levels (2). The most widely enforced BAC is 0.1 g/100 ml (0.96 mg/g), almost double the level in most Scandinavian countries. Figure 1 gives examples of the legal limits of alcohol concentration enforced in some countries defined in terms of blood-alcohol and breath-alcohol depending on the specimen approved for analysis.

2. TRENDS ON TWO CONTINENTS

The role of alcohol as a causative factor in road traffic accidents was recognised very soon after motor vehicles began to appear in significant number (5). The need for legislation to discourage drinking drivers and reduce alcohol-related deaths on the highway became increasingly obvious in post-war years as the availability of automobiles markedly increased (6,7). But how should alcohol-traffic legislation be enforced?

Early attempts to prosecute impaired drivers were not very effective because conviction hinged on the outcome of a medical examination with a clinical diagnosis of gross intoxication (8). Some tangible evidence of dangerous driving such as causing a serious single vehicle accident or mounting the pavement was also needed. A doctor was called to determine whether the suspect was "under the influence" to such an extent as to be incapable of having proper control over the vehicle. Various simple tests were devised to evaluate visual, sensory and motor-function of the suspected driver. These clinical signs and symptoms were recorded on a check-list according to a standard protocol (8). The doctor's final judgement and the evidence of the arresting police officer or other witness to the accident was the main thrust of the prosecution case.

The appearance of greater numbers of automobiles with more powerful engines capable of higher speeds and the construction of better and faster roads meant that the hazard of the drinking driver took on a new dimension (5,6). A radical change in government policy was called for to deal with this drink-driving problem. More effective methods of enforcement and supervision of road traffic were urgently needed.

In the early 1940s rapid progress was being made in basic research on the fate and actions of alcohol in the body (9). This led to the notion of enacting punishable limits of alcohol concentration in a specimen of blood or other body fluid to aid in the diagnosis of intoxication. The
Table 5. Percentage of drivers exceeding 100 km/h 1973-1986. Rural national motorway at Gl. Holte north of Copenhagen, direction north, right lane.

<table>
<thead>
<tr>
<th></th>
<th>Fri 8-10 a.m.</th>
<th>Sat 9-11 a.m.</th>
<th>Mon 10-12 a.m.</th>
<th>Mon 4-6 p.m.</th>
<th>Thu 10-11 a.m.</th>
<th>Mean value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1973</td>
<td>21.0</td>
<td>16.0</td>
<td>22.0</td>
<td>19.0</td>
<td>23.0</td>
<td>20.2</td>
</tr>
<tr>
<td>1974</td>
<td>7.0</td>
<td>9.0</td>
<td>7.0</td>
<td>9.0</td>
<td>12.0</td>
<td>8.8</td>
</tr>
<tr>
<td>1978</td>
<td>24.0</td>
<td>29.0</td>
<td>26.0</td>
<td>16.0</td>
<td>29.0</td>
<td>24.8</td>
</tr>
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<td>1979</td>
<td>5.0</td>
<td>4.0</td>
<td>19.0</td>
<td>17.0</td>
<td>18.0</td>
<td>12.6</td>
</tr>
<tr>
<td>1983</td>
<td>22.0</td>
<td>18.0</td>
<td>17.0</td>
<td>15.0</td>
<td>12.0</td>
<td>16.8</td>
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<td>1984</td>
<td>32.0</td>
<td>26.7</td>
<td>25.6</td>
<td>19.1</td>
<td>23.1</td>
<td>25.3</td>
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<td>1985</td>
<td>31.9</td>
<td>26.9</td>
<td>21.9</td>
<td>19.2</td>
<td>25.4</td>
<td>25.1</td>
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<tr>
<td>1986</td>
<td>27.0</td>
<td>25.1</td>
<td>27.4</td>
<td>16.9</td>
<td>23.3</td>
<td>23.9</td>
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</table>


<table>
<thead>
<tr>
<th></th>
<th>Fri 8-10 a.m.</th>
<th>Sat 9-11 a.m.</th>
<th>Mon 10-12 a.m.</th>
<th>Mon 4-6 p.m.</th>
<th>Thu 10-11 a.m.</th>
<th>Mean value</th>
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</thead>
<tbody>
<tr>
<td>1973</td>
<td>87.0</td>
<td>76.0</td>
<td>81.0</td>
<td>55.0</td>
<td>87.0</td>
<td>77.2</td>
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<td>1974</td>
<td>44.0</td>
<td>49.0</td>
<td>64.0</td>
<td>71.0</td>
<td>74.0</td>
<td>60.4</td>
</tr>
<tr>
<td>1978</td>
<td>87.0</td>
<td>82.0</td>
<td>90.0</td>
<td>68.0</td>
<td>62.0</td>
<td>77.8</td>
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"La Gestion de la limitation de la vitesse :
Problèmes et Perspectives"

Par

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"La gestion de la limitation de la vitesse : problèmes et perspectives"

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I - Situation

En 1986, en France, la diminution du nombre des accidents corporels et celle du nombre des blessés s'est poursuivie (respectivement -3,4 % et -4,3 % par rapport à 1985). Mais par contre nous avons constaté une croissance du nombre des tués (+4,9 %) qui traduit une remontée de la gravité moyenne des accidents corporels (6 tués pour 100 accidents corporels en 1986, contre 5,5 en 1985); le taux de tués pour 100 Millions de véhicules/km atteint 2,92, en croissance de 1,2 % par rapport à 1985.

Cette aggravation ne paraît pas particulière à la France : en Belgique, en Espagne, aux Pays Bas, en RFA on a déploré un accroissement significatif du nombre des tués, de telle sorte que l'Année Européenne de la Sécurité Routière a été une année de croissance de risque; ce fait qui n'a pas été assez relevé a valeur de signal d'alarme : au delà de ses aspects conjoncturels il justifie un réexamen des conditions du progrès de la Sécurité Routière.

En effet, on n'a pas assez remarqué que les résultats positifs obtenus dans la période antérieure étaient partiellement dus à des phénomènes indépendants de l'action préventive, facteurs qui peuvent avoir épuisé leur potentiel positif (il en est ainsi en France de l'effondrement du parc des cyclomoteurs qui explique en grande partie la remarquable diminution du nombre des victimes cyclomotoristes, partiellement compensée il est vrai par une croissance du nombre des victimes motocyclistes, ou être susceptibles de retournements péjoratifs pour la sécurité routière (il en est ainsi des fluctuations de l'économie, puisqu'une reprise de la croissance est susceptible d'accroître la mobilité automobile de catégories d'usagers spécialement affectés par un haut niveau de risque, les jeunes conducteurs par exemple)(1).

C'est dans ce contexte de réévaluation de l'action préventive que nous aborderons le problème de la gestion de la limitation généralisée de la vitesse : il s'agit nous semble-t-il d'une question essentielle pour deux raisons complémentaires :

- d'abord parce qu'il ne suffit pas de disposer de mesures réglementaires pour en obtenir le rendement optimal et durable ! N'oublions pas que dès 1972 les rédacteurs de l'OCDE après recensement minutieux de nombreuses études entreprises dans plus de dix pays différents n'hésitaient pas à recourir à l'emploi d'un truisme apparent pour conclure que "lorsqu'une limitation réglementaire des vitesses a pour effet de réduire effectivement les vitesses, on observe une réduction globale du nombre des accidents et des victimes". (2) En fait, le rendement des limitations généralisées de la vitesse est insuffisant, ce qui en d'autres termes plus positifs signifie qu'en ce domaine de véritables gisements de productivité, peut-être les plus importants de toute l'action de sécurité, restent disponibles et largement inexploités.

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- ensuite parce que la maîtrise de la vitesse joue comme facteur multiplicateur des autres actions qui portent sur le système route-véhicule-conducteur. Sans nul besoin d'admettre l'appareil théorique de l'homéostasie du risque, et ses excès (3) tous les praticiens de la circulation et de la sécurité routière savent qu'un accroissement des vitesses même discret est contreproductif, dans la mesure même où il diminue ou efface l'apport positif d'une amélioration de l'infrastructure (4). Dès lors la gestion des vitesses devrait être considérée comme la condition nécessaire d'une amélioration de la productivité, en termes de sécurité, des investissements dispendieux consacrés à la route ou à l'automobile.

Or la situation actuelle de la limitation généralisée de la vitesse peut être considérée comme préoccupante : dans divers pays, dont la France, on constate une reprise de la tendance à l'accroissement progressif des vitesses des automobiles mais aussi des poids-lourds. Alors que les limitations de vitesse n'ont eu, dans la dernière décennie, aucun effet significatif sur les économies d'énergie, mais des effets importants en matière de sécurité routière tout se passe comme si l'éloignement de la crise énergétique réactivait les appréciations négatives des limitations de vitesse : c'est un paradoxe cruel que les responsables et chercheurs devraient analyser. Aux États-Unis le Congrès vient de décider l'abandon de la limitation à 55 mp/h et le relèvement des limites à 65 mp/h alors que les plus hautes autorités avaient reconnu après évaluation que l'institution du 55 mp/h était peut-être "la plus importante mesure de sécurité des temps modernes" (5) et alors que les projections prévoient que la nouvelle législation entraînera un accroissement très sensible du risque sur les routes rurales et les liaisons inter-États (6). En Europe, les débats du Parlement Européen et ceux d'un récent conseil des Ministres permettent de constater le désaccord durable quant à l'harmonisation des limitations de vitesse, désaccord qui révèle bien l'importance des intérêts et des enjeux. Parallèlement, nous y reviendrons, nous assistons à une élévation progressive de la puissance et de la vitesse de pointe théorique des produits offerts par l'industrie automobile, de telle sorte que dans un pays comme la France, en l'espace d'environ une décennie, le mode de la distribution des vitesses de pointe des véhicules neufs s'est accru de plusieurs dizaines de kilomètres/heure !

Certes les limitations généralisées de la vitesse sont en vigueur dans la totalité des pays. Néanmoins ces signes que nous avons relevés parmi bien d'autres montrent l'instabilité de la situation et peuvent conduire à se demander si la tendance lourde (le trend) à l'augmentation permanente des vitesses n'a pas repris après une interruption d'une décennie ?

Cette situation ne doit pas surprendre; nous mêmes, à plusieurs reprises nous avons annoncé que la limitation généralisée de la vitesse, acquise parfois après une "dure bataille" (7), était une conquête essentielle, mais une conquête fragile (8).
II - Fragilité de la limitation de la vitesse.

Rappelons brièvement les quatre classes de facteurs qui, isolément et en interaction, expliquent cette fragilité permanente, et "menacent" la limitation généralisée de la vitesse :

1. le conducteur effectue une tâche, la conduite de l'automobile, qui, selon les circonstances, se révèle être très diversément exigente (9). Or il n'est pas niable que le respect strict des limitations de vitesse exige l'accomplissement par l'usager d'un travail supplémentaire, parfois incommode et souvent fastidieux, d'autant que cet ajustement doit s'effectuer de manière permanente ce qui, dans l'économie de la décision, est certainement coûteux (10). D'autre part le respect strict de la limitation de vitesse ne peut que contrarier l'attrait de la vitesse qui repose sur une base psychophysiologique (recherche de l'activation) et sur une base psychosociale particulièrement manifeste chez les jeunes hommes en phase d'affirmation sociale (11).

La vitesse d'un automobiliste est partiellement sous la dépendance de celle des autres automobilistes : cette dimension irréductiblement collective de la circulation conduit l'automobiliste à remarquer et à surestimer la fréquence et l'amplitude des violations de limitation commises par les autres usagers; dès lors il suffit qu'une proportion faible d'usagers ne respecte pas, de manière systématique, les limitations de vitesse pour induire progressivement, chez les autres automobilistes, le sentiment de l'inégalité et de l'injustice; on a d'ailleurs (5) souligné que les Poids Lourds servent de référence, toute dérive de leurs vitesses entrainant une dérive des vitesses des automobilistes.

Enfin, si la sécurité est l'objectif fondamental de la limitation généralisée de la vitesse, il n'est pas indiffèrent de constater que généralement, aux limites fixées, le conducteur ne perçoit pas directement et physiquement l'augmentation de risque qu'une vitesse plus élevée comporte : pour lui faute des informations recueillies et analysées par le statisticien la limitation, comme "seuil", n'est "renforcée" que par l'action de contrôle des forces de police ou par les hypothétiques manifestations d'une désapprobation sociale.

Les deux logiques, celle de l'usager et celle du spécialiste de sécurité ne peuvent coïncider, en raison même de la nature des informations qui les alimentent.

1. L'évolution technologique marque profondément le système de la circulation routière; outre l'augmentation sensible de la puissance et de la vitesse de pointe qui se perpétue, l'amélioration des qualités dynamiques, celles du freinage et des pneumatiques est une réalité, en particulier dans le haut de gamme; l'amélioration des suspensions, celle de l'isolation phonique, tout concourt à rendre la conduite rapide plus confortable, et "en apparence" sûre, ce qui représente pour la limitation de vitesse un handicap indiscutable. - Parallèlement on a assisté au développement de réseaux routiers conçus pour améliorer la fluidité, la capacité et la performance, réseaux qui facialement "autorisent" et "justifient" des vitesses plus élevées, le conducteur pouvant ressentir un écart grandissant et finalement frustrant entre la vitesse possible et la vitesse permise. La généralisation de la circulation sur autoroute contribue sans doute à accroître le "besoin" du déplacement rapide et peut induire des élévations de vitesse sur des réseaux dont les caractéristiques structurelles, et donc le niveau de risque objectif, sont très différents. Jusqu'ici, de manière très
générale on doit remarquer que les remarquables potentialités de la technologie ont été utilisées, le plus souvent délibérément, dans le sens d'une offre de vitesse plus élevée.

Le conflit est la forme permanent du débat social sur la limitation généralisée de la vitesse. Alors que la majorité des actions de sécurité routière font l'objet d'un consensus apparent (12) la limitation de vitesse oppose une majorité (de citoyens et même d'automobilistes) approbatrice, à une minorité qui, en paroles et en actes considère que cette réglementation est peu légitime (13,14); les caractéristiques de cette minorité sont bien connues aujourd'hui et sont d'ailleurs assez semblables dans des pays aussi différents que la France (15) ou les États-Unis (16) : ce pôle d'opposition est plutôt composé d'hommes, jeunes, conduisant beaucoup et souvent dans un cadre professionnel, acheteurs de véhicules récents, puissants, et pour qui "time is money"; cette population est culturellement, socialement et économiquement mieux armée pour exercer une pression qui prend les multiples formes de l'imposition de modèles, par exemple par la voie de l'action publicitaire. On sait aussi qu'en matière de vitesse structure des attitudes et structure des comportements effectifs sont relativement stables, ce qui autorise une prédiction valide des comportements (17).

Enfin le contrôle du respect de la réglementation est, dans l'état actuel, particulièrement inefficace, ce qui conduit, notamment les grands rouleurs, à douter de la capacité de la police à surveiller strictement le respect de la réglementation dans ce domaine.

Ce rappel des facteurs qui rendent particulièrement fragile la limitation généralisée de la vitesse pourrait raisonnablement conduire au pessimisme, ou au moins au scepticisme : puisque ces facteurs semblent permanents (en tous cas, au cours de la dernière décennie ils n'ont pas été transformés ni durablement affectés par les variations conjoncturelles, sauf peut-être par la crise de l'énergie ce qui, au regard des enjeux réels, est paradoxal) ne doit-on pas considérer que l'érosion des effets qui affecte toute innovation sociale est inéluctable ? et, le pessimisme faisant le lit de la démobilisation ne doit-on pas en prendre son parti et finalement réduire l'investissement que toute gestion exige ? Trois remarques nous conduisent au contraire à une conclusion inverse :

1) Si l'érosion des effets d'une mesure de régulation est dans la "nature des choses" encore faut-il relativiser cette érosion; le respect unanime des limitations de vitesse est une pure utopie en raison du caractère de l'obligation et de la complexité des mécanismes qui "produisent" le choix de sa vitesse par le conducteur, hic et nunc. Mais l'effet d'une limitation doit être jugé de façon équitable, par comparaison avec l'absence de limitation ou avec celle d'une limitation fixée à un niveau supérieur : dans ce cas, en dépit des pertes d'efficience généérées par l'érosion de la mesure et la croissance du taux des infractions, le plus souvent le bilan global reste positif.
2) L'importance de l'enjeu est considérable : toute augmentation de la moyenne des vitesses, s'accompagnant de déformations de la forme des distributions des vitesses, induit une très sensible augmentation des accidents, et surtout celle des accidents graves et mortels (18, 19); dès lors, à la mesure de cet enjeu, toute gestion de la limitation de vitesse qui permettrait de limiter et de contenir la dérive des vitesses serait très hautement productive.

3) Enfin la dernière raison qui fonde et justifie notre optimisme relatif, qui n'est au vrai qu'un pessimisme actif, c'est que la gestion de la limitation de vitesse est certainement susceptible d'amélioration et même de mutation : au dispositif classique de contrôle d'une législation doit se substituer une politique permanente, large et ambitieuse, faisant de la maîtrise de la vitesse une priorité manifeste.

III - Voies et conditions d'une véritable gestion de la limitation de vitesse.

Lorsqu'on a pris la mesure de la force et de la permanence des facteurs qui fragilisent la limitation de vitesse ou est obligatoirement conduit à poser le problème de la gestion d'une manière nouvelle qui combîne l'indispensable technicité de la connaissance et de l'intervention avec l'activation du débat social qui doit modifier les bases culturelles qui régissent les représentations des acteurs de la circulation. Trois objectifs, qui sont autant de principes d'action, nous paraissent devoir être simultanément poursuivis, chacun gageant les autres :

(1) - ACCROITRE la LEGITIMITE de la maîtrise de la vitesse, et spécialement, celle de la limitation de vitesse.

Si la difficulté de l'entreprise est évidente, elle ne doit pas être accablante :

a) La première tâche est d'ordre conceptuel et concerne d'abord les praticiens et les théoriciens de la circulation et de la sécurité routière : compte tenu du fait que la vitesse, dans tous les domaines de la technologie et de l'action est considérée comme une Valeur, critère et symbole de l'efficience et de la puissance, la limitation de vitesse apparaît, y compris dans le discours et même la représentation intime des acteurs de la sécurité routière comme un MAL nécessaire, catégorie honorable mais peu valorisante et peu gratifiante. Dans ce domaine les acteurs de la sécurité se laissent enfermer dans la négativité; qui est toujours réductrice de légitimité.

Or, au fur et à mesure de l'accroissement de la complexité et de l'évolution considérable des enjeux de sécurité nous constatons dans tous les grands systèmes industriels (production d'énergie, chimie et bientôt biotechnologies) l'émergence des objectifs de sécurité, correlative du développement des conceptualisations, de la spécialisation et de la hiérarchisation des compétences. Le temps de la sécurité considérée comme un "supplément d'âme" n'est pas clos, mais il est d'ores et déjà contesté et dépassé.
De même dans la sécurité routière, la compétence, la technicité l'amplitude des ambitions sont susceptibles de faire peu à peu accéder la sécurité au rang des valeurs positives : il ne s'agit pas d'être les comptables de la mort et du malheur mais les constructeurs rationnels de la sécurité. En peu de mots c'est en réalité une véritable révolution culturelle qui est ici suggérée : elle concerne d'abord les chercheurs et les praticiens de la sécurité qui doivent pleinement assumer les conditions de cette positivité de l'action de sécurité. La maîtrise de la vitesse, dont la limitation de vitesse est un moyen, doit être considérée comme une condition centrale de la construction de la sécurité d'un système de circulation routière. La légitimité de la limitation de vitesse passe d'abord par une véritable théorie de l'action de sécurité qui reste aujourd'hui segmentaire et par conséquent mal protégée de la contestation et du scepticisme.

b) - Les ressorts de la légitimité ne sont pas seulement d'ordre intellectuel, mais aussi d'ordre social. C'est pourquoi il faut assurer le fondement démocratique d'une entreprise de régulation et de prévention en organisant et en favorisant le débat et l'expression des conflits. Rien de plus nocif et de plus trompeur que le prétendu consensus en matière de sécurité routière (12). En réalité l'analyse approfondie des représentations sociales de l'accident et de l'action de sécurité (13) révèle que la limitation de la vitesse divise l'opinion d'une manière profonde et durable : d'un côté une majorité qui reconnaît dans la limitation de vitesse une nécessité essentielle du système de circulation, de l'autre une minorité contestataire qui ne l'admet pas le bien fondé de cette réglementation et qui, sous diverses formes, prétend s'en affranchir; or cette minorité que les constructeurs automobiles et les publicitaires connaissent bien et utilisent c'est majoritairement celle des "grands usagers" de l'automobile et de la route : hommes, jeunes et dans la force de l'âge, actifs, grands rouleurs, acheteurs de véhicules neufs, puissants, nerveux, intéressés par la technique et ses développements, affirmant leur "capacité" et leur "maîtrise". Laisser libre cours aux discours, bien relayés par la publicité, la presse spécialisée, le cinéma d'action,... de cette minorité c'est à l'évidence miner la légitimité de la limitation de vitesse qui va devenir frein, brimade et manifestation d'une attitude ridicule et frileuse. C'est pourquoi le débat et le conflit doivent être recherchés et d'abord par la communication d'une information précise aujourd'hui trop peu disponible : il faut afficher le coût d'insécurité de la vitesse, compris le coût différentiel selon la marque et le type du véhicule, insécurité pour soi et pour autrui, ou insécurité interne de l'occupant du véhicule et insécurité externe subie par les "adversaires" très inégalement protégés (piétons, utilisateurs de deux roues, automobilistes différenciés selon la masse de leur véhicule, utilisateurs de poids lourds)(20); il faut aussi préciser et diffuser l'ampleur des effets des limitations de vitesses "réussies", ce que l'on fait très peu et très mal, comme si curieusement, la conviction manquait. Puisque la limitation de vitesse est l'objet d'un conflit latent on ne doit nullement craindre les effets d'un conflit manifeste; au contraire il importe que les individus, les groupes, les associations, les institutions intéressées à la sécurité manifestent leur prise en charge du problème de la légitimité sociale de la limitation de vitesse : l'enjeu, à terme, c'est celui d'un déplacement des attitudes par la diminution de la légitimité.
"technique" des grands usagers de la route et l'accroissement de la légitimité, non seulement morale, mais aussi scientifique et technique des constructeurs de la sécurité. Car la légitimité sociale génère sous des formes multiples un contrôle social entre pairs qui est la véritable condition d'une première intériorisation de la loi.

(2) - Intégrer la limitation de vitesse dans l'ensemble des moyens de la MAITRISE de la VITESSE. Il importe en effet de bien tirer toutes les conséquences du fait que le choix de la vitesse s'analyse en grande partie comme la réponse de l'opérateur, le conducteur, à une situation saisie dans sa dynamique; proposer perpétuellement des classes de situations qui accentuent l'écart entre la vitesse "possible" et la vitesse limite, c'est à coup sûr placer le conducteur dans une position difficile et c'est à terme diminuer de manière certaine l'effet attendu de la limitation de la vitesse. Il convient donc de développer une véritable ergonomie de la limitation de vitesse dont l'ambition est de réduire l'abstraction de la réglementation en offrant au conducteur des situations qui "induisent" le choix d'une vitesse compatible avec la limitation; il s'agit en somme, en termes de gestion, de considérer la vitesse comme variable dépendante ou résultante, et pas comme une variable indépendante qu'elle n'est pas (a). Cette ergonomie de la vitesse dont seuls les rudiments sont aujourd'hui disponibles peut utiliser trois moyens complémentaires :

- le tracé routier, et plus généralement la conception globale de la route, doivent être adaptés à la limitation de vitesse, le principe de base de toute orientation ergonomique résidant dans l'adaptation de la tâche à l'homme et non l'inverse. Certes le traitement ergonomique peut se révéler très difficile à concevoir et à mettre en œuvre, notamment en rase campagne; mais à partir du moment où la conception de la route intègre une véritable dynamique de la conduite les principes fondamentaux de rythmicité, de réduction de l'incertitude, de gestion des transitions assurant une homogénéité modulée permettent de proposer des solutions efficaces; d'ores et déjà le traitement des points singuliers, celui des intersections, des voies d'insertion, des giratoires permet d'intégrer la vitesse comme variable résultante (21).

- l'équipement de la route, la signalisation statique et dynamique est un moyen puissant de régulation de la vitesse lorsqu'il est utilisé en synergie avec les caractéristiques routières et en fonction des caractéristiques du trafic (22).

- enfin l'ergonomie de la vitesse, et spécialement celle de la limitation de vitesse est susceptible de générer dans les futurs automobiles divers systèmes de régulation et d'aide à la conduite qui doivent être développés à partir d'une analyse objective des difficultés rencontrées par les conducteurs (23). Sans s'en étonner on remarquera le faible investissement consenti par l'industrie de l'automobile dans l'ergonomie de la maîtrise de la vitesse; or toute gestion de la limitation de vitesse exige qu'un effort sérieux soit lancé et poursuivi, en spéfifiant les classes de situations-problèmes et en validant en vraie grandeur les solutions proposées, dont certaines hélas peuvent être de simples gadgets, ou même comporter des effets pervers inattendus. C'est d'ailleurs l'occasion de faire remarquer l'ambiguïté dangereuse de certains grands projets qui se proposent d'utiliser les potentialités de l'électronique pour produire des voitures "intelligentes" (24) : chez certains des promoteurs de ce développement technologique l'espoir de permettre ainsi une augmentation sensible des performances, et notamment de la vitesse, est
manifeste; cette illusion techniciste est une nouvelle menace pour la sécurité routière et spécialement pour la limitation de vitesse. Au contraire il importe de réunir les conditions de développement d'une technologie de la maîtrise de la vitesse permise par les progrès de l'électronique, et sur laquelle nous reviendrons plus avant.

(b) - L'exploitation de la route est nécessairement appelée à des développements importants induits par l'augmentation de la circulation et les limites physiques et économiques des grands investissements routiers. Nous assistons progressivement à l'émergence d'un nouveau métier, celui d'exploitant ou de gestionnaire de la route et de la circulation : de même qu'il ne suffit pas de construire des voies ferrées et des locomotives pour disposer d'un système performant de circulation et de transport, de même, toutes proportions gardées et spécificités reconnues, il ne suffira plus d'offrir des routes et de vendre des automobiles pour en être quitte avec la circulation automobile. Ce que nous proposons c'est que la limitation de vitesse, parce qu'elle aura été pleinement reconnue comme essentielle (voir plus haut) soit partie intégrante des objectifs et des responsabilités des gestionnaires de la route et de la circulation. Beaucoup plus qu'aujourd'hui la vitesse doit être pleinement intégrée à la gestion, ce qui exige qu'elle soit réellement connue, analysée, modélisée, de telle sorte qu'elle accède progressivement au rang de variable de sortie, variable résultante, véritable caractéristique d'un produit. Bien entendu ces nouveaux gestionnaires de la circulation devront disposer de concepts, de méthodes et de mesures qui exigent un développement technologique de la saisie et du traitement des informations de vitesse.

A notre sens cet accès à une nouvelle perspective, celle de la gestion intégrée et de la direction par objectif est certainement un élément d'innovation essentiel qui doit s'imposer dans la perspective de la construction rationnelle de la sécurité et de la qualité de service : la limitation de vitesse y trouvera une nouvelle signification et un nouveau statut.

(3) - Accroître la cohérence et la crédibilité de la limitation de vitesse.

Nous avons indiqué plus haut la nécessité d'une plus grande légitimité de la limitation de vitesse. Mais une régulation normative ne doit pas être menacée par l'incohérence, apparente ou réelle, et doit être renforcée d'une manière probante.

(a) - Il faut donc d'abord prendre la mesure d'une situation que nous qualifierons de schizophrénique : dans le temps même où nos sociétés ont, à contre coeur le plus souvent, reconnu la nécessité de la limitation de vitesse elles ont aussi, par le canal de l'industrie automobile, produit et offert des engins de plus en plus puissants capables de performances sans aucune commune mesure avec les niveaux les plus élevés des limitations de vitesse. Et cette offre, qui d'ores et déjà a profondément modifié la structure du parc des véhicules en circulation, a vu son impact majoré et amplifié par l'orientation publicitaire de célébration de la puissance, de la vitesse et de l'agressivité. Schizophrénie, le mot n'est pas trop fort, dont les effets individuels et sociaux mériteraient une évaluation sérieuse. A tout le moins cette forme éclatante, et même provocante, de l'incohérence, inscrit la limitation de vitesse dans le registre de l'impuissance, et le respect de cette limitation dans celui de la plaisanterie. - Certes, en vertu de
de l'adage du client roi, "le client a toujours raison", certains prétendent que c'est la demande qui importe, l'offre de l'industrie étant seconde... En réalité l'offre, si elle répond à une demande ne fait que l'amplifier et surtout elle lui confère une légitimité "sérieuse", celle des producteurs, des techniciens; celle de l'argent et de la différenciation sociale. Quelque soient les raisons qui conduisent à cette situation (retombées inattendues de l'effort de recherche consacré à la motorisation, politique de marketing orientée par la recherche des marges les plus confortables, concurrence plus ou moins faussée par l'hétérogénéité des législations...) il est important de la placer au coeur de notre interrogation sur la gestion de la limitation de vitesse : tout progrès passe par une réduction de cette incohérence; il appartient à tous les acteurs intéressés de proposer les voies de l'action capable de réduire une dérive nuisible à la sécurité, c'est à dire à l'intérêt général : l'autonomie technologique et mercantile doit elle rester sans limites et sans contreparties ?

(b) - L'amélioration de la crédibilité de l'action normative passe par une croissance tangible du rendement du système de contrôle et de sanction; certes le calcul des probabilités montre que rapportée à l'unité élémentaire (l'infraction hic et nunc), la probabilité de détection ne peut qu'être faible, sauf à modifier complètement les conditions du contrôle. Il y a là une difficulté objective qui rend indispensable l'élaboration d'une stratégie d'action fondée sur la recherche de l'optimum, compte tenu des moyens, des enjeux et des caractéristiques des infractions à la vitesse; mentionnons quelques unes des pistes de cette stratégie :

- le progrès de la technologie doit se manifester sous deux aspects complémentaires : d'une part, comme il a été dit plus haut, les aides à la conduite doivent effectivement assister le conducteur dans sa tâche de respect de la limitation de vitesse puisque certaines infractions s'analysent comme des dérives et des erreurs et les aides à la régulation doivent, chaque fois que le paramètre sera utile et pertinent comporter une prise en compte de la limitation de vitesse (signalisation dynamique interactive par exemple)(22).

- d'autre part les techniques de détection et d'enregistrement de l'infraction sont susceptibles d'être améliorées et diversifiées, qu'il s'agisse de la précision et de la fiabilité, de la facilité d'emploi et de mise en oeuvre, de la fréquence et de la discrétion. Dans certains cas l'enregistrement, partiellement effacable ou non, ne saurait être écarté sans examen attentif des finalités : tous les systèmes de transports évolués comportant ces modalités d'enregistrement, outils de gestion, d'enquête et de recherche : pourquoi, sauf à relativiser les enjeux de la sécurité routière, la route ferait-elle exception ?

- les comportements d'infraction à la limitation de vitesse ne sont pas répartis de manière aléatoire; en effet, si tous les usagers de la route sont susceptibles de commettre une infraction à la vitesse on constate des régularités qui permettent de caractériser des "groupes à risque" : diverses études montrent l'existence d'une remarquable stabilité des comportements dans ce domaine, qui fait d'une infraction constatée un bon prédicteur d'infractions antérieures et postérieures (17) et qui justifie d'ailleurs le concept de "comportement de base" (25). En conséquence la gestion du contrôle ou de ses suites peut en être singulièrement facilitée, à condition d'élargir, de manière sélective, la gamme des moyens mis en oeuvre.
la sanction proprement dite, conséquence de l'infraction détectée est évidemment un élément constitutif de la crédibilité du système. Faute d'un bilan de l'efficacité de la sanction et de ses caractéristiques on retiendra quelques principes soumis à évaluation : progressivité du barème, en fonction de l'ampleur de l'infraction d'une part, du caractère de récidive d'autre part; recours à l'amende considérée comme le moyen de base; recours à une échelle graduée de restrictions de conduite; prise en compte des infractions pour le calcul du bonus/malus de l'assurance automobile.

- en matière de vitesse les "déviants" caractérisés ont en général construit un système d'attitudes et d'opinions très affirmé et peu sensible à la simple remontrance normative que comporte la sanction. C'est pourquoi il convient de réfléchir aux moyens d'ébranler la légitimité de l'infraction : on peut recourir à l'information qui doit être une énonciation rigoureuse des faits habituellement ignorés ou scotomisés (la relation étroite entre vitesse et insécurité); mais aussi à l'activation de processus de relations inter-personnelles, dans l'esprit des groupements "d'alcooliques anonymes" : il faut traiter l'infraction à la vitesse pour ce qu'elle est, une maladie de l'adaptation sociale et de la reconnaissance d'autrui.

Ces principes constitutifs d'une stratégie d'action doivent être mis en œuvre par de véritables gestionnaires; ce que nous avons dit de l'exploitation de la route est valable dans ce domaine du fonctionnement du système de contrôle et de sanction, mais l'application des principes d'une gestion par objectifs est ici directement soumise aux spécificités, et en l'espace, à l'universalité du droit et de la justice. Néanmoins l'amélioration du rendement du système est une nécessité qui justifie une approche pluridimensionnelle (26). Reste le problème du sous-système qui lie, parmi d'autres variables, le seuil nominal de l'infraction, la tolérance de fait, la proportion des infractionnistes : contentons nous de répéter ici que même un taux élevé d'infractionnistes n'invalidé pas obligatoirement une réglementation dont les effets généraux, comparés à l'absence de réglementation ou à une limitation à un seuil plus élevé, restent positifs; néanmoins un taux élevé d'infractionnistes atteint la légitimité sociale de la norme qui à terme se trouve menacée : le récent relèvement des limitations américaines, dont le coût d'insécurité est inéluctable, illustre ce processus de perte de crédibilité et de légitimité.

CONCLUSION :

Il est aujourd'hui temps de comprendre que la limitation de vitesse ne doit pas être le placage provisoire et empirique de l'abstraction réglementaire sur la réalité multiforme et évolutive de la circulation; ce sont les caractéristiques fondamentales du système de la circulation routière qui sont déterminantes : système ouvert de déplacement de masse d'unités quasi-autonomes, libres de leur départ, de leur trajet, de leur itinéraire; système où la valeur centrale est celle de la liberté et de la souplesse, ce qui implique une grande variabilité des états, des situations et des acteurs. Dans l'économie d'un tel système la limitation de vitesse est une règle a minima qui conditionne le fonctionnement optimal. Il est regrettable que, même chez les bons
esprits, la limitation de vitesse n'aït pas été perçue pour ce qu'elle sera de plus en plus, un signe d'accès au fonctionnement adulte; mais il est vrai qu'en matière automobile, comme ailleurs, le dépassement du stade infantile reste pénible et coûteux, et toujours à merci d'un "coup" de nostalgie.
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Traffic safety in Canada has benefited from the experiences of many countries, e.g. seat belt legislation from Australia, drinking-driving laws from the U.K., and motor vehicle safety standards from the United States, by adapting these laws and practices to meet the needs of Canadians. Since the traffic milieu in Canada is most similar to that in the U.S. with similar vehicles, roads and driving conditions, it is not surprising that Canadian road safety countermeasures are also similar to those in the U.S.

Notwithstanding the similarities between the two countries, there are differences, for example in the mix of vehicles and road types (multilane vs two lane) and safety measures which affect Canadian decisions on motor vehicle safety standards. The Canada-U.S. Automotive Trade Agreement and the resultant integrated North American motor vehicle industry have made the harmonization of vehicle safety standards a high priority. With almost 30% of the vehicles sold in Canada being manufactured outside of North America, an effort is also made to ensure compatibility between Canadian and non-North American vehicle safety standards.

This paper describes how Canadian social values and institutions, political framework, economic policies and safety countermeasures currently in place, affect motor vehicle safety standard decisions. The Canadian Parliament, by enacting motor vehicle safety legislation in 1970 and successive governments through their decisions and directives, have established the criteria and policies which guide the development and adoption of safety standards. The existing driver, road and vehicles-in-use safety countermeasures in Canada which have been implemented by each of the Provincial governments according to their needs and preference, have a direct effect on the potential benefits that can be expected from proposed vehicle standards.

The manner in which these factors affect Canadian efforts to further motor vehicle safety standard harmonization are described: examples from the development of occupant protection, daytime running light, bumper and headlight standards are used to illustrate the problems identified. Some of the factors and decisions described may be unique to Canada, however, most will be similar to those experienced by other smaller countries making independent safety decisions.
appropriate measures they may be enabled to get the necessary insight into the patterns of their misbehaviour.

2. The very first roots lie in the thirties

As reported by HENDERSON and KOLE the first American driver improvement attempts were made in 1938. One year later the first evaluation study showed less accidents for a group of drivers who had undergone a driver improvement programme in contrast to a group that remained untreated.

The first official institution for re-education of traffic offenders was founded in 1952 at Trenton, New Jersey. It was named 'Accident Prevention Clinic'. In his guide 'Driver Improvement Schools', that he wrote for the American Automobile Association, Traffic Engineering and Safety Department, in 1963, FLETCHER reported about 150 driver improvement schools being operated country-wide.

When European researchers began to be interested in these new measures they found a wide range of activities that all had the same objective but differed considerably in terms of methods and intensity. The variety of educational approaches and referral procedures had been demonstrated not only in articles and reports that were available but also could be observed on the occasion of a first study trip carried out in 1970.

In the meantime the first German attempt to establish a driver improvement programme was made by conducting group meetings of four sessions with multiple traffic offenders who were close to or exactly at or even above the crucial mark of 18 demerit points which mean revocation of the driver's licence (SPOERER 1972a). The first course of that programme was run in September 1968.

The beginning of the development of driver improvement programmes in Austria was eight years later when psychologists of the Austrian Road Safety Board (Kuratorium für Verkehrssicherheit) started a treatment programme for imprisoned drinking drivers.

3. The classes turn to small groups

With the establishment of the first German programme an important decision was made concerning the size of groups that were assembled for improvement purposes. Most programmes in Austria, Germany and Switzerland are run today with groups of not more than 12 drivers. Only two Swiss programmes are carried out with 14 resp. 16 students at the very most. This former decision also was a denial of the large group concept that could be watched at some stages of the study trip mentioned before.

Many American programmes in the early seventies were restricted to teaching as many people as possible at the same time as many traffic rules and principles of defensive driving as possible (the so-called 'does and donts') mostly by administration officers, police officers, judges or alike.

Disappointed at the limited influence they could have on the participants of those classroom type mass events some authorities
began to use self-administered teaching materials (DELAIN 1968a, 1968b). Others tried to work with small groups (6 to 10 students) conducted by specially trained experts who were called 'driver improvement analysts' (State of Wisconsin).

They were encouraged by study findings of HACKLEY and SCHLESINGER demonstrating impressively that the gain drivers could get by participating in small group sessions was more socially related than that of drivers who were subjects of large group meetings. When the latter were asked whether the course changed any of their opinions and attitudes, and if so, by what means, typical answers were 'I will use my turn signal more often' or 'I drive now more attentively'. In contrast to these statements were those of members of small groups. Their typical comments were e.g. 'The programme changed my attitude towards other drivers and the traffic rules' or 'My picture of the police, of driving women and of children has been changed in so far as I am trying now to give them a chance' or 'I will be more patient with other drivers and will try to understand them better than in the past.'

A bitter comment on the value of large group events was made by DELAIN (1968a) who stated that the participants of driver clinic sessions took over the vocabulary of traffic safety and defensive driving without changing their driver behaviour.

The State of Wisconsin approach has been of great influence on the further development of driver improvement programmes in the Federal Republic of Germany and, with a slight delay, of those in Austria and Switzerland.

Some techniques that were taken into European programmes unchanged or in a modified version were e.g. 'let off the steam' in the beginning of the course, role-playing, paradoxical arguments, feed-back and others.

4. The analyst takes over from the instructor

Not only the specific techniques that could be found in the former Wisconsin driver improvement programme were of great importance but also the role and function of the group leader. He was no longer the 'untouchable' representative of the traffic authority who has to preach the incontrovertible truth of lawful and safe driving while the audience more or less has to swallow the wise knowledge that is presented.

The tasks of the group leaders in this second generation of driver improvement programmes were quite different. The 'analyst' had to leave the solution of the problems which brought the single driver into a conflict with the society in the care of the group. He only was allowed to point out ways of problem solution by suggesting themes, collecting opinions, emphasizing agreements and disagreements, provoking judgements, supervising the tracking of the programme objectives and so forth. In order to use an appropriate description of the group leader's activities the term 'moderator' was chosen for experts who conducted courses in the mentioned Central European countries.
5. Laws for new measures on probation

Another observation of American procedures was of remarkable importance. It concerned the temporary legal force of acts just for the purpose of scientific gain of knowledge, in other words only to evaluate new measures. The problem in Germany was and still it is in Austria and Switzerland that scientists could not prove the value of a programme that could not be run for lack of an adequate legal basis for referral procedures, and that politicians refused to introduce new measures unless they were not convinced of their quality and usefulness (SPOERER 1972b).

Though an Austrian evaluation study on recidivism of drinking drivers showed positive effects, the further development of driver improvement programmes there is stagnant. There is no legal basis that rules the referral of drivers who should undergo a driver improvement programme. Local driver licensing authorities seldom admit the participation in a programme as evidence in judging the driver's re-qualification.

The evaluation of driver improvement programmes would not have been possible if the relevant authorities in Germany were not willing to care for the legal requirements that were necessary to test programmes for a definite period of time. The former state enactments allowing comprehensive evaluation studies on programmes for multiple traffic offenders and drunk drivers or DWIs (driving while intoxicated / impaired / under the influence of alcohol) were followed by a unique change of the traffic code concerning the licence on probation and herewith the compulsory entry into re-education (resp. rehabilitation) programmes for those licensees (mostly young drivers) who failed in the probation period.

6. DWIs - a separate target group

When we look back to the seventies and watch the development of driver improvement programmes in Europe so far we remember that the moderators soon realized that those drivers who attended the meetings because of their DWI offences could not gain from the courses to the same extent as ordinary traffic violators did. The outcome of this experience was the installation of separate courses for DWI offenders only (WINKLER 1974, KUNKEL 1979, WINKLER 1979).

The same decision was made in the USA and in Canada some years earlier. Meanwhile there the ASAPs (Alcohol Safety Action Projects) dominated the discussion on how to cope with the drinking-and-driving problem (NICHOLS and REIS 1975). So the time was right to learn from the experience and practical knowledge of those who administered rehabilitation programmes for DWIs.

Another study trip was carried out in 1975. It covered 21 institutions at 12 different places in the USA and Canada between Vermont and Alaska. The variety of approaches and procedures was impressive as well as hardly to overlook (SPOERER 1976).

Like the State of Wisconsin that had a considerable influence on the development of German driver improvement programmes in general five years earlier, now the City of Phoenix, Arizona,
programme was interesting enough to function as model in some important aspects as far as programmes for DWIs were concerned.

When in 1975 the Phoenix system has been studied in detail the second or third generation of approaches to rehabilitate the drinking driver could be observed. The course of STEWART and MALFETTI, developed in the mid sixties, had become a model for many DWI programmes in the United States and was adopted by the American Automobil Association (AAA) as 'DWI Counterattack Programme'.

About ten years later the Phoenix programme emphasized the importance of motivation (instead of information) and working with groups that were smaller than those in the past. Different programmes were provided for different groups of drinking drivers (e.g. social drinkers, problem drinkers).

7. Psychological approaches take effect

With the so-called 'Power Motivation Training' (BOYATZIS 1973) the Phoenix system showed a remarkable progress in so far as this programme could be regarded the first approach of rehabilitating drinking drivers by using a stringent theoretical concept. All other programmes that were used so far were more or less eclectic.

This experience encouraged the German Federal Road Research Institute (Bundesanstalt für Straßenwesen) which co-ordinated most of the driver improvement efforts by three project groups (Bundesanstalt für Straßenwesen 1977, Bundesanstalt für Straßenwesen 1978, HEBENSTREIT, HUNDHAUSEN, KLEBE, KROJ, SPOERER, WALTHER, WINKLER and WUHRER 1982) to cooperate with two scientific groups that were commissioned to develop two programmes for DWI repeaters (second offenders) each using a particular psychological approach. One of these programmes has been orientated towards behaviour therapy (KRAEMER 1978, KRAEMER, KUHNERT and KRAUTHAN 1983), the second used principles of the individual psychology by Alfred Adler (JENSCH and LEMM-HACKENBERG 1981). Both programmes proved to be very efficient and are still in use (JENSCH, RUBY, SPOERER AND ZUZAN 1985).

Another influence concerns the connection of course participation and court action. Not that the Phoenix 'PACT' (Prosecution Alternative to Court Trial) - system could be taken over, but since a couple of years there are some programmes in Germany that earns a defendant an abbreviation of the revocation period for his driver's licence if he participates in the programme.

8. It's time for an interim balance

After nearly 20 years of development and evaluation of driver improvement programmes a documentation of all programmes that are in use in Austria, Germany and Switzerland has been carried out recently (SPOERER, RUBY and HESS 1987).

The compilation shows an impressive variety in terms of theoretical background, methods and techniques as well as target groups and referral procedures.
As far as Austria is concerned there are six different programmes, all attempting to rehabilitate the DWI (KLEBEL, MICHALKE and SCHMIDT 1979, MICHALKE 1979, SCHMIDT and SCHUTZENHOFER 1977, SCHUTZENHOFER 1981, ZUZAN and RUBY 1986). One of these programmes is run in prisons. It is for DWIs, who are imprisoned because of the severe consequences of their drinking-and-driving events, mostly negligent physical injury.

All Austrian programmes are based on group dynamics techniques, two programmes use a behaviour therapeutical approach, three use techniques of client-centered therapy by Rogers, one programme combines principles of the individual psychology of Adler and psychodrama techniques as developed by Moreno (RUBY 1985, JENSCH, RUBY, SPOERER and ZUZAN 1985, ZUZAN and RUBY 1986).

An essential tool in four programmes is the participant's self-report of his drinking habits. One programme uses a screening form for self-observation. The increase of knowledge of drinking and driving is objective in all programmes. This is partly done by oral presentation, partly by using special information material.

In the Federal Republic of Germany there are 15 programmes in use now. One programme is provided for licensees who failed in their probation time with particular offences except offences against the drinking-and-driving law (BRESSENSDORF, BRUCKNER, FINGSKES, KAJAN, LANGWIEDER, WALTHER 1986). Two different programmes are for those drivers with a licence on probation who have a DWI offence (JENSCH 1987, Fachausschuß medizinisch-psychologische Arbeitsgebiete der Vereinigung der Technischen Überwachungsverein 1986).

Five programmes are open for drivers who have a certain amount of demerit points recorded in the national driver register (Bayerisches Staatsministerium des Innern 1981, Bundesvereinigung der Fahrlehrerverbände 1979, GORTEN, NEUMEIER and WIEGAND 1987).


Last but not least there is one programme in the stage of evaluation that is open to drivers with at least three DWI offences. This programme is run for a period of about six months.

In addition to the methods and techniques that were not mentioned before the German documented programmes contain: neuro-linguistic programming, driving tests, commentary driving, relaxing exercises, consultation of dependants, freshening-up meetings, long-term treatment.

For Switzerland the documentation shows no use of particular therapeutic approaches. No wonder because all programmes are limited to the maximum duration of one day by legislation. Four of the six programmes emphasize the increase of knowledge on traffic code and defensive driving. Four programmes include practical exercise with cars in order to learn to cope with hazardous traffic situation (BAER 1985).
All evaluation studies that have been carried out so far showed positive effects (UTZELMANN and HAAS 1985), some programmes reduced the recidivism rates of DWIs by one half (SPOERER 1985, WINKLER 1985, WINKLER, JACOBSHAGEN and NICKEL 1986).

9. Sharing experience and perspectives

Since 1978 the three Central European countries regularly share their experience and perspectives through International Driver Improvement Workshops (ZUZAN 1979, HUGUENIN and HESS 1982, Bundesanstalt für Straßenwesen 1985). Salzburg (Austria) in 1978, Gwatt (Switzerland) in 1981 and Damp (Germany) in 1984 were the locations where these meetings took place so far. The fourth International Driver Improvement Workshop will be held in spring 1988 probably at Baden that is close to Vienna.

There is good reason to assume that the future catalogue of measures for traffic offenders will not omit driver improvement programmes. We are convinced that the effect of these activities has stimulated traffic safety efforts at all especially driver education.

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EXPERIENCES IN FATALITIES BY AGE AND ROAD USER GROUPS -
U.S.A. VS. WESTERN EUROPE 1970-1983

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The objectives of the study were: (1) to identify various changes in fatalities and fatality rates for different age and road user groups, as experienced by eleven Western European countries and by the United States from 1970 through 1983, and (2) to determine whether there were statistically significant changes in the traffic accident characteristics studied.

For Western Europe as a whole it was found that all age and road user groups showed significant or at least marginal improvements in safety for the entire time period observed; however, the U.S. experienced significant deteriorations in safety for many of the investigated human and vehicular involvements, especially during the second half of the 1970's. Contrary to this trend, the study determined that since 1980 the fatality reduction in the U.S. was nearly similar to that of Western Europe and that most age and road user groups revealed significant improvements in safety in both continents.

In the year 1983, the fatality rate in the United States was about 48 percent lower than that of Western Europe, which is a clear indication that it is still much safer to drive on U.S. roads.
INTRODUCTION

In the work presented here, fourteen consecutive years (1970-1983) of traffic accident data are used to obtain a better perspective of the traffic safety problems of the two continents and to negate short-term changes in accident patterns. Eleven Western European countries (Western Europe) were studied: Austria, Belgium, Denmark, Federal Republic of Germany, France, Italy, Norway, Sweden, Switzerland, the Netherlands, and the United Kingdom (Great Britain) and the U.S.A. The goal of the study is to generate information to assist traffic safety authorities to determine "WHO?", that means: "Which Age and Road User Groups?" are most frequently involved in traffic accidents. In other words, the study identified the statistical characteristics of motor vehicle accidents with respect to age and road user groups, thereby assisting in the identification of human and vehicular involvements in accidents in Western Europe and the United States. Particularly in this connection especially Western Europe as a whole, including the eleven Western European countries, and the U.S. will be compared to address the following tasks:

1. identify various changes in fatalities and fatality rates for different age and road user groups and
2. determine whether there were significant changes in the traffic accident characteristics.

At the time the manuscript was completed, the data were as up to date as possible; readers may wish to add later statistics as these become available. For this reason, the form of the tables has generally followed the presentation of official statistics, which can thus readily be used to update the information. Details of the sources are shown in reports by the authors to the Alfried Krupp von Bohlen und Halbach-Stiftung, Essen, Federal Republic of Germany (1,2).

DATABASE AND METHODOLOGY

The data used for the study spans a fourteen year period from 1970-1983. The majority of the data were obtained from the United Nations "Statistics of Road Traffic Accidents in Europe," (3) and the U.S. Department of Transportation "Fatal Accident Reporting System" (4). Additional data were obtained from various national statistics. The reader who is interested in further information on the data used should consult (1,2,5-8).

The data was broken down into two categories:

1. Demographic characteristics, which include population, land area, number of registered motor vehicles, and number of vehicle kilometers of travel and
2. Traffic accident characteristics, which include number of fatalities per year, number of injuries per year, number of
fatalities per $10^9$ vehicle-kilometers per year, number of fatalities per $10^5$ inhabitants per year, number of fatalities by age groups per year, and number of fatalities by road user groups per year; see Table 1 (Western Europe) and Table 3 (U.S.). These data exist additionally for the individual eleven Western European countries (1,2).

Property damage accidents were excluded from the analysis since police property damage accident reporting procedures are not uniform throughout the investigated countries. Furthermore, a primary goal of transportation agencies is to prevent the loss of life and to reduce personal bodily injury. The reductions of vehicle property damage and subsequent economic savings are important, but they are still a secondary goal.

The comparability of accident data is hampered by the differences between countries - and even within a country - not only with regard to details of the definitions used and groups covered, but also by differences in the methods of collection, classification and tabulation of the data. For example, while a death within 30 days of an accident is classified in most countries as a fatal injury, some other countries tend to use shorter or longer intervals. To compensate for these discrepancies the European Conference of Ministers of Transport, CEMT (1970) recommends that the number of fatalities (interval 30 days) can be achieved by simply applying the following correction factors (9):

- Died within three days 1.15 (Austria)
- Died within six days 1.09 (France)
- Died within seven days 1.08 (Italy)
- Died within one year 0.97 (Switzerland).

To achieve the objectives stated previously, this study includes two major tasks: 1) identification of accident trends (fatalities and fatality rates), and 2) identification of safety improvement needs.

The purpose of the first task is to reveal the similarities and dissimilarities among the subject countries and to show quantitatively the changes in fatalities and fatality rates as experienced by each of the subject countries from 1970 through 1983. The primary concerns of this task include the trend of fatalities and fatality rates on a yearly basis.

The second task is intended to determine the specific safety improvement needs for each of the subject countries. To accomplish this, t-tests (10) are conducted to determine whether there are real changes in the accident trends. These changes are analyzed respectively for different age and road user groups for the following four time periods:

- Time period I contains the years 1970, 1971, and 1972 to enable us to describe the fatality situation at the beginning of the 1970's,

*The unlisted data in Tables 1 and 3 for the years 1971, 1973/74, and 1976/77 are found in references (1) and (2).
- Time period II* contains the years 1974, 1975, and 1976 to enable us to describe the fatality situation after the energy crisis of 1973 which had a great impact on the accident trends in nearly all observed countries,
- Time period III contains the years 1978, 1979, and 1980 to enable us to describe the fatality development at the end of the 1970's, and
- Time period IV contains the years 1981, 1982, and 1983 to enable us to describe the fatality development at the beginning of the 1980's.

The analysis is based on the average number of fatalities and fatality rates per year. Fatality rates are measured in two ways. One is in terms of fatalities per $10^9$ vehicle-kilometers, and the other is in terms of fatalities per $10^5$ inhabitants.

The null hypothesis tested with the fatality data was as follows: "There is no significant difference between the mean number of fatalities/fatality rates between any two time periods in each of the subject countries or continents."

The hypothesis testing was conducted by computing the t-statistic where t is a measure of the difference between the mean number of fatalities/fatality rates compared. The calculated t-value was then compared with an appropriate critical t-value obtained from the standard statistical tables for the corresponding degrees of freedom and confidence interval used (95%). If the calculated t-value was smaller than the critical t-value, the hypothesis was accepted. A higher t-value resulted in the rejection of the null hypothesis. The implications of the acceptance or rejection of the hypothesis are as follows:

1. Acceptance of the null hypothesis signified that there was no real difference between the mean number of fatalities/fatality rates between any two time periods. Whatever small difference might have been observed between two data sets was indeed attributable to random chance.

2. Rejection of the hypothesis implied that there was a significant difference between the mean number of fatalities/fatality rates between any two time periods in each of the subject countries.

The reader who is interested in a further discussion of the t-tests should consult Brownlee (10) and Lamm et al. (1,2).

TRENDS OF FATALITIES AND FATALITY RATES BETWEEN 1970 AND 1983

Table 1 reveals that the first major reduction in fatalities in Western Europe, which includes the eleven Western European countries mentioned earlier, occurred between 1972 and 1975 and coincided with the energy crisis of 1973/1974. After 1975 the safety improvements continued at a slower pace until 1983.

With respect to fatalities by age groups, Table 1 reveals that all age groups experienced increases in fatalities between 1970 and 1972. After 1972 all age groups, with the exception of the age group "15-24," experienced continuous decreases in
Table 1. Example of Vital Statistics for Western Europe. Area = 2,343,969 Sq. Km

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</tr>
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<td>10.0</td>
<td>10.4</td>
<td>11.1</td>
<td>11.1</td>
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<td>7.9</td>
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<td>17.3</td>
<td>17.0</td>
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<td>25-64</td>
<td>Over 64</td>
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<td>Per 10$^9$ V. km *</td>
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<td>37.8</td>
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<td>Per 10$^5$ Inhabitants</td>
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<td>Pedestrians</td>
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<td>15709</td>
<td>14659</td>
<td>15024</td>
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<td>Motorcyclists and Moped Riders</td>
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<td>33092</td>
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<td>Truck and Bus Occupants</td>
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</table>

*Without Denmark

The unlisted data of the years 1971, 1973/74, and 1976/77 are found in references (1) and (2).
With respect to fatalities, Table 1 reveals that all road user groups experienced increases in fatalities between 1970 and 1972. After 1972, only the road user groups "Pedestrians and Bicyclists" experienced continuous decreases in fatalities until 1983. The other road user groups showed fluctuations in fatalities during the same time period.

In terms of statistical significance, Table 2, which shows the t-test results and percent changes for different fatality categories and different time periods, indicates that Western Europe experienced significant safety improvements between 1970 and 1983 for the majority of the fatality categories. These include: total number of fatalities, fatality rates, fatalities by age groups "0-14," "25-64," and "over 64," and fatalities by road user groups "Pedestrians". The other age and road user groups, with the exception of the age group "15-24" which experienced marginal deterioration in safety between time periods II and III, experienced significant or at least marginal improvements in safety between the different time periods.

Similar to the fatality development in Western Europe during the first half of the last decade, Table 3 indicates that the first major reduction in fatalities in the U.S. between 1972 and 1975 concurs with the energy crisis of 1973/1974. However, contrary to the fatality trend in Western Europe after 1975, Table 3 shows a steady climb in fatalities until 1979, no change in 1980, a current drop beginning in 1981 until 1983. The overall drop from the 1980 peak of 51,091 to the 1983 estimate of 42,584 is 16.7% or 8507 fatalities. The only comparable decrease was during the energy crisis of 1974.

With respect to fatalities by age and road user groups, Table 3 reveals that after the energy crisis of 1973/1974, only the age group "0-14" experienced continuous decreases in fatalities until 1983. All the other age and road user groups experienced more or less increases in fatalities until 1980, followed by decreases until 1983.

In terms of statistical significance, Table 4, which shows the t-test results and percent changes for different fatality categories and different time periods, indicates that the U.S. experienced significant deteriorations in traffic safety for most fatality categories during the second half of the last decade (time periods II-III). However, significant or marginal safety improvements for all fatality categories are obvious from the end of the 1970's to the beginning of the 1980's (time periods III-IV).

Another way of looking at fatalities is through the fatality rate (fatalities per 10^9 vehicle-kilometers). As noted in Table 5, fatality rates in Western Europe and the United States showed decreases between 1970 and 1983. There was a continuous downward trend in Western Europe, which reaches a fatality rate reduction of 52 percent during the observed time period. The comparable number for the U.S. was 45.9 percent. However, it is interesting to note that there was a stagnation during the second half of the last decade that confirms the previous results.

But it is worth mentioning that over the whole time period observed the fatality rate in Western Europe was always...
Table 2. T-Test Results and Percent Changes for Different Fatality Categories and Different Time Periods (Western Europe)

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<td>-16.9</td>
<td>10.074&gt;2.518</td>
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<td>Fatalities</td>
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<tr>
<td>Per 10⁹ V.km</td>
<td>-27.6</td>
<td>11.053&gt;2.237</td>
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<td>Fatalities</td>
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<td>Per 10⁵ Inhab</td>
<td>-18.4</td>
<td>13.307&gt;2.262</td>
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<td>Age Groups</td>
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<td>0-14</td>
<td>-25.3</td>
<td>10.330&gt;2.318</td>
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</tr>
<tr>
<td>15-24</td>
<td>-3.4</td>
<td>1.72&lt;2.160</td>
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<td>Over 64</td>
<td>-13.3</td>
<td>8.646&gt;2.362</td>
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<td>Road User Groups</td>
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<td>Pedestrians</td>
<td>-22.7</td>
<td>7.656&gt;2.880</td>
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<td>Bicyclists</td>
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<td>13.381&gt;2.321</td>
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<td>Motorcyc. &amp;</td>
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<td>1.056&gt;2.699</td>
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<td>Passenger Car Occ.</td>
<td>-17.3</td>
<td>7.580&gt;2.641</td>
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<td>Truck and Bus Occ.</td>
<td>-15.7</td>
<td>4.030&gt;2.572</td>
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Table 3. Example of Vital Statistics for the U.S.A.  
Area = 9,519,662 Sq. Km

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<td>Population ($10^6$)</td>
<td>203.8</td>
<td>209.3</td>
<td>215.5</td>
<td>221.2</td>
<td>224.2</td>
<td>227.2</td>
<td>229.3</td>
<td>231.5</td>
<td>234.0</td>
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<td>Pop. density (Inh/KM$^2$)</td>
<td>21.4</td>
<td>22.0</td>
<td>22.6</td>
<td>23.3</td>
<td>23.6</td>
<td>23.9</td>
<td>24.1</td>
<td>24.3</td>
<td>24.6</td>
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<tr>
<td>Total ($10^6$)</td>
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<td>122.6</td>
<td>130.0</td>
<td>153.9</td>
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<td>161.5</td>
<td>164.1</td>
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<td>121.7</td>
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<td>Trucks &amp; Buses ($10^6$)</td>
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The unlisted data of the years 1971, 1973/74 and 1976/77 are found in references (1) and (2).
Table 4. T-Test Results and Percent Changes for Different Fatality Categories and Different Time Periods (U.S.A.).

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<td>T-test</td>
<td>Significance</td>
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<td>crit.</td>
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<td>Per 10^5 Inhab</td>
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<td>Bicyclists</td>
<td>+27.2</td>
<td>6.190&lt;2.727</td>
<td>S</td>
</tr>
<tr>
<td>Motorcyclists</td>
<td>+40.7</td>
<td>20.258&lt;2.171</td>
<td>S</td>
</tr>
<tr>
<td>&amp; Moped Rid.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger</td>
<td>-25.1</td>
<td>19.334&lt;2.766</td>
<td>S</td>
</tr>
<tr>
<td>Car Occ.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Truck and</td>
<td>+7.8</td>
<td>1.886&lt;2.696</td>
<td>NS</td>
</tr>
<tr>
<td>Bus Occ.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
significantly higher than that in the U.S., (see Table 5). Generally, it can be stated that the risk of being killed in a traffic accident was always about twice as high in Western Europe as it was in the U.S. Furthermore, Table 5 reveals that traffic safety in Western Europe (as expressed by fatality rates) had reached by the year 1983 a level that was already reached in the U.S. in 1970.

<table>
<thead>
<tr>
<th>Year</th>
<th>Western Europe</th>
<th>U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970</td>
<td>64.2</td>
<td>29.6</td>
</tr>
<tr>
<td>1971</td>
<td>62.7</td>
<td>27.9</td>
</tr>
<tr>
<td>1972</td>
<td>61.3</td>
<td>27.1</td>
</tr>
<tr>
<td>1973</td>
<td>54.5</td>
<td>25.7</td>
</tr>
<tr>
<td>1974</td>
<td>48.1</td>
<td>22.1</td>
</tr>
<tr>
<td>1975</td>
<td>45.1</td>
<td>21.0</td>
</tr>
<tr>
<td>1976</td>
<td>43.5</td>
<td>20.2</td>
</tr>
<tr>
<td>1977</td>
<td>41.0</td>
<td>20.4</td>
</tr>
<tr>
<td>1978</td>
<td>37.8</td>
<td>20.3</td>
</tr>
<tr>
<td>1979</td>
<td>35.5</td>
<td>20.9</td>
</tr>
<tr>
<td>1980</td>
<td>34.8</td>
<td>21.0</td>
</tr>
<tr>
<td>1981</td>
<td>33.5</td>
<td>19.7</td>
</tr>
<tr>
<td>1982</td>
<td>32.1</td>
<td>17.1</td>
</tr>
<tr>
<td>1983</td>
<td>30.8</td>
<td>16.0</td>
</tr>
</tbody>
</table>

Table 5. Fatality Rates in Western Europe and the U.S.

FATALITIES BY AGE GROUPS

The age distribution of fatalities is different between Western Europe and the United States. In particular, the percentage of fatalities by the age group "15-24" is substantially higher in the U.S. than in Western Europe, (see Table 6). This may be explained by the higher motorization ratio and the driving permit laws in the U.S., which enables the participants of this age group to engage in extensive driving at an early age, thereby increasing the risk to be fatally injured.

<table>
<thead>
<tr>
<th>Age Groups</th>
<th>1970</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WE</td>
<td>USA</td>
</tr>
<tr>
<td>0-14</td>
<td>10.0</td>
<td>10.8</td>
</tr>
<tr>
<td>15-24</td>
<td>22.6</td>
<td>30.9</td>
</tr>
<tr>
<td>25-64</td>
<td>47.4</td>
<td>45.0</td>
</tr>
<tr>
<td>over 64</td>
<td>19.9</td>
<td>13.3</td>
</tr>
</tbody>
</table>

Table 6. Comparison of Fatalities by Age Groups in Percent for the Years 1970 and 1983.
On the other hand the percentage of fatalities by the age group "over 64" is lower in the U.S. as revealed in Table 6. This may be related to a higher motorization ratio and other traffic patterns. In Western Europe persons in the age group "over 64" represent a high proportion of pedestrian fatalities. For example, in the Federal Republic of Germany about half of the fatally injured pedestrians are elderly people over 64 years of age. Or another comparison: Related to 100,000 people in the age group "over 64" the number of pedestrian fatalities is 13.5 while for all other age groups the comparable number is only 2.6 (11).

As Table 6 reveals, there were substantial changes in the age distribution of fatalities in Western Europe and the U.S. between 1970 and 1983. The percentage of fatalities for the age group "0-14" was nearly the same in 1970 and dropped for about one third until 1983 in both continents. The age group "15-24" reveals only major reductions for the U.S. Minor fluctuations could be noted for the age group "25-64," while the age group "over 64" shows nearly the same percentages for 1970 and 1983.

**FATALITIES BY ROAD USER GROUPS**

Passenger car occupants represent the largest group of fatalities in Western Europe and the United States. However, for the other road user groups there are considerable differences as Table 7 reveals.

<table>
<thead>
<tr>
<th>Road User Groups</th>
<th>1970 WE (%)</th>
<th>1970 USA (%)</th>
<th>1983 WE (%)</th>
<th>1983 USA (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pedestrians</td>
<td>28.1</td>
<td>17.3</td>
<td>21.2</td>
<td>17.7</td>
</tr>
<tr>
<td>Bicyclists</td>
<td>8.6</td>
<td>1.5</td>
<td>7.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Motorcyclists</td>
<td>14.5</td>
<td>4.4</td>
<td>16.7</td>
<td>11.1</td>
</tr>
<tr>
<td>Passenger Car Occ.</td>
<td>44.8</td>
<td>66.6</td>
<td>50.1</td>
<td>59.7</td>
</tr>
<tr>
<td>Trucks and Bus Occ.</td>
<td>4.0</td>
<td>10.2</td>
<td>4.4</td>
<td>9.4</td>
</tr>
<tr>
<td></td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 7. Comparison of Fatalities by Road User Groups in Percent for the Years 1970 and 1983.

For example, in 1970 pedestrians and bicyclists accounted for 36.7 percent of all fatalities in Western Europe and for 18.8 percent in the U.S. This means that the percentage of "pedestrian and bicyclist" fatalities in Western Europe was nearly twice as high as that in the U.S. On the other hand, while the percentage of "pedestrian and bicyclist" fatalities in Western Europe dropped to 28.8 percent in 1983 due largely to a reduction in pedestrian fatalities, the U.S. experienced only a minor change. As Table 7 reveals, bicyclist fatalities in the U.S. represent a very low percentage of the total number of fatalities. For motorcyclist fatalities, a minor increase from 14.5 percent to 16.7 percent was observed in Western Europe, while the percentages in the U.S. more
than doubled from 4.4 percent to 11.1 percent between 1970 and 1983. For the road user group "passenger car occupants" the differences between Western Europe and the United States diminished mainly caused by an increase in Europe and by a decrease in the U.S. The difference is remarkable for truck and bus occupant fatalities between Western Europe and the U.S. Although the percentages remained nearly constant from 1970 to 1983, it is worth noting that the percentages of fatalities in this category are more than twice as high in the U.S. than those in Western Europe.

SUMMARY OF FINDINGS FOR THE TIME PERIOD III-IV (1978 to 1983)

In the following, we will concentrate on the issue of fatality development at the end of the 1970's and the beginning of the 1980's since these two time periods represent a crucial turning point in traffic safety, especially in the United States. Table 8 shows a summary of important findings for Western Europe and the United States from 1978 to 1983. As revealed in Column 1 the United States has an area that is about four times that of Western Europe which includes the eleven Western European countries: Austria, Belgium, Denmark, Federal Republic of Germany, France, Italy, Norway, Sweden, Switzerland, The Netherlands, and the United Kingdom (Great Britain). Column 2 shows that Western Europe has a population density which is about five times that of the U.S. Columns 3 and 5 indicate that between 1978 and 1983, the increases in the number of registered motor vehicles and the vehicle-kilometers of travel are more or less comparable in both continents. Column 4 shows that the U.S. has, with 1.4 inhabitants per registered motor vehicle, a higher motorization ratio than Western Europe.

Column 6 indicates that while the number of injuries in Western Europe showed a reduction of 5.6% between 1978 and 1983, the number of injuries in the U.S. showed an unexplainable drastic increase.

Column 7 indicates that the reduction in fatalities between 1978 and 1983 is nearly comparable in both continents. However, it is interesting to note that in 1983 the U.S. had 16 fatalities per 10^9 vehicle-kilometers, which is 48 percent lower than that of Western Europe, (see Column 8).

Table 9 shows the t-test results for the changes in fatality trends of different age groups and road user groups between 1978 and 1983. As can be seen Western Europe experienced significant safety improvements for six fatality categories. These include all age groups and the road user groups "pedestrians" and "passenger car occupants." The United States experienced significant improvements in safety for the age groups "0-14" and "15-24" and for the road user group "passenger car occupants." For all other age and road user fatality categories, at least marginal safety improvements were observed in both continents. This development decisively contradicts the experiences of the U.S. during the second half of the last decade (see Table 4) when most of its fatality categories revealed significant safety deteriorations.

Of interest is finally Table 10 which presents the t-test
Table 8. Summary of Important Findings for Western Europe and the U.S.A.

<table>
<thead>
<tr>
<th></th>
<th>Area Popul. Density</th>
<th>% Change (Motor Regist.)</th>
<th>Inhab./km²</th>
<th>% Change (Vehicle Motor Regist.)</th>
<th>% Change (Vehicle Travel)</th>
<th>% Change (Vehicle Injuries)</th>
<th>% Change (Fatalities)</th>
<th>Fat./10⁹ Veh. km</th>
<th>% Change (Fat./10⁹ Veh. km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Europe</td>
<td>2,343,969</td>
<td>121</td>
<td>+10.7</td>
<td>2.3</td>
<td>+9.2</td>
<td>-5.6</td>
<td>-12.1</td>
<td>30.8</td>
<td>-18.5</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>9,519,662</td>
<td>25</td>
<td>+7.9</td>
<td>1.4</td>
<td>+7.2</td>
<td>+1.7</td>
<td>-15.4</td>
<td>16.0</td>
<td>-21.2</td>
</tr>
</tbody>
</table>

¹Without Denmark

Table 9. Summary of Findings for Western Europe and the U.S.A. in Terms of Their Experience in Fatalities by Age and Road User Groups.

<table>
<thead>
<tr>
<th>Fatalities by Age Groups</th>
<th>Fatalities by Road User Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Western Europe</td>
<td>X</td>
</tr>
<tr>
<td>U.S.A.</td>
<td>X</td>
</tr>
</tbody>
</table>

Legend:
X: Significant improvement in safety
0: Marginal improvement in safety
-: Marginal deterioration in safety
+: Significant deterioration in safety

For the time period III-IV
Table 10. Summary of Findings for the Western European Countries in Terms of Their Experience in Fatalities by Age and Road User Groups.

<table>
<thead>
<tr>
<th></th>
<th>Fatalities</th>
<th>Fatalities</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Age Groups</td>
<td>Road User Groups</td>
</tr>
<tr>
<td>Fed. Rep. of Germany</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>France</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Italy</td>
<td>X</td>
<td>-</td>
</tr>
<tr>
<td>Austria</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>Switzerland</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Belgium</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Denmark</td>
<td>0</td>
<td>X</td>
</tr>
<tr>
<td>Sweden</td>
<td>X</td>
<td>0</td>
</tr>
<tr>
<td>Norway</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>Western Europe</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Legend:
- X: Significant improvement in safety
- O: Marginal improvement in safety
- -: Marginal deterioration in safety
- +: Significant deterioration in safety

For the time period III-IV
results for the different age and road user groups between 1978 and 1983 as experienced by each of the eleven Western European countries. In summary, the trend of fatalities for the different age and road user groups revealed significant or at least marginal improvements in safety in most Western European countries. Exceptions were several marginal safety deteriorations for the age group "15-24" and the road user groups "bicyclists" and "motorcyclists." Only Switzerland revealed a significant deterioration in safety for the road user group "motorcyclists" during this time period. The reader who is interested in specific fatality developments in any single country should consult references (1) and (2).

CONCLUDING REMARKS

During the investigated four time periods between 1970 and 1983, Western Europe as a whole experienced a persistent downward trend in fatalities and fatality rates per 10^9 vehicle-kilometers which was statistically significant at the 95% level of confidence. With regard to human and vehicular involvements, all age groups and road user groups experienced (with the exception of the age group "15-24") significant or at least marginal improvements in safety during the whole observed time period.

Contrary to this development, the United States experienced significant deteriorations in traffic safety for most fatality categories, especially during the second half of the last decade (time period II-III). However, since the beginning of the 1980's significant or marginal safety improvements for all fatality categories were observed until 1983.

Over the whole observed time period from 1970 to 1983 the fatality rate in Western Europe was always significantly higher than that in the U.S. Generally, it can be stated that the risk of being killed in a traffic accident was always about twice as high in Western Europe as it was in the U.S.

The positive development in the U.S. at the end of the 1970's and the beginning of the 1980's may be, at least, partially attributable to the introduction of mandatory use of seat belts and the stricter enforcement of existing and new laws about drunk driving in many states of the U.S. since the beginning of the 1980's. Corresponding laws and enforcement activities were put into effect in most Western European countries since the mid-seventies.

REFERENCES


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Elderly Drivers in Europe

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ABSTRACT

Elderly citizens of today are healthier and wealthier than in the previous generation. The car plays a steadily increasing role in their social life. Without it they run the risk of being socially isolated. Such an isolation speeds aging while contacts and activity delays it. The elderly need the car.

This paper concentrates on the question whether the ageing driver is a safety problem and if so why and what can we do about it? Initially it is shown that the elderly driver has a higher accident rate than the middle aged. The problem with older drivers will increase in the years to come since the proportion of elderly drivers will increase. The handicaps of the elderly driver are of physiological and cognitive character. But these limitations are partly compensated mainly by increased caution. The influence of these functions on seven specified driver tasks (planning, navigation, road following, traffic interaction, speed control, rule compliance, vehicle manoeuvring) is discussed. Some countermeasures are discussed and analyzed.
ELDERLY DRIVERS IN EUROPE

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Linköping, Sweden

1. AGE AND MOBILITY

For thousands of years age has normally been followed by a decrease in mobility. The main and natural reason has been a based decrease of physiologically bodily mobility (motor and perceptual skills). But it has also for several reasons been the case concerning travelling during the last hundred years - partly because of health problems, partly due to economical problems, partly because the person has no license or no car or both. In Sweden in the beginning of the 80's the number of trips decrease rapidly for men from about the age of 60 and for women from about the age of 40(1). For men the most common transport is by car up to the age of 70. For women the corresponding age is 45. After that most trips are made walking (Lundberg 1982).

But we have reasons to believe that this pattern will continue to change - at least in the industrialized countries e.g. in Europe. The limiting effects of age and of age and sex will decrease. In the future the elderly will be healthier, they will have considerably better economy and they will have driver's license as well as car.

![Graph showing predicted number of trips per year for road users over 65 years in Sweden from 1978 to 2003.](Holmberg 1986)
The elderly and the handicapped really need the car in order to be able to participate in society. Their physical mobility decreases. But by means of a car they can maintain their mobility and their contacts — also the somewhat distant ones. We know now that the decline in many functions today is ascribed to age will be slower and delayed if the aged person lives an active life — and vice versa — if the person is inactive the decline will come earlier and go faster.

2. AGE AND ROAD USER CATEGORY

This paper deals mainly with driver age. But the reason for this is not that age is a larger problem for drivers than for other road user categories. On the contrary — both recent accident studies (e.g. Salusjärvi & Mäkinen 1986) and recent studies of perceived problems (e.g. Ståhl 1986) show that the problems are larger for cyclists and pedestrians.

But while the problem of driver age can be decreased by medical and legislative measures this is not possible with cyclists and pedestrians. Here other measures have to be applied.

The reason for concentrating on drivers is that aging drivers is a problem and an increasing one that has received a growing interest from legislative and medical point of view.

Most of the examples used in this paper come from Europe. But the problem is of course a general one in industrialized countries.

How can we help and support the aging drivers in car design, road design, traffic control, rule making? Do we have to be more restrictive in our licensing policy towards the aging drivers?

The term elderly in this paper normally refers to persons older than 65 years.

3. IS DRIVER AGE A PROBLEM?

3.1 Accidents

Accident statistics show us that even if the injury fatality risk of old drivers is normally lower than that for young drivers it is clearly substantially higher than that for middle age drivers (see figure 2).
Figure 2. Killed and injured drivers per million km for various age groups in Denmark. (Hvoslef 1986)

Furthermore, in depth analyses of accidents reveal that the specific problems that the elderly drivers encounter are different from those of young and middle age drivers. Table 1 illustrates these differences for some main broad accident categories.

Table 1. Distribution (%) of fatal accidents for drivers of two age groups in Finland 1982-1985 (Salusjärvi & Mäkinen, 1986)

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Age 15-64</th>
<th>Age 65-</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crossing collision</td>
<td>Head on collision</td>
</tr>
<tr>
<td>Crossing collision</td>
<td>6</td>
<td>28</td>
</tr>
<tr>
<td>Head on collision</td>
<td>42</td>
<td>20</td>
</tr>
<tr>
<td>Single accident</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Other accidents</td>
<td>20</td>
<td>35</td>
</tr>
</tbody>
</table>

3.2 Injury

When the elderly road user is injured the treatment and rehabilitation take much longer time and higher costs. To a large extent this is due to the fact that an unproportional large part of the elderly belongs to the vulnerable category "unprotected". But the main reason is probably that the higher the age the weaker and more difficult to repair is the organism (see figure 3).
Therefore we should have done more thorough studies of aged drivers long ago. But now the need for such studies and such knowledge is enhanced by some changes that have already started but that will be more pronounced in the years to come.

3.3 Driver population

In many countries, especially in the developed ones, the proportion of older people in the total population will continue to increase during coming years (see figure 4). The main reasons are increased life expectancy and decreased fertility.
Figure 4. Percentage of the total population, 60 years and over for various regions 1950-2025. (OECD 1985)

And since the proportion of persons with driving licences is higher the lower the age the proportion of elderly people holding a driver's licence will increase even more than the population percentage increases (see figure 5). As the years go the curve in figure 5 will gradually move to the right in the figure.
Increased economical welfare and health will lead to larger possibilities to keep the car also after retirement and to larger needs for transport as part of the mentally important continued socialization. Therefore driving of old drivers will increase considerably at the expense of walking, bicycling and public transport (see figure 1).

4. EFFECTS OF AGEING

Growing old is simple (!) but describing what it means in scientific terms is difficult. It has many aspects:

- physiological (accelerated decline of several functions)
- cognitive (e.g. information processing, memory)
- social (change of activity, contacts, travel pattern and caution)
- economic (decrease of income)

Here we shall concentrate on the first three trying to establish which effect they may have on the tasks that confront drivers.

Of course these aspects interact in a complex way. It is important to stress the complexity of the process since it is much too common to base decisions on simple laboratory studies of e.g. reaction time or visual accommodation. The validity of such simple measures is highly questionable. But first let us look at the single functions of ageing.

4.1 Physiological

The more important physiological functions that decline with age seem to be perception and motor capacity.
- **Vision:** Vision is no doubt the most important information input channel for a driver. Most visual functions decline considerably from the age of about 45. Especially large impairment is noted for low levels of illumination, dynamic situations, low contrasts, accommodation capacity.

- **Hearing:** For road users in general the importance of hearing is probably underestimated. It plays a very large role as main warning system for pedestrians and cyclists. It is not as important for drivers. The impairment of age concerns mainly higher frequencies.

- **Mobility:** Muscular force and speed decline with age. Reaction time increases as a combined effect of decreased peripheral and central capacity. Also the range of mobility is decreased - e.g. capacity to turn the head. But most of these deteriorations are again more important for unprotected road users than for drivers.

- **Pathology:** Due to decreased immunological defence the elderly more often get infections. A higher frequency of illness and pathological conditions also leads to high usage of medicines and drugs. Also due to a decline of skeleton strength injury effects of minor accidents are often serious. It is, however, often difficult to separate effects of "normal" ageing from pathological effects.

### 4.2 Cognitive

The general character of the deterioration of cognitive ability is the lowered capacity to deal with complex information, especially under conditions of time constraints. The probable reason for these changes is the gradual reduction of the number of active brain cells.

Among the specific cognitive functions that are influenced by age the following seem to be the most important:

- **Short term memory:** Decreasing more the more complex and new the situation is, the less perception time available, the more information concerned. Visual stimuli seem to be more influenced than auditive.

- **Decision time:** Reaction time (e.g. brake reaction time) consists of two parts - decision time and movement time. It is mainly the decision time that is influenced by age. Studies of eye movements (Mourant & Mourant, 1979) show that elderly need longer times on target, longer search times - especially in new and complex situations. This seems to indicate that the perceptual structuring is an important part of the prolonged decision time.

### 4.3 Social

The change of activities after retirement has a pronounced effect on travel needs and travel pattern. But the important socially influenced effects are longer experience and change of values in life.
- Experience: The longer experience together with the previously mentioned impaired short term memory and prolonged decision time make elderly more dependent on expectation and prediction.

- Values: Of course the basic needs are not changed. But older persons tend to value caution, correctness, comfort and absence of risk higher on the one hand and speed, rush, errors and excitement lower than younger persons.

As mentioned above these three factors (physiological, cognitive and social changes) interact closely. Ruth (1986) has presented a simple model for this interaction (see figure 6).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Effect</th>
<th>Psychological aspect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiological</td>
<td>Limited information input</td>
<td>Fluency</td>
</tr>
<tr>
<td>Cognitive</td>
<td>Limited information processing</td>
<td>Flexibility</td>
</tr>
<tr>
<td>Social</td>
<td>Increased</td>
<td>Creativity</td>
</tr>
</tbody>
</table>

**Figure 6.** A model of the interaction between the three main factors behind influence of age on behaviour. (Ruth 1986)

What the figure illustrates is that information input is delayed or even prevented, and that fewer bits of information are treated over time. Consequently, there is no time for creation of alternative solutions and new information is not allowed while the old information is being processed. These are obvious limitations. But the increased tendency to be cautious, not to take risk is probably to a large extent counter-balancing these limitations - compensating low performance and avoiding difficult situations. This explains why the accident risk is not as high as should be expected from pure performance data.

5. WHICH ARE THE DRIVER TASKS?

In order to estimate which effects these declining functions may have on driving we have to discuss the tasks of the driver.

There are many ways to describe this. A combination of Rumar (1986) and Brown (1986) gives the following model.
The primary goal for the driver is of course to reach the destination. But he does not accept that goal at any price. He requires a certain time, safety, economy, and comfort. These are the secondary goals of the driver.

However in order to be able to analyze driver tasks we have to transform these general goals into operational goals.

(1) - Strategic tasks (choice of transport mode, time of departure, route)
(2) - Navigation tasks (to follow the chosen route in traffic)
(3) - Road tasks (to choose position and course on the road)
(4) - Traffic tasks (to interact with other road users in such a way that mobility is maintained but collisions avoided)
(5) - Rule compliance (following rules, signs, signals)
(6) - Manoeuvring tasks (to handle the vehicle so that (3), (4), (5) and (6) are reached).
(7) - Speed control (choice of speed in and before every situation)

Which effects do the above mentioned age variables have on these tasks?

6. BEHAVIOUR OF ELDERLY DRIVER

Let us look at the seven driver tasks described above presuming that the older driver has the same potential possibilities to drive (fit, drivers' licence, car available).

From strategical point of view the older driver more often choses another mode of transportation than driving. The reasons are several - e.g. perception of the physiological and cognitive limitations, more cautious, avoiding stress, less dependent on time. This avoidance reaction is especially pronounced in darkness, rain, fog, winter conditions, rush and city traffic. The avoidance may also take the form of choosing a longer but less difficult route or planning the trip during low traffic periods.

In the navigation (route finding) tasks the elderly driver is especially handicapped in unfamiliar situations and even more so in dense traffic and night traffic. The reasons are several - limitations concerning vision information input, information processing and short term memory.

The road tasks (route following) normally do not cause any specific problems to the elderly driver. Since the driver task is a self paced one the elderly driver simply lowers his speed if the informational and decisional task is getting difficult for him.

The traffic tasks (road user interaction) seem to be the ones that cause elderly drivers most problems. The reason is probably that the character of such tasks coincides exactly with the specific limitations of the old drivers - several new, complex, dynamic events within a short time which require immediate decision and action.
Table 2 and figure 7 illustrate some of the problems facing the elderly drivers. Also note here that the old drivers are under-represented in some accident types (e.g. speed, overtaking, head on collisions).

The fact is that when an elderly driver gets into a familiar situation (which he can predict) his reaction is often faster than that of a young one (who might not have been in that situation before).

Table 2. The proportion (%) of type of automobile accidents in Sweden for older and other drivers in urban and rural areas (TSV 1974)

<table>
<thead>
<tr>
<th>Type of accident</th>
<th>Urban</th>
<th>Rural</th>
<th>Sweden</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-64</td>
<td>65-</td>
<td>-64</td>
</tr>
<tr>
<td>Overtaking</td>
<td>5.2</td>
<td>0.4</td>
<td>16.7</td>
</tr>
<tr>
<td>Lane change</td>
<td>0.8</td>
<td>1.1</td>
<td></td>
</tr>
<tr>
<td>Rear end</td>
<td>8.7</td>
<td>6.7</td>
<td>11.1</td>
</tr>
<tr>
<td>Head on</td>
<td>7.7</td>
<td>4.7</td>
<td>36.3</td>
</tr>
<tr>
<td>Turning</td>
<td>24.1</td>
<td>26.8</td>
<td>19.8</td>
</tr>
<tr>
<td>Crossing</td>
<td>54.3</td>
<td>60.6</td>
<td>16.1</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

%
Table 3. Offence frequency in a sample of drivers in Gothenburg, Sweden (Ysander & Herner, 1974)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Serious offences</th>
<th>Several offences</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-44</td>
<td>22.2</td>
<td>13.5</td>
</tr>
<tr>
<td>60-64</td>
<td>14.0</td>
<td>5.3</td>
</tr>
<tr>
<td>65-69</td>
<td>10.0</td>
<td>2.3</td>
</tr>
<tr>
<td>70-74</td>
<td>12.7</td>
<td>-</td>
</tr>
<tr>
<td>&gt;75</td>
<td>4.3</td>
<td>1.4</td>
</tr>
</tbody>
</table>

Figure 7. Violation per $10^5$ miles for various types and age groups. (State of California 1982)
Rule compliance is one of the good sides of the elderly driver (see e.g. Table 3). But the rule compliance seems to be so good that it is almost too good. Younger drivers violate many rules. But normally this violation does not lead to accidents. They (often rightly so) give priority to the traffic situation instead of the rule. To many older drivers rules are sacred and are followed even into dangerous situations (e.g. the right hand rule in T-crossings). Another rule error of the elderly driver may be that they follow the rule (e.g. stop sign) but fail to give way when they start again (see figure 7), probably due to information processing problems.

In the manoeuvring tasks (vehicle handling) finally the elderly drivers are seldom seriously handicapped. But since they are more cautious and well aware of their limitations they tend not to make use of the full range of vehicle capacity. They do not brake or accelerate as strongly as younger drivers, they do not make full use of the width of the road. Normally this is good but in some critical situations it might create problems. Also they may forget to turn on or off signals. They have difficulties in changing attention and accommodation between the traffic situation and the instrument panel, to focus in convex view mirrors with short radius.

The speed is the regulating function. Since the elderly driver is characterized by information and decision limitations as well as by higher caution and lower risk taking his speed is considerably lower both in and before specific situations than that of younger drivers (see figure 8).

**Figure 8.** Relation between speed and age group among drivers involved in accidents in North Carolina. (Waller 1972)
7. COUNTERMEASURES

We have established that the proportion of elderly drivers during the years to come will increase in most countries in Europe. They suffer from physiological and cognitive degradation which however is to a large extent counterbalanced by a larger caution. But this compensation is not complete as is illustrated by higher risks—especially in some situations.

What can we do to lower the risks for the elderly drivers? Well, in principle the same type of countermeasures are available for these problems as for other road safety problems. One way of describing the possibilities available to improve the safety for elderly drivers is given in matrix form in Table 4.

Table 4. Ways in principle to improve the safety of elderly drivers.

<table>
<thead>
<tr>
<th>System variable</th>
<th>Measure</th>
<th>Driver</th>
<th>Vehicle</th>
<th>Road</th>
<th>Traffic control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection</td>
<td>1) e.g. testing of elderly drivers, upper age limit for drivers</td>
<td>2) e.g. elderly avoiding driving motorcycles, bicycles</td>
<td>3) e.g. elderly avoiding icy roads, dense traffic, night traffic</td>
<td>4) e.g. elderly avoiding uncontrolled (non-signal) crossings in dense traffic</td>
<td></td>
</tr>
<tr>
<td>Improvement</td>
<td>5) e.g. information campaigns, education, training aimed at old drivers</td>
<td>6) e.g. ergonomically improved controls, instruments, signals, rear view mirrors instep and outstep</td>
<td>7) e.g. decreased number of potential conflict points in crossings, introduction of road lighting</td>
<td>8) e.g. improved design and contrast on limits, traffic signals</td>
<td></td>
</tr>
</tbody>
</table>

The selection of elderly drivers (1) has to be used with caution. We must not as now base it on simple laboratory measures. Measures (2), (3), and (4) are all used by elderly drivers. The problem is that it is not always possible to avoid difficult situations (darkness, ice, fog). Improvement of elderly drivers (5) could be further developed. They need training in special situations, they need special educational methods.
No doubt the technical and traffic control improvements and adaption to the limitations of the elderly drivers (6), (7), and (8) have the highest potential although they are costly and time consuming. Such measures will also have a positive effect on the safety of all other driver categories.

In fact the elderly driver could be used as the normative driver in road traffic. The elderly might constitute the ideal normative driver to whom we should adapt vehicle, road and traffic control design.
REFERENCES


ACCIDENTED AGING PEOPLE

PROGRAM FOR STUDIES OF LOGICAL ACCIDENTS AND HANDICAPS

A. M. Begue-Simon, J. C. Chignon, F. Borgel, N. Mulhrad, Bluet, Dobias, C. Hamonet, France

On the recommendation of the working groups of WHO and OECD, a team of specialists on "handicapology" on the one hand the ATHENA laboratory of applied research for evaluating handicap (Dr. A. M. BEGUE-SIMON from the University of PARIS VAL DE MARNE) and on the other hand INRETS' (ARCUEIL) unity of research on accidents, have associated in order to establish study programs jointly. These programs have just been initiated. They principally concern the consequences of persons aged 66 years who are the most accidented in the district of VAL DE MARNE (1,200,000 inhabitants) near PARIS.

A pre-study has shown that of a first actual number of 85 elderly persons who had been involved in accidents on public roads and who had been treated surgically by Dr HUGUENARD at the hospital of H. MONDOR à CRETEIL, 25% survived for 6 months. Often the husband or wife died during this period.

Our aim is to study the functional being and insertion in society of these persons thanks to a new total measurement method of the handicap.

At the same time the circumstances of the accidents will be studied in collaboration with the Police.

Simultaneously, elderly persons' tendency to fall will be investigated. This is also carried out in co-operation with a working group from WHO in which we have participated.

ATHENA Laboratory of applied research for evaluation of handicap. Responsible dr. A. M. BEGUE-SIMON.

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Unity for accident research (Responsible Mr. BLUET).

National Institute for research and studies of transports and their security. Rue du Général MALLERET JOINVILLE VILLEJUIF FRANCE.
CONSEQUENCES OF TRAFFIC INJURIES IN SENIOR CITIZENS


In the framework of a research made in common by handicapology and accidentology laboratories, a preliminary survey on the evolution of the senior citizens aged 65 and more who where injured in traffic accidents in the department of Val de Marne (1,2 million inhabitants) located in the Parisian urban community was undertaken. It was achieved with the collaboration of the first-aid service of the university hospital H. Mondor in Créteil (Professeur HUGUENARD) and the French police.

One find it difficult to evaluate the consequences of the traffic accidents where senior citizens are injured, since their recuperation ability decreases with age. As a result an immediat assessment of the "lesions" should not be drawn up without caring for the afterbacks.

This limited survey in the Val de Marne aims at gathering information on this topic.

Methodology

The people who were tested are 65 years old or more injured in traffic accidents and reveived first aid only from the SMUR-SAMU (first aid service) of the hospital Henri Mondor. These accidents happened during two years between july 1984 and july 1986. This survey allows us to cast quite a precise glimpse on the real situation. In limiting our survey to these case, we were able to profit by the homogeneity of the reports and the medical exams. Moreover a large number of these people were afterwards hospitalized in Henri Mondor, making it easier to study them.

Here are the data we used:
1) very first examination of the injured person.
2) assessment of the "lesions" and its functional consequences when the patient goes out the hospital (generally between the 3rd and the 6th week after the accident).
3) in some cases, we used a functional and situationnal evaluation of the patient six months after the accident.
4) an evaluation of the physical capacities of the patient before the accident made thanks to talks with its family after the accident.
5) Then, the police report on the condition of the accident and the determination of the responsabilities.
The results: 85 persons, both male and female, were followed.

1) evolution

<table>
<thead>
<tr>
<th>Immediate death</th>
<th>Dead soon after the accident</th>
<th>Dead long after the accident</th>
<th>Survivors</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>30</td>
<td>12</td>
<td>33</td>
</tr>
<tr>
<td>12%</td>
<td>36%</td>
<td>14%</td>
<td>38%</td>
</tr>
</tbody>
</table>

"Immediate death" means a lethal accident
"Dead soon after the accident" means a death occurring before 10 days after the accident
"Dead long after the accident" between 10 days and the 6th month.

2) circumstances:

- 50 victims were pedestrians
- 4 victims were cycling when the accident happened
- 14 victims were driving
- 17 victims were being driven

3) responsibilities:

- 42 victims were fully responsible for the accident
- 17 victims half responsible for the accident
- 24 victims were not at all responsible for the accident.

We don't know for two of them.

Discussion

It is hard to foresee the future handicaps of a victim for only 38% of them survive the accident.

The average time of hospitalization is long: 5 weeks and a 1/3

It is often necessary (for 2 out of 3 persons) that the victim should be cured in a different hospital after the time spent in Henri Mondor.

The aged person is much more at risk when a pedestrian. Unfortunately, the aged person is for 50% of the cases responsible for the accident.
BIBLIOGRAPHIE

BEGUE-SIMON A. M.,

HAMONET CI.,


Supported by a grant of caisse primaire de sécurité sociale du Val de Marne.
DRIVING AND THE ELDERLY

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Bundesanstalt für Straßenbewesen
Bergisch Gladbach
Federal Republic of Germany

Today, about 10% of the licensed drivers in the Fed. Rep. of Germany are at the age of 60 or older. Till the year 2000, the part of the elderly drivers will have grown up to 25%. In addition, more elderly people are expected to own a car on their own. This trend towards increased mobility of the elderly is confronted with the age-related reduction of the physical and mental functions, and particularly with the growing impairment of the perception. Inquiries show that active drivers younger than 60 feel bothered by the increasing number of elderly drivers, while drivers above the age of 60 feel reassured by the greater amount of consideration they pay to the road traffic. These figures point to a certain conflict potential in the future.

The fact that elderly drivers can decide on their own whether to continue to drive or not highlights the importance of information campaigns. This decision requires being well informed, attentive self-observation and a self-critical attitude. Therefore campaigns should concentrate in the future on strengthening the elderly driver's critical self-consciousness. Towards this end drivers should first be made aware of the warning signals associated with specific physical impairments and should be assisted accordingly. It is necessary on the one hand to discuss critical aspects such as reduced vision in twilight conditions and at night, the susceptibility to glare and reduced orientation and reaction and on the other hand to caution the drivers accordingly.

Additionally, it has been found that these problems do not only affect the elderly but young drivers as well. It will be quite difficult to make the drivers concerned aware of the problems involved. The experiences acquired have however also shown that the elderly who are the most concerned are the people most difficult to reach at the same time. Here appropriate ways to inform and to address the elderly have to be found and developed.
1. SOCIODEMOGRAPHIC DEVELOPMENT

In 1985, a Joint OECD-WHO Scientific Expert Group presented a report on the "Traffic Safety of Elderly Road Users". The group's conclusion can be summarized briefly as follows:

"What we are concerned with in future is not only the mobility of the young but above all the maintenance of the mobility of the elderly. It is not least the casualty rate of elderly drivers which proves that this age group is not necessarily less safe than car drivers aged 25-64 years, it merely shows that they are more vulnerable when involved in an accident."

The sociodemographic development in the coming decades will require industrial nations to reconsider--especially in Europe. In most countries the proportion of aging persons increases sharply, and the trend is likely to continue through the first three decades of the 21st century.

A consideration of the transportation and mobility requirements of the elderly is not least becoming an acute matter owing to their growing proportion in the population of licensed drivers in Germany within the coming decade. In 1976, a mere 18 % of those 65 years and over were licensed compared with 79 % in the age group 21-25
years and 84% in that aged 25-34 years.

Between 1976 and 1982, the number of license owners over the age of 65 years grew considerably. It is important to bear in mind here that in the majority these people have been license owners for quite some time. Half of these licenses have reached an age of over 40 years. Till the year 2000, presumably 53% of the population over the age of 65 years will own a driving license. This is a distinctly conservative estimate. Even after the turn of the century the rate of license ownership among the population 65 years and over will continue to go up steadily (l).

There are clear indications that elderly people now continue to lead an increasingly active life--physically, psychically, in their human relations and professionally--despite the age-related decline of their maximum functional abilities. However, a higher quality of life for the elderly also implies the greater probability of continuing active participation in the everyday life of society. This is also characterized by an increasing use of the driving license after the age of 65.

In terms of numbers, the elderly will thus play a more important role in the population of license owners than hitherto. Numerically expressed this means the following: today about 10% of all license owners are 60 years and over. Till the year 2000, the proportion of elderly drivers will have grown from 10% to between 20 and 25%. But: do aging license owners participate in road traffic? Are cars available to them? There are clear indications
that car ownership is becoming ever more widespread among elderly people of both sex. In 1981, 10% of the car owners 60 years old and over amounted to 10%, in 1983 they were already up to 12%. In a study undertaken in 1977, 54% of the license owners questioned, who were 60 years old and over, rated themselves as active drivers (5).

Assuming that car ownership among the elderly is growing, the following changes in road usage will have to be expected:

- the decline in mobility among the elderly will lessen in extent
- distinct differences will emerge in the aging population between the group of elderly people either owning a car or having one at their disposal and the group of people that does not.

The trend towards increasing mobility among the elderly is confronted with the age-related progressive reduction of the maximum physical and mental capabilities, especially that of the sensory and perceptual capacity. The continuous reduction the maximum functional abilities suffer and the associated activity losses can lead to an increasing dependence on external aids. According to the opinion of the Joint OECD-WHO Group this should be accounted for by facilities on the sectors of public transportation and road traffic as well as by safety improvements for vehicles (4).

A survey of road users in lower age groups revealed the following:
they expect that the growing number of aging road users results in traffic becoming slower, but nevertheless more risky, more of a burden on everybody and more dangerous (1). Negative expectations turned out to be in the majority. Without exception, active drivers below the age of 60 reported to feel bothered by the growing number of elderly drivers. As opposed to that, the drivers older than 60 years expressed a feeling of reassurance because of this development, even expecting a greater amount of consideration because of it. The figures point to a potential of a conflict which, if compounded, can become acute in the coming years. I will come back to this once more in Chapter III below.

2. ACCIDENT ANALYSIS

The data from eight countries (cf. Table 1) indicate that the risk of being involved in a fatal accident (i.e. number of traffic deaths per vehicle-kilometer or unit of time spent in traffic) is between two and five times as high in the case of elderly drivers as in the case of drivers aged 25-64 years (3). The risk of being involved in an injury accident (based on the estimates of five countries) is only the same or double the risk run by the control group above. A considerable increase in risk was found in the group of drivers aged 75 years and over in the various countries studied (4).
A more recent analysis of accidents from the Federal Republic of Germany points to the fact that elderly drivers (65 years and over) are less frequently involved in single-car accidents than younger drivers, but instead more frequently in collisions (2). The traffic situations leading up to accidents in the case of elderly drivers are distinctly different from those causing accidents to drivers in other age groups: relatively frequent is overlooking signs or disregarding rules at intersections (e.g. nonobservance of right of way regulation) whereas the complex cause "loss of control over the vehicle" happens much less frequently with elderly drivers. In the case of collisions, it has
been found that elderly drivers are more likely to be the ones legally responsible for having caused the accident than the younger parties involved. This may however also be partially due to the recording practice of the police and not necessarily only the fault of the elderly. But without any further information on the exposure and circumstances involved, the data mentioned do not provide any conclusive evidence of the disproportionately high risk of elderly drivers.

Taking into account all due caution with respect to forecasts, not only German studies (1, 2) but also the Joint OECD-WHO Study (4) arrive at similar findings with respect to the future accident involvement of elderly road users:

- due to the general speed level reduction, there will be a decrease in accident severity
- caused by adaptive changes in road usage habits, i.e., abolishing the role of pedestrian in favor of that of driver, the number of pedestrian accidents will go down
- owing to the fact that more elderly people are acquiring experience as pedestrians and drivers, elderly pedestrians will become increasingly aware of the dangers inherent in road traffic
- due to the decreasing proportion of young drivers, there will be a relative reduction in the number of injury accidents
- there will be a relative decrease in single-car accidents, especially running-off-the-roadway accidents
the number of accidents at intersections and T-junctions will go up
the increase in the mileage of elderly drivers will have negative effects on the frequency of accidents as a whole.

3. SITUATION OF ELDERLY PEOPLE IN SOCIETY AND AS ROAD USERS

Chronological age is not necessarily a good approximation of an individual's performance and feeling. These characteristics are rather strongly dependent on an individual's physical health, psychic and social living conditions. In the following, not only the biological aspects of aging but also its social conditions will be described as far as this is possible in a delivery of 20 minutes. It should however not be overlooked that aging will frequently restrict the margins of autonomy, independence and adaptability of elderly people. With age the organism is progressively weakening and the ability to adjust to new and complex demands decreases. Accidents may be looked at as a warning signal alerting to the fact that highly industrialized societies with the rapid advances of modern technologies do not only offer advantages but impose constraints as well—especially on the elderly. The status of aging persons and their recognition thus are greatly a function of the norms of a particular society and its concept of age and aging. They essentially determine the role and place of the elderly and the esteem they enjoy, also as road users.
The social environment and traffic infrastructure as important components of the mobility of elderly road users therefore deserve special attention. Viewed in this connection, age need not bring only constraints but, under favorable conditions, can also extend a person's mobility. Especially with the foregoing in mind, a certain reserve is called for regarding deficit definitions of age and strictly quantitative risk descriptions which only too easily may end in calls for legal measures and so-called prescriptions for how to behave carefully as elderly citizen.

What is needed much more is information about how elderly drivers can be encouraged to observe and control themselves responsibly and adopt adaptive behavioral strategies and how to better the understanding and acceptance of the population as a whole for senior citizens on the traffic scene.

3.1 Elderly drivers and their vehicles

In this connection, the following results of a recent survey (1) may be of interest:

Elderly drivers buy more frequently new cars and cars in the higher engine displacement category. They place a higher value on driving comfort and are willing to pay for it, too. Safety improvements advertized as designed to especially help the "elderly" and which are felt as segregating or relegating features are met with disapproval. For that reason, considerations of how to design and equip cars to adapt them to the situation of elderly drivers hardly play a role of any importance.
The rate of everyday driving changes drastically after retirement. Business trips and trips to and from work are no longer necessary. The annual average mileages decrease and remain about 25% below the annual average mileage level of the driving population. In general, however, elderly drivers are hardly aware of the decreasing use they make of their cars. More than half of them believe to drive as often as they did before.

When elderly drivers voluntarily refrain from driving in general, there are mainly the following three reasons they give for doing so:

- difficulties in driving
- negative experiences on the traffic scene
- social pressure. (1).

3.2 Opinions about elderly drivers

The public makes a clear distinction between drivers of different age groups. Stereotypes are greatly the result of an opinion making process, associating elderly drivers with negative characteristics. The negative image mainly comprises characteristics, such as "slow", "unsafe" and "can't cope". At the same time, however, elderly drivers are reputed to be more careful and considerate than young drivers (1).

Elderly drivers regard themselves in the majority of cases as far more careful and considerate than young drivers. At the same time,
they accept that drivers of middle age are rated better than 
people of their age. In essence, the negative characteristics 
associated with seniors can be described by the common denominator 
"slow". At the same time, the elderly view young drivers in a 
distinctly negative light (1).

There is a wide gap between the way somebody assumes another person 
to be and the way somebody views himself: above all in ascribing 
characteristics such as "unsafe" and "can't cope" there is a great 
discrepancy in how the elderly view themselves and in how others 
presumably view the elderly (3). Negative characteristics dominate 
in all the ways others are viewed. These negative assessments 
decrease with age. Attitudes towards the elderly are also a 
function of the level of education: with better education the 
positive assessments of the elderly tend to become less positive 
(1).

4. STATE OF THE ART OF EFFORTS AND PROSPECTS FOR THE FUTURE

In the Federal Republic of Germany, a program for seniors launched 
by the German Traffic Safety Council (DVR) has been in operation 
for several years, addressing the group of elderly pedestrians. 
For the elderly as car drivers, a brochure and a film have been 
put out by Volkswagen (VW) in which in simple and comprehensible 
terms the sources of hazards are described resulting from the 
impact on performance of age—in particular on the apparatus of 
perception. The same subject is the concern of the General German 
Automobile Club (ADAC) in its information leaflet "Safe driving
for the elderly" put out in 1986. As has been pointed out before, some of the problems discussed do not in the least only concern aged drivers. They may affect that age group more heavily or may be simply encountered there more often. A fact of special importance with respect to the education and publicity efforts is that aging drivers normally decide on their own whether they are fit and able to drive or whether they would better refrain from driving. Decisions of this nature require a good deal of information, attentive self-observation and a self-critical attitude. This self-critical attitude, that is to say that a person realizes, registers and admits experiencing difficulties, cannot be taken for granted in everybody. The primary objective of future educational campaigns therefore must be to strengthen the critical self-awareness of aging drivers. This requires that these drivers be made aware of the problems that may emerge and also of the warning signals indicating specific problems and be told what they can do in such situations.

The efforts at imparting the required problem awareness may meet with difficulties. The experience acquired thus far indicates that among the elderly those are easiest to approach who are active and self-critical anyway and do not really need a great deal of information whereas exactly the aging drivers who are particularly in need of additional information and helpful hints are the ones most difficult to approach. Here suitable ways of communication, information and forms of addressing the elderly have to be developed in future. At the beginning of this year, the DVR established a working team which in consultation with the bodies
responsible for safety measures and particularly in collaboration with the group affected by such measures has the task of developing a suitable safety concept. In order to support these efforts, the Federal Highway Research Institute (BASt) has been sponsoring work on the following research projects: An analysis of the situation of life, the attitudes and behavioral patterns of elderly road users to provide information on the extent to which these persons are prepared to critically face and examine the risks associated with advancing age. The age-related reductions of driver performance capabilities are the content of another project. In this case it is important to point out the situations placing an excessive burden on drivers, the extent and rate of the biological and psycho-physical changes with age, which are relevant to driver performance, and the possibilities of compensation by means of adaptive strategies of behavior.

Perhaps this is a way to succeed in finding suitable solutions to the traffic safety problems which are bound to emerge in the nineties.

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