RECENT EUROPEAN PROJECTS ON DRIVER IMPAIRMENT

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Summary: This paper gives an overview of recent European Union projects on the assessment of driver impairment. Whereas previous research has focused on vehicle technology (DREAM, DETER) or Human Machine Interfacing (SAVE), more recent efforts have been based on methods to detect the presence of substances (ROSITA) or the level of impaired performance at the roadside (CERTIFIED, IMMORTAL). This paper will summarize the objectives and main conclusions of the most recent projects.

THE EUROPEAN SCENE

Since the beginning of auto mobility the number of accidents shows a steady and seemingly uncontrolled increase, causing as much as up to 1,700,000 injured and 55,000 deaths in Europe each year in the nineties, amounting to over 150 million KEuro each year. Thus, traffic accidents are amongst the three most common causes of death within Europe. This has inspired the European Commission to finance research and development programs to diminish the accident rates.

Smiley and Brookhuis (1987) concluded that some 90% of all traffic accidents can be attributed to human failure in general. It is estimated that at least 30% of all serious car accidents must be attributed to problems concerning driver state, by factors such as alcohol or drug use and / or abuse, drowsiness or fatigue, prolonged periods of inattention and health problems (e.g. heart attack, epileptic seizure, fainting). The costs of this type of accidents for society are considerable, and efforts must be made to significantly reduce this accident type.

The prevention or reduction of traffic accidents requires countermeasures to prevent or mitigate driver behaviours that contribute to accidents. Brookhuis & Brown (1992) argue that an ergonomic approach to behavioural change via engineering measures, in the form of ITS driving aids and detection methods, should be adopted in order to improve road safety, transport efficiency and environmental quality.

The Commission of the European Union launched ambitious so-called framework programmes in the field of road transport informatics and telecommunications (ITS) to improve the mentioned conditions with respect to road safety, transport efficiency and environmental quality (www.cordis.lu). These programmes seek to create favourable conditions for the development of an integrated road transport environment through collaborative efforts in information technology

and telecommunications applied to road transport. Certain projects within these programmes aim to detect inadequate vehicle control under conditions where the driver's cognitive, perceptual and motor abilities may become impaired (i.e. accident risk is increased) as a consequence of psychoactive substances.

INTERVENTIONS TO DRIVER IMPAIRMENT

Legislation and enforcement of driver impairment based on detection is a common intervention method for traffic safety. The common aspect of each of these approaches is the need for a reliable and valid metric to quantify impairment and the establishment of a criterion to determine the level of impairment that can be justified to be 'unsafe'. Whereas the provision of a suitable metric is subject to usual psychometric considerations for performance testing, the determination of a criterion level is most problematic and can be elusive. While a variety of methodologies exist to derive a criterion (see also Brookhuis et al., in press), the effort required may be extensive and the underlying assumptions may be dubious.

The first stage of this process is to relate the impairment metric to a risk function. For example, this may involve relating the range of dose, or psychomotor impairment, or driving performance to corresponding levels of risk. Risk itself can be quantified in two ways, either directly or indirectly:

- *Risk* – Directly compute the risk curve in terms of the probability of being in an accident with a specified level of detected substance or condition (relative to non-accident cases). The effort required for this epidemiological approach is intensive although an appropriate case-control methodology can produce valuable and valid results (e.g., Grand Rapids study).
- *Surrogate* – Indirectly relate performance level to an approximation of an accident or increase in accident probability (e.g., correlate lane position variability with a proxy for accident liability such as exceeding lane boundaries). The validity of the predictive model is dependent on the strength of the relationship of the proxy measure to the actual accident risk and has limited application outside the initial value range of the performance measures.

Once a risk (or surrogate) function can be estimated, a threshold value to demarcate unacceptable risk can be set. There are several rationale for setting the threshold:

- *Precedence* – Select threshold comparable to a level obtained with an existing reference level that is currently enforced such as BAC 0.08%. This assumes that the risk function and the form of impairment is similar to alcohol.
- *Reference* – Select threshold comparable to a normative task such as tuning a radio which is common to the driving environment. This also assumes a similar risk function and form of impairment, but also assumes that the existing risk is 'acceptable'.
- *Consensus* – Concede threshold level from agreement amongst experts and authorities. This approach might derive a compromise level that satisfies pragmatics and politics, but is not consistent with scientific consideration of the underlying assumptions.

- *Baseline* – Rather than consider risk directly, this approach sets the threshold in terms of a percentile in the baseline metric. For example, driver performance may be compared to own baseline performance without impairment with the threshold set to an extreme percentile (95th). At present it is impractical to obtain baselines date for all drivers, and it is not clear what between subject baseline population is appropriate. Indeed, the threshold criterion is also not a standard.

Once a threshold risk value has be determined, it can then be related back to the function which quantifies the impairment metric to determine the corresponding criterion level. For example, if the risk level associated with BAC 0.08% is chosen as the threshold value, the criterion for fatigue could be the amount of steering variability which corresponds to that same risk threshold as derived by a function relating accident risk to fatigue level operationalized by the steering metric of impairment.

The form of detection that may be proposed is specific to the type of impairment factor, the level of impairment metric used (e.g., dose, psychomotor, driver performance), and the type of legislation considered. Two proposed forms of detection of impairment from the (acute) driver state are in-vehicle monitoring and roadside testing. A third form of detection based on the evaluation of (chronic) driver fitness (i.e., aptitude and ability) is licensing assessment. The SAVE project (System for effective Assessment of the driver state and Vehicle control in Emergency situations) aims at in-vehicle detection of impaired driver performance, by psychoactive substances among others. Other projects aim at improving methods of roadside psychomotor impairment testing, such as CERTIFIED (Conception and Evaluation of Roadside Testing Instruments to Formalise Impairment Evidence in Drivers) or developing methods of substance detection (dose) with roadside drug screening as was done in ROSITA (ROadSIde Testing Assessment).

The SAVE Project (http://www.iao.fhg.de/projects/SAVE/)

The objective of the SAVE project was to develop a demonstration prototype of an actual product (in-vehicle SAVE monitoring unit) that will in real time detect impaired driver state and undertake emergency handling, prior and during the emergency situation occurrence. This will be realised by instant detection of driver impairment, whereupon firstly the driver is warned, then if necessary drivers in the immediate environment and ultimately an emergency centre, hence shifting the car operation to an automatic driving mode, in order to ensure safe control of the vehicle.

Central to this approach was the development of an in-vehicle driver impairment monitor, the Integrated Monitoring Unit (IMU), introduced and found feasible in earlier EU projects (DREAM and DETER, see De Waard & Brookhuis 1991). It concerns the development of a prototype system, capable of detecting driver impairment from vehicle sensors alone. The IMU itself is divided into three functional units, the vehicle sensors that collect instantaneous driving data, an advanced diagnosis or classification subsystem that analyses and interprets this data and the storage / retrieval device which is used as a template of normal driving behaviour. The diagnosis or classification subsystem consists of a series of processing algorithms in sequence centred on a Neural Network. The sequence consists of pre-processing by Independent

Component Analysis (a for this purpose more suitable form of Principal Component Analysis), processing by an Artificial Neural Net, after which final diagnosis is performed with the aid of Fuzzy Logic.

The classification or diagnosis by the system is either normal or abnormal driving, for which the critical values of driver actions are of two types, absolute and relative. Absolute critical values refer to levels of measured driver actions that would imply a direct, acute danger of accident involvement to the vehicle and driver. For example, driving at 0.1 second time-headway to a lead car whereas a minimum human reaction time in laboratory circumstances is around 0.2 seconds. Relative critical values are individual and refer to decrements in driver actions that indicate psychological impairment, without direct relationship to likelihood of accident involvement. For a more extended review on critical values, see Brookhuis et al. (in press).

The CERTIFIED Project (http://www.psyc.leeds.ac.uk/certified/)

The CERTIFIED Project aimed to contribute to the existing knowledge base concerning drugs and traffic safety, supporting the development of methods for roadside testing applicable to driver impairment from licit and illicit drugs. The project had the following objectives:

- Review impairment and accident risk evidence for drugs and medicines;
- Review existing methods of impairment testing and propose new methods (including pilot studies of testing efficacy);
- Formulate verification methodology for testing methods based on user, legal and operational requirements;
- Identify key issues relevant to policy formulation.

A preliminary safety prioritisation of drug groups on the basis of a newly developed (standard) metric is:

- High Priority = Alcohol, Benzodiazepines
- Medium Priority = Amphetamines, Opiates, Cocaine, Cannabis
- Low Priority = Methadone, Antihistamines, Antidepressants

To meet the established requirements of a new, suitable roadside test, it is likely that it comprises several types of measurement in a standardised format. Account should be taken of both within- and between-subject variances of drivers, and an adequate normative database needs to be established. The test should maximise the chances of detection while keeping the number of false positives to a minimum.

The ROSITA Project (http://www.rosita.org/)

The aim of the ROSITA project was to identify the requirements for roadside testing equipment based on the detection of substances and to make a comparative assessment of equipment for this purpose. This assessment considered the reliability, validity, practicality, and cost-benefit of these devices for roadside detection of impairment substances. Thus, ROSITA can be considered the sister project to CERTIFIED which reviewed requirements for roadside assessment of behaviors indicative of impairment. The following main conclusions were offered:

- There is a need for roadside testing to support legislation regarding impairment and drug use.
- The perceived need is so great that some enforcement officers would rather use an imperfect device than have no device at all.
- Roadside testing should be used to support police action on-site, but legal sanctions should be corroborated with reference methods based on (i) confirmation analyses with blood samples, or (ii) identification of behavioral impairment.
- Whereas the majority of users prefer saliva as the fluid for testing, this method can be problematic (e.g., some drugs may produce a dry mouth) and requires that the device is highly sensitive. Moreover, whereas the correspondence between saliva and confirmation analyses with blood may be acceptable for some drugs (e.g., Cannabinoids, Opiates, Cocaine, Amphetamines), tests for other common drugs in the driving context are less sensitive with saliva sampling. Indeed, current methods for testing saliva samples are considered to be 'too complex'.
- There is not sufficient data to propose criterion levels for detected substances in terms of cut-offs for pass/fail determination.
- A EU Technical Review Committee and the adoption of a single set of regulations for impaired driving would benefit advancement of roadside testing.

The Next Steps – AWAKE and IMMORTAL[1]

As part of the key action Sustainable Mobility and Intermodality in the European Fifth Framework Program, the Commission of the European Union has funded consortia to conduct research in support of transportation policy on driver physical fitness and physical state. These projects are both a sequel of the above mentioned projects. The first one is called System for effective Assessment of driver vigilance and Warning According to traffic risK Estimation (AWAKE) and the second one is entitled Impaired Motorists, Methods Of Roadside Testing and Assessment for Licensing (IMMORTAL), comprising a total of 10 partners from 7 different European countries. They are planned to be 3 year projects scheduled to be funded from 2001.

The objectives of AWAKE are to (i) develop a hypovigilance diagnosis module that will detect and diagnose driver hypovigilance in real time, (ii) develop a modular, on-time driver warning system and (iii) develop a traffic risk estimation module. All these modules are to be integrated in a passenger car and a heavy goods vehicle demonstrator, and tested.

The main research areas for IMMORTAL are (i) ageing, mental illness and medical disease; and (ii) alcohol, licit and illicit drugs. This research aims at contributing to policy support activities including cost-benefit analyses of intervention methods and user workshops with policy makers to review the research conclusions in the European transportation context.

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[1] Information about AWAKE can be derived from K.A.Brookhuis or the co-ordinator Angelos Bekiaris (trnspcon@compulink.gr). Information from IMMORTAL can be obtained from N. Ward as the Technical Advisor for this project (nicw@hfrl.umn.edu) or from Bob Hockey who is the project co-coordinator (bobh@psychology.leeds.ac.uk).

The primary objective of this research is to provide evidence to propose intervention methods for driver impairment, and support the future development of European policy governing driver impairment legislation. The forms of intervention method considered will be licensing assessment for chronic impairment of driver fitness, and roadside impairment assessment for acute impairment of driver state:

At present, there is insufficient information to support policy and the development of valid and standard protocols to evaluate driver impairment. On this basis, both AWAKE and IMMORTAL have a number of specific evidentiary objectives to support the stated aim:

- Investigate the influence of chronic and acute impairment factors on driving performance and accident risk;
- Recommend criteria ('tolerance levels') for high risk categories of impairment;
- Provide key information to support European policy on licensing assessment and roadside testing.

CONCLUSION

There have been a number of European projects dedicated to driver impairment. The trend has been for a change in research from early attempts to make online assessment of driver performance with in-vehicle systems, to the assessment of driver impairment either by roadside testing or licensing assessment.

Whereas recent projects have evaluated methods to detect impairment substances in drivers, future research will examine methods to test impairment of driver functions. These methods consider 'unsafe' impairment levels regardless of the source. Accordingly, such methods may be more generic and directly related to the intent of enforcement law that stipulates that driving while impaired is illegal without specifying the source of impairment. However, the key obstacle to all such endeavours of this type is to devise a method by which a valid criterion for 'unsafe' impairment can be determined.

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