

Behavioural Research in  
Road Safety 2005:  
Fifteenth Seminar

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ISBN 1 90476361 8  
ISBN-13 978 1 90476361 1

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Printed in Great Britain on paper containing at least 75% recycled fibre.

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# 1

## Department of Health's accidental injury research initiative

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### Background and context

In 1999 the Government's White Paper *Saving Lives, Our Healthier Nation* identified accidental injury as a priority for action. It set national targets to reduce the rates of death associated with accidental injury in England by 2010 by at least one-fifth; and to reduce the rate of serious injury by at least one-tenth.

In 2000 Heather Ward and Nicola Christie were invited by the Department of Health (DH) to undertake a strategic review of research priorities for accidental injury (Ward and Christie, 2000). In our review we looked at the policies and research programmes of government departments with responsibilities for reducing accidental injury or of activities that might lead to injury, such as sport. We also looked at the research programmes and spend profiles of research councils and charitable trusts.

Two of our main conclusions were as follows:

- There is a small amount of injury research aimed at a large injury problem. Multi-disciplinary research is therefore needed to bring about greater understanding of the context in which accidental injury occurs.
- Different funders/departments commission research in different ways, which tends to mean that methodology cultures grow up amongst different groups of researchers depending on the style of research methodology favoured by the funder. This tends to lead to little overlap in research methodology and

dissemination practice between different groups of researchers engaged in injury prevention work, which is a barrier to increasing the capacity to take forward a multi-disciplinary research agenda.

## The burden of injury

Accidental injury is a leading cause of death and disability in the UK. The following figures illustrate the scale of the problem and the room for improvement; the fact that the burden of accidental death and injury is disproportionately heavy on the most disadvantaged in society; and that the costs to individuals, to the NHS, and to society of these deaths and injuries are considerable (DH, 2002):

- Injury is the leading cause of child death in England and Wales. In the period 1998–2000 in England, 1,003 children aged 0–14 years died as a result of accidental injury.
- Falls (62%), road traffic accidents (12%), fire (3%) and suffocation (3%) cause the largest number of fatal injuries in older people.
- There were 320,283 road accident casualties in Great Britain in 2000, of whom 16,184 were child pedestrians (0–15 years) and 5,832 were older pedestrians (60 years and above).
- There were some 4,000 accidental deaths in the home in 1999. Half were adults of working age (15–64 years).

The burden of accidental death and injury is disproportionately heavy on the most disadvantaged in society:

- Residential fire deaths for children are 15 times greater for children in social class V compared to those in social class I.
- Child pedestrian deaths are five times greater.

There is a variation between the sexes for falls, with the female death rate being 1.5 times the male death rate for older people. There is little evidence that rates of falling increase with deprivation.

The death rate in domestic fires is 2.7 times the death rate for all ages where there is evidence of a social gradient, with fires more likely to occur in lower income and rented households (Measuring and Monitoring Injury Working Group report, DH, 2002).

The cost to individuals, to the NHS, and to society of these deaths and injuries is considerable:

- The estimated cost to the NHS in England of injury in 2000–01 (including poisoning and intentional injury) is £2.2 billion.

- The estimated value of preventing road traffic accidents in Great Britain in 2000 was £12.2 billion.
- The cost to society of home accidents in the UK was estimated in 1996 as £25 billion per annum.

## The Accidental Injury Task Force

Arising from a commitment in the White Paper *Saving Lives, Our Healthier Nation*, an Accidental Injury Task Force was set up to advise on how the targets within it should be achieved. Its report to the Chief Medical Officer, *Preventing Accidental Injury – Priorities for Action*, was published in October 2002 (DH, 2002). It was endorsed by five government departments, in addition to the DH, reflecting the spread of responsibilities across Government for preventing accidental injury and the need for co-ordinated action:

- the Department for Transport (DfT) was responsible for road safety;
- the Office of the Deputy Prime Minister (ODPM) was responsible for fire safety;
- the Department of Trade and Industry (DTI) was responsible for consumer safety;
- the Department for Work and Pensions (DWP) was responsible for health and safety at work; and
- the Department for Culture, Media and Sports (DCMS) was responsible for sport.

The Task Force report identified a number of key programmes already in place across Government to improve safety on the roads, at home and at work, but recommended that a more concerted effort was needed to achieve sustained reductions in injury.

In line with DH priorities, the Task Force focused on children and young adults (0–15 and 16–24 years), and older people (defined as 60 years and over for the purposes of the Task Force's remit), and recommended that interventions to prevent accidental injury should be targeted, in particular, at areas of health inequalities.

The Task Force adopted two population groups for priority attention:

- children and young adults; and
- older people.

The burden of injury is greatest for falls by older people. The next highest burden is road accidents followed by dwelling fires; both affect the young and the old.

In headline terms, the intervention areas which have the scope to make the biggest impact in the short term are as shown in Table 1:

Priority areas	Headline interventions
Falls at or near home	<ol style="list-style-type: none"> <li>1. Referral of individuals to a falls prevention programme</li> <li>2. Targeted exercise programmes for falls prevention</li> <li>3. Prevention and treatment of osteoporosis</li> <li>4. Home safety checks*</li> </ol>
Road accidents	<ol style="list-style-type: none"> <li>1. 20 mph speed limits in areas of higher pedestrian activity</li> <li>2. Local child pedestrian training schemes and safe travel plans</li> <li>3. Systematic road safety intervention in inner-city areas</li> <li>4. Advice and assessment programmes for elderly car drivers</li> </ol>
Dwelling fires	<ol style="list-style-type: none"> <li>1. Installation of smoke alarms by fire brigades</li> <li>2. Home fire risk assessments, safety checks and escape plans*</li> <li>3. Target deprived groups, particularly children and older people in privately rented and temporary accommodation, and households in which people smoke</li> </ol>
Play and recreation	<ol style="list-style-type: none"> <li>1. Increase the number of children undertaking cycle training and wearing cycle helmets</li> <li>2. Produce guidelines for safety in children's sports</li> <li>3. Strengthen risk and safety education in schools</li> </ol>

\* scope to combine the two.  
(Source: DH, 2002)

The report recommended that these interventions should be targeted in particular at areas of health inequality.

The report also identified priority areas for action in the longer term. These included young car drivers and passengers, sports injuries, injuries at work, and home and leisure injuries.

## The need for research into accidental injury and its prevention

The research gaps identified in the Task Force report have been supplemented by more recent work. This includes the reports of Towner *et al.* (2004) and the Task Force's own Working Group Reports into children and young people, older people, and measuring and monitoring injury.

In 2003 Heather Ward produced a scoping report on a possible accidental injury research programme for the DH's Policy Research Programme. The research agenda developed for injury prevention took into account:

- the burden of injury;
- Government priorities and initiatives;
- possible opportunities for cross-departmental collaboration;



- research capacity within Britain; and
- budget.

Many gaps in existing knowledge were identified over a wide range of subjects. Three main themes were identified and suggestions were made for research topics that might form the basis of a research programme in injury prevention:

- inequalities in deaths and injuries from accidents;
- staying healthy, protecting health and reducing risk;
- framework for delivery and developing infrastructure

During 2003 discussions were held with people within the DH with various policy responsibilities in the priority areas. In October 2003 the following research programme worth about £2 million over about four years was put out to tender.

## The research programme

Across the initiative as a whole, two population groups were prioritised:

- children and young adults (0–14 and 15–24 years); and
- older people (primarily 60 years and over, but the most appropriate age ranges to be determined by specific research questions).

## Overarching issues

There were three overarching issues that the DH wanted addressed within the initiative:

- *Inequalities* in accidental injury and death within these population groups.
- The burden and cost to society and individuals of accidental injury are important to estimate. Interventions to prevent accidental injury not only need to work but they have to be of a *cost* that is commensurate with the burden of injury and the ability of the intervention to reduce it.
- The DH was interested in drawing out any lessons for public policy on increasing *physical activity* for children and young adults, and older people, in ways that do not increase the level of injury.

Ten topics were identified under three streams and the academic community was asked in open tender to bid for work under these headings. The next section has a brief description of each topic area the DH wished to be covered.

## Stream 1: Children and young adults

### Topic 1: Injury trends and social gradients

More information and analysis of injury trends and social gradients is fundamental to our understanding of the problem of inequalities in accidental deaths and

injury among children and young adults, and where interventions need to be targeted.

Research is needed to examine trends over time in accident mortality and morbidity rates among children and young adults aged 0–24 years by social and ethnic group, with respect to a range of causes of accidental death and injury and a range of injury severity. There is a need to identify where social gradients are steep, where they are not and where they can be levelled. There is also a lack of knowledge about geographic variations in accidental injury rates.

**Topic 2: Developing the evidence base on interventions that are effective in reducing inequalities in childhood injury**

There is a gap in existing knowledge about interventions that are effective in reducing inequalities in childhood injury. Research is needed which develops and evaluates the acceptability and effectiveness of new interventions for reducing inequalities in childhood injury, or evaluates existing ones that have proved effective with different target populations.

**Topic 3: Reduction of risk for young children in the home environment**

In order to inform interventions for risk reduction, greater understanding is needed about the relationship between exposure to risk, social disadvantage and injury occurrence for young children in the home environment. This includes gaining better understanding about parents' perceptions of child risk and the examination of ways in which children are supervised in the home environment and the effects of this on accidental injury occurrence (e.g. falls, burns and scalds, poisoning, drowning, farm accidents).

An assessment framework needs to be developed for professionals to use in assessing environmental and personal risk of accidental injury in a more systematic way; and strategies need to be devised for risk reduction that professionals can develop into programmes for working with families to reduce risk (e.g. reducing exposure to the hazard and increased supervision).

**Topic 4: Systematic review of 12–14 and 15–24-year-olds in relation to accidental injury and risk-taking behaviour**

There is an urgent need to update existing knowledge of the relationship between accidental injury occurrence and risk-taking behaviour amongst young people. This information is needed to inform the development of intervention strategies that are more appropriate to these age groups, and sub-groups within them, and to allow strategies to be tailored to the different patterns of risk-taking behaviour. Of interest is the drawing out of any findings that will help address inequalities in injury amongst young people and where interventions need to be targeted.

A key research question relates to how the pattern of risk-taking behaviour, especially outside the home, changes across the years, including the effects of impairment through the use of alcohol, illicit drugs and volatile substance abuse (VSA) on unsafe behaviour and injury occurrence. Little is known about the views and perceptions of young people themselves in terms of how they define, perceive, assess and manage risk-taking behaviour in relation to accidental injury.

## Stream 2: Older people

### **Topic 5: Inequalities**

There is little research evidence available in the area of older people and inequalities in injury occurrence, mainly because information on factors such as social class, deprivation and ethnicity is not routinely collected; and also, because there is debate about the concept of social class amongst groups that are largely retired from paid work. More information and analysis of trends is fundamental to our understanding in this area of accidental injury and to focusing our preventive efforts.

Research is required to examine trends in accident mortality and morbidity rates, and to investigate the association (if any) between accidents and factors such as social class, deprivation and ethnicity amongst older people aged 50 years and over. One of the areas in which some methodological work is needed is around the concept of social class for those who have retired from paid work.

### **Topic 6: Compliance with effective interventions to reduce falling and fractures**

The aim of Standard Six of the National Service Framework for Older People is to reduce the number of falls which result in serious injury and to ensure treatment and rehabilitation for those who have fallen. To help achieve this aim, a greater understanding is needed of why individuals may resist acceptance of, or fail to comply consistently with, falls injury prevention strategies and programmes (all types, including environmental modification), together with the identification of opportunities and barriers to implementing successful and acceptable falls injury prevention programmes.

### **Topic 7: Development of acceptable and effective strategies to reduce falling and fractures for older people with cognitive impairment and/or dementia**

A greater understanding is needed about how to reduce falling and fractures for older people with cognitive impairment and/or dementia. Those in hospital, nursing and residential home settings are especially at increased risk for falls and of sustaining a major injury, such as a fracture, as a result.

There is a need to review the evidence base for examples of the interventions shown to be effective in terms of reducing the incidence of falling and the incidence of fractures for individuals with cognitive impairment and/or dementia. This can then lead to the development and testing of effective and acceptable prevention strategies to reduce the risk of falling and incidence of fractures in older people with cognitive impairment and/or dementia in hospital, nursing and residential home settings.

## Stream 3: Developing the infrastructure

### **Topic 8: Definition of severity of injury**

The lack of an agreed definition of severity of injury is hampering progress on developing evaluation methodologies for injury prevention programmes. Without an agreed definition it is difficult to assess adequately the burden of injury except for death. National and international collaboration work is in progress on developing an agreed definition of severity of injury. What is needed is to draw on this to identify a

suitable definition of severity for use in UK injury prevention programmes that is independent of length of stay in hospital.

Any definition of severity would involve consultation with leading practitioners, surveillance agencies, Government policy officials and academics in the UK, and would need to be applied to routinely collected data sources (e.g. DH's Hospital Episode Statistics (HES) database), based on the information currently collected by these sources.

#### **Topic 9: Assess the burden of accidental injury**

One of the reasons why accidental injury is not given the attention commensurate with its size as a problem is because we do not have an adequate account of the burden of injury to compare with other public health threats. Broad estimates would be helpful to policy makers and practitioners for decision making, planning and prioritising at both the national and local levels.

New research is required to assess the burden of accidental injury on the basis of its occurrence, longer-term consequences, and its costs to individuals and society, including the NHS and Personal Social Services. Broad estimates are needed of the burden of injury to the young (0–24 years), to adults (25–59 years) and to older people (60 years and over) using internationally recognised methods, including Quality Adjusted Life Years (QALYs), as this would aid comparison with other major public health threats in England.

#### **Topic 10: Injury related disability**

We have insufficient knowledge about the types of accidental injuries that lead to disability, and the level and extent of disability that follows. This includes needing to know more about the proportion of injuries that lead to significant disability as opposed to those that do not. It is important to increase knowledge in these areas so that preventive interventions can be targeted at injury types that result in long-term disability.

Research is needed to increase the evidence base about the types of accidental injuries that lead to disability and the level and extent of disability that follow. We also need to know about the proportion of injuries that lead to significant disability as opposed to those that do not. This increased knowledge should lead to recommendations about practicable ways of improving the capture and quality of injury related disability data.

## **Projects funded under the accidental injury prevention initiative**

### **STREAM 1: CHILDREN AND YOUNG ADULTS**

#### **Injury trends and social gradients**

This project will be a secondary analysis of existing data sets including Office for National Statistics (ONS) mortality data, Hospital Episode Statistics and the Health Survey for England morbidity data and DfT travel survey data. These will be analysed using census denominators to identify social classes, regional and (where possible) ethnic group injury rate trends.

**Application:** Through identifying where gradients have narrowed or widened over the last 10 years, findings from this project will contribute to our understanding of how recent health and social policies have successfully addressed inequalities in injury rates, where work still needs to be done, and what priorities for action should be identified. Work on relating injury rates to exposure to risk in the area of transport injuries will inform the debate about the most appropriate interventions to develop. In tandem with outputs from the other projects in the programme (in particular those reviewing interventions), the findings from this study will help inform evidence-based policy to address both the burden of accidental injury to the population and those areas of continuing inequalities.

### **Accidental injury, risk-taking behaviour and the social circumstances in which young people live: a systematic review**

This study will employ the standard methodology for undertaking systematic reviews: searching; keywording and mapping; data extraction and quality assessment; synthesis and recommendations. Three syntheses will be conducted:

- 1) describing how young people define, perceive, assess and manage risk-taking behaviour in relation to accidental injury and the social context in which they live ('qualitative' synthesis);
- 2) examining the factors or behaviours which are associated statistically with injury amongst young people ('qualitative' and 'quantitative' synthesis); and
- 3) a cross-study synthesis which: combines the results from 1) and 2) in order to identify strategies for future interventions; identifies the strategies in key areas which have been evaluated and where there are research gaps; quantifies the need and extent of injuries in these areas.

**Application:** This systematic review will provide greater clarity about who is most at risk, what they are at risk of, the factors which are associated with increased or decreased risk, and how social, cultural, material and psychological factors interact. Gaining insights from the perspectives of young people themselves offers the potential to develop new strategies for acceptable and relevant interventions.

### **Neighbourhood and household influences on injuries to preschool children**

Injuries caused by accidents are a particular problem in young children and children's injury rates vary considerably from place to place. Low-income neighbourhoods have higher child injury rates than high-income neighbourhoods, and recent research suggests that only part of the difference is due to variations in the social, economic and demographic composition of local populations.

The Avon Longitudinal Study of Parents and Children (ALSPAC) will be used which relates to about 14,000 children born in 1991 and 1992 and which was subsequently followed up to track their progress, health and changes in their family circumstances. Multi-level modelling will be used to identify family and neighbourhood characteristics that explain variations in injury rates between children and between different parts of the Bristol region. Family characteristics include housing characteristics and safety behaviour together with income, the number of children and adults in the household, and the age of the parents. Neighbourhood characteristics will include the average level of poverty or affluence in the locality, the strength of local social networks and the amount of green space. Neighbourhoods in Bristol and

its surrounding region will be defined by identifying adjacent small areas with similar social, economic, demographic and ethnic characteristics.

**Application:** A better understanding of how neighbourhoods influence injury risk would enable a more coherent development of policy on both child accident prevention and health inequalities, and would help determine whether policy innovations should be focused on families or neighbourhoods.

Local services require this information in order to enable a more cost-effective combination of individual and area-based interventions and to guide the design of specific interventions. For example, knowledge of the housing features or community characteristics that confer protection in otherwise poor neighbourhoods would inform community development projects tackling childhood injury.

### **Environmental and personal risk of accidental injury to young children**

The study will examine these effects both cross-sectionally and longitudinally in a contemporary representative sample – the ALSPAC birth cohort. Data on accidents and the use of accident prevention measures in the ALSPAC cohort have been collected when the children were 6, 15, 24, 38 and 54 months of age, and they provide a rich dataset to investigate the parental factors which may influence monitoring and supervision (e.g. economic deprivation, family adversity, alcohol/drug use and parental mental health) alongside the child's temperament, development and behaviour, and environmental factors such as housing. To improve our understanding of contemporary parenting, a series of socially representative focus groups will be held in Bristol and surrounding rural areas in order to gain insight into parents' views on child safety and supervision in the home.

**Application:** Although accidents are the most important cause of mortality and morbidity to young British children, the evidence base is inconclusive with regard to the effectiveness of preventative measures initiated on home visits. An effective UK policy on accident prevention needs more evidence of what actually happens in our homes and how young children are supervised. This research will provide up-to-date detailed information from a large contemporaneous cohort (ALSPAC), supplemented by the views of parents on current practice in supervising their children, which will be used to develop an assessment framework for use by health professionals on home visits. This framework will be of considerable utility, as it will enable a quick assessment of environmental and personal risk in order to target interventions on families most at risk. The final report will incorporate the views and experiences of families from ethnic minorities and from deprived urban and rural areas, and will recommend relevant and practical strategies for reducing the risk of accidental injury in the home.

## **STREAM 2: OLDER PEOPLE**

### **Systematic review on injury prevention programmes and strategies for older people with cognitive impairment and dementia in hospital and care home settings**

The established Cochrane Methodology will be used for the systematic review, where evidence exists of effective interventions to prevent falls or injuries (e.g. medication review, bone strengthening), and evidence will be reviewed of interventions which have improved process in these aspects of care without *per se*

reducing falls. The literature review will incorporate legislation, legal precedent and ethical/consent issues around interventions to prevent falls in this group. Cost and cost-effectiveness analyses of interventions will be carried out.

**Application:** The majority of older persons reside in their own homes and the emphasis both on services and on research for falls and injury prevention has been on this population. Nonetheless, the incidence of falls in care home and hospital setting is high. Such falls lead to considerable physical and psychological morbidity for individuals, anxiety, complaint and litigation from relatives, concern, financial and opportunity costs for institutions – all currently lacking guidance on best practice in falls and injury prevention. Cognitive impairment – whether dementia or delirium – has consistently been shown to be a major risk factor for falls in these settings. However, relatively few fall prevention studies have focused on care home or hospital settings, fewer still specifically on persons with cognitive impairment and dementia.

### **Facilitators and barriers to older people accepting and complying with interventions to reduce falling and fractures**

The first phase consists of a systematic literature review. Through inclusion of all available studies, including grey literature, the views, preferences and experiences of older people in relation to falls prevention strategies will be assessed alongside the effectiveness of interventions to promote falls injury prevention. The second phase, informed by the review, will involve focus groups and interviews to provide an in-depth investigation of older people's perceptions of fall injury prevention strategies. This will cover a broad range of interventions and will include the recruitment of attendees, non-attendees and non-completers.

**Application:** Despite the many existing guidelines and reviews on fall and fracture prevention, more information is needed to further the understanding of how older people perceive the prevention strategies. This proposed project will bridge that gap by exploring the views of older people and so will help shape fall prevention service development and delivery locally and nationally.

### **Preventing falls amongst older people: socio-economic and ethnic factors**

Routine data will be used to examine variations in fall-related mortality, hospitalisation rates and health care seeking behaviour. An 'equity audit' data collection mechanism will be piloted to collect data on service provision and service use, including socio-demographic and ethnicity. Focus groups and interviews will explore the attitudes, beliefs and intentions of older people from differing socio-economic and ethnic groups, including differences by people's experience of falling and fall prevention interventions. These data, along with findings from reviews, will be used to inform the final content of a large (n = 5,000) cross-sectional survey of belief and intentions amongst populations with large Afro-Caribbean and South Asian communities, so as to determine preferences for different interventions, strengths of beliefs about risks of falling, and costs and benefits of falls injury prevention programmes.

**Application:** The programme will provide the scientific basis for recommendations on the reasons for ethnic and socio-economic variations, and what sorts of intervention programmes are needed and will be acceptable to older people from different social and ethnic backgrounds. In addition, a simple system will be developed and piloted for routinely monitoring the extent to which NHS provision

and falls services is equitable and appropriate for people from different socio-economic and ethnic groups.

### **STREAM 3: INFRASTRUCTURE**

#### **Estimating the costs and quality of life loss due to fractures**

Fractures are a serious cause of morbidity and cost to society. Equally important is the health-related quality of life (HRQoL) loss due to hip and other fall-related fractures. Cost and quality of life consequences will be ascertained of both fractures and falls in a primary care sample of women. These data will also allow a more detailed description of the costs and consequences of fractures.

Changes overtime in the quality of life of patients with and without a fracture/fall in terms of utility scores and psychometric measures will be estimated using a linear mixed model. Utility weights will be combined with patients' survival data to estimate quality adjusted life years for individuals aged 70 years and over who have and have not had a fracture/fall. Primary cost data will be collected in a postal survey where patients will be asked about: treatment received; length of stay at hospital; length of stay at residential care/sheltered or nursing accommodation; and social services support. Resource use data will be combined with 2004 unit prices to obtain an updated estimate of the cost of treating hip, wrist, vertebral and other fractures.

**Application:** This research project aims to provide a more accurate estimate of the longer-term consequences of falls and fractures in terms of cost and changes in HRQoL. This would aid the comparison of falls and fractures with other significant public health treats in England. The data produced from this project will help to inform future economic evaluations for both fracture and fall prevention programmes.

#### **The long-term health and health care outcomes of accidental injury**

Six existing injury datasets will be re-examined. Five of these datasets were collected between 1988 and 1997, and include a total of 8,588 injured patients admitted to over 50 different hospitals. A sample of 1,753 of these patients also had a follow-up morbidity assessment at six months. As well as re-assessing this cohort, we will follow-up a sample of patients in the Northern General Hospital, Sheffield, Major Trauma Outcome Study database who were injured since 1997.

The follow-up will include identifying deaths and cause of death at the NHS Central Registry. A postal questionnaire will be sent to survivors and an assessment of the use of resources in the past year. A sample of 400 patients will have a disability assessment using the OPCS disability survey instrument.

**Application:** Preventive interventions need to be targeted as far as possible where they will achieve most benefit by focusing on accidents, injuries and patients which result in significant loss of life, quality of life, and costs. However, little is known about the relative health and health care burden of different types of accidents, patients and injuries. This research will address this gap, and will enable accident prevention policy to focus clearly on areas where the biggest public health problems arise.



# Programme-wide project

## **Moving from observation to intervention to reduce inequalities in injury**

A considerable amount is known about factors which cause or precipitate injuries and also that many injury types show large socio-economic gradients. However, the research base on testing the effectiveness of injury prevention initiatives, and particularly in less affluent areas and individuals, is extremely scanty. Our knowledge of the impact of injuries on disability, quality of life and the impact on wider society is also very limited.

The first project is a mixed methods study based around a cluster randomised trial in four areas of the UK. The basic area of analysis is the electoral ward, with analysis identifying wards in deprived areas with particular high injury rates to vulnerable pedestrians (children and older people). Information on the number and distribution of injuries will be sent to councillors representing intervention wards and general information of child injury prevention to councillors from matched control wards. The outcomes being measured include the introduction of additional engineering and educational safety measures, and differences in attitudes and experiences.

The second project is a randomised controlled trial of the acceptability and effectiveness of installing thermostatic mixing valves in domestic properties to reduce hot water temperatures.

The third study is the UK Burden of Injury study, a multi-centred prospective study of 1,320 people attending Accident and Emergency (A & E) or admitted to hospital with an injury. The study collects details on the nature and cause of the injury, pre-injury status and 1, 6 and 12 month follow-up, using standardised tools programme to tackle health inequalities. The data will then be modelled against regional and national A & E and inpatient datasets to estimate the UK burden of injuries.

**Application:** Children are a key focus, reflecting the Green Paper *Every Child Matters*, but other vulnerable groups are also a feature. The proposal is influenced by an evidence-based approach, derived from the Health Development Agency's (HDA) Evidence Briefings and Cochrane Collaboration reviews. The consortium will encourage research capacity development in the field within their teams and in the dissemination of results.

The association of accidental injury with social deprivation permeates all projects. There is a dearth of well-conducted trials in the field and this work includes two controlled trials, one relating to thermal and one to pedestrian injuries, injury types with the greatest socio-economic mortality gradients. The trial contents – changing the environment within the home and an advocacy package designed for local councillors – all have relevance to the government-wide programme of *Tackling health inequalities*. The trials actively engage individuals, communities and professionals in intervention development.

The UK Burden of Injuries study will provide, for the first time, measures of the impact of injuries on individuals, the NHS, and wider society, subdivided by major cause of injury. These data will be extremely valuable in informing policy development relating to injury prevention across government departments.

# Conclusions

The projects chosen for inclusion in the programme demonstrate a wide variety of research methodologies. Some 15 universities are involved, with contributions ranging from a few months to up to four years. The programme is planned to take until 2008 to complete, but interim reports will be available along the way. Our knowledge will be enhanced of what works and what interventions are suitable for use in areas or in populations with elevated risk.

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## 2

# Have injury intervention studies addressed inequalities?

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## Introduction

The novelist and social reformer Charles Dickens uses the dramatic scene of a road traffic collision rather than a portrayal of poor housing conditions in his novel *A Tale of Two Cities* to highlight the inequalities between rich and poor. The Marquis Evrémonde drives through the streets of Paris in his carriage in the late eighteenth century: ‘the carriage dashed through streets and swept around corners, with women screaming before it and men clutching each other and clutching children out of the way . . . swooping at a corner by a fountain, out of its wheel came a sickening little jolt.’ (Dickens, 1859). A child is killed in this collision, but Monsieur the Marquis’ response is both callous and victim blaming, and he is more concerned about the fate of his horses rather than the child: ‘It is extraordinary, to me that you people cannot take care of yourself and your children. One or other of you is forever in the way.’ Dickens encapsulates the struggles between the powerful and powerless in society, contrasting the reckless carriage driver and the vulnerable pedestrian.

Unintentional injury is still strongly linked with social and economic deprivation. This paper sets the scene by examining a number of descriptive and epidemiological studies of child injury and inequalities, before considering whether injury intervention studies have addressed inequalities and whether they can bridge the gap in relation to socio-economic inequalities.

# Descriptive and epidemiological studies

Studies in England and Wales show that child deaths from fire and flames have a ratio of 1:16 and child pedestrian deaths a ratio of 1:5, when rates of injury in social class I are compared with those in social class V (Roberts and Power, 1996). Striking differences are also found in higher income countries in other parts of the world. For example in Montreal, Canada, the annual injury rate of children living in the poorest income quartile neighbourhoods is four times that of the least poor neighbourhoods (Dougherty *et al.*, 1990), and in Memphis, USA, the census tracts with reported pedestrian injuries had the greatest population of children living below the poverty line (Rivara and Barber, 1985). In Aotearoa, New Zealand, fatal fire incident rates in the most deprived census areas are six times those of the least deprived census areas (Duncanson *et al.*, 2002).

However there is no consensus on what social deprivation means in different countries. In some cases, disadvantaged individuals or groups are targeted, but the way deprivation is defined and the way target groups are identified varies. For example, these can include census areas with high rates of poverty, social housing and overcrowding, and low levels of education. In other cases, schools, childcare centres and health settings serving deprived communities have been used (Dowswell and Towner, 2002).

There is considerable accumulated evidence on injury and socio-economic inequalities internationally but 'the mechanisms responsible for the differences remain poorly understood' (Laflamme and Diderichsen, 2000). Millard (1994) has suggested a broad conceptual framework, which includes three tiers of factors. The first is the proximate tier, which includes those immediate conditions that result in exposure to hazards and an injury event. The second is the intermediate tier, which includes factors such as childcare practices and other behaviour that increases exposure to the proximate tier. The third is the ultimate tier, which encompasses the wider social, economic, political and cultural processes that lead to a differential distribution of resources in society.

Social and economic factors affect injury risk in a number of ways:

- lack-of-money families may not be able to buy safety equipment, such as safety gates or bicycle helmets, or they own older cars which do not have seat belts fitted in the back;
- exposure to hazardous environments – lack of facilities for safe play, lack of garden, small cramped conditions in kitchens, speed of traffic in inner city areas;
- the ability of parents/carers to supervise children – single-parent families, parental maturity, depression and family illness;
- children's attitudes and behaviour, such as risk taking; and
- access to information and services.

As the causes of injury are multi-factorial and interrelated there is a need for wide-ranging policy solutions (Graham, 1999).

## Have injury intervention studies addressed inequalities?

A recent review published by the Health Development Agency examined 146 evaluated interventions that related to the prevention of childhood injuries (Towner *et al.*, 2005). Each intervention study was examined to see whether they explicitly addressed social and economic inequalities, and three questions were asked about each study:

- Have inequalities been taken into account in the selection of the target group or setting?
- Has the intervention been designed explicitly to take such inequalities into account?
- Have results or outcomes been reported for different groups, e.g. more deprived/less deprived?

Examples of intervention studies, which have targeted a deprived group or setting, include two community-based programmes from the United States, the Safe Block Project based in a poor African-American community in Philadelphia (Schwartz *et al.* 1993), and the Safe Kids/Healthy Neighborhoods Program in inner city Harlem (Davidson *et al.*, 1994). From the UK, the Drumchapel Project specifically targeted children attending local schools in a deprived community in Glasgow (Thomson and Whelan, 1997).

There are relatively few examples of interventions where the intervention has been designed to take deprivation into account. The main strategy adopted has been the provision of free or low-cost safety equipment. Examples include the Safe Block Project, which provided smoke detectors, and the Safe Kids/Healthy Neighborhoods Program, which provided bicycle helmets. Home visits can be utilised to provide help advice and support. A study from Northern Ireland used lay workers from the same community to visit the homes of families in deprived areas (Mullan and Smithson, 2000). In the Drumchapel project, community volunteers were recruited to train children in the acquisition of pedestrian skills (Thomson and Whelan, 1997). Other interventions targeting deprived families included advice about state benefit entitlement (Colver *et al.*, 1982) and advice about employment opportunities (Olds *et al.*, 1994).

There are relatively few examples of interventions where the impact on different social groups has been assessed. A notable example is that of bicycle helmet legislation for children in Ontario, Canada. A study conducted in East York, Toronto, observed bicycle helmet use by children in low-, medium- and high-income areas before and after legislation had been introduced (Parkin *et al.*, 2003). In low-income areas helmet use was 33% pre-legislation and 61% post-legislation; in medium-

income areas helmet use rose from 50% to 79%, and in high-income areas from 73% to 77% after legislation. What was striking was that, ‘the legislative effect was most powerful among children who resided in low income areas’ (Parkin *et al.*, 2003).

Few intervention studies explicitly address inequalities in targeting a deprived group or setting. Even fewer take deprivation into account in the design of the intervention. There are very few examples which report whether there has been any differential impact in relation to social deprivation. ‘What emerges is a patchwork of examples – the threads are not woven throughout the studies’ (Towner *et al.*, 2005).

## Can injury intervention studies bridge the gap in relation to socio-economic inequalities?

In the broader field of health promotion, Whitehead (1995), in her review of approaches to tackle socio-economic inequalities in health, suggested that there are four broad approaches: (1) strengthening individuals; (2) strengthening communities; (3) improving access to services and facilities; and (4) encouraging macro-economic and cultural change.

How can these approaches be applied to the prevention of childhood injuries? The first approach is that of strengthening communities. In relation to preventing child pedestrian injuries, interventions include child pedestrian skills training, parent and child education through traffic clubs and the education of drivers. In relation to house fire, injury prevention interventions include parent and child education on home hazards, smoke alarms and escape routes.

Approaches that can help to strengthen communities include the recruitment of parent volunteers to work in schools on pedestrian skills training, involving the community in developing safe play areas and supervising child pedestrian journeys to school. House fire injury prevention interventions can include community-wide smoke alarm programmes and home safety check lists.

Road safety plays an important part in improving access to a range of different services within a community, including access to health, education and leisure services. Improving access to services can also include developing professional knowledge and skills, improving the reach of health promotion activities and targeting interventions to those at most risk.

In relation to broader macro-economic and cultural change, land use and transport policies have an important part to play in reducing road traffic injuries, for example school location and busy roads, recognising the needs of all road users, and house design which incorporates safe outdoor play areas. Prevention of house fires could also include safe house design and safe furniture design and regulations.

Upstream health promoting policies are needed to tackle the underlying causes of child poverty. A recent UNICEF report on Child Poverty in OECD countries has constructed a child poverty league table (UNICEF, 2005). Until the late 1990s the UK had one of the highest child poverty rates of rich countries, but in the last decade the UK has achieved the largest decline in child poverty. Although the UK's child poverty rate has considerably improved, it still has one of the highest rates in Europe. One of the major factors determining the fall in child poverty rates in the UK has been the change in government support for families and income transfers (Chen and Corak, 2005). It will be interesting to see whether over the next decade inequalities in child injury rates will reflect these changes in child poverty rates.

Finally, there are some groups in society which are in extreme positions of vulnerability and are exposed to much higher levels of injury risk and where the risk factors are additive and cumulative over time (Towner *et al.*, 2005). These groups include families in temporary accommodation, traveller families, refugee and asylum seeker families, and families with disabled children. An illustration of children in temporary accommodation can show how injury risk can be ratcheted up. The physical conditions of temporary accommodation – cramped cooking and laundry facilities, limited indoor and outdoor places for safe play – can expose children to more physical hazards. Multiple occupation can also reduce the ability of parents to protect their children, and stress caused by poor living conditions and insecurity can reduce the parents' abilities to supervise their children.

## Conclusions

Clearer definitions of poverty and information on the scale and nature of the problem are needed in order to tailor more appropriate interventions. Injury prevention interventions have rarely addressed socio-economic inequalities in a systematic manner. Yet mortality gradients for injury are steeper than for any other cause of death in childhood. Progress in addressing the gaps is still in its early stages. Some groups of children are in positions of extreme vulnerability. Specific interventions may be needed to address their needs. Clearly the research and policy agenda in the field of injury inequalities has a considerable way to go.

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# 3

## The Neighbourhood Road Safety Initiative: understanding the wider impacts of road safety interventions on the behaviour of communities

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### Abstract

In 2002 the Department for Transport (DfT) added a requirement to the 2010 casualty reduction target to tackle the significantly higher incidence in disadvantaged communities. In October 2002, the Government launched the £17 million Neighbourhood Road Safety Initiative (NRSI). Fifteen local authorities, mainly in the north of England, with high casualty rates and levels of deprivation were invited to participate in the initiative and bid for funding. Local authorities were encouraged to think holistically about their individual situations, seeking to treat root cause rather than symptom targeting interventions to break road accident causal chains at any number of points.

The DfT expected authorities to include a variety of solutions, including a mix of engineering, education, enforcement and health promotion activities. It also encouraged authorities to work with one another to share experience and expertise, and to work in partnership with a range of local stakeholders. The central objective is to reduce the accident rates in the most deprived wards in each local authority

to a greater extent than the rest of the wards in the local authority, and thereby reduce inequalities. Whilst accident reduction is the primary aim of the NRSI, it is hoped there are wider impacts. By improving environmental safety, creating or improving facilities for play and social interaction, this may lead to greater mobility and greater experience of social capital, both of which can impact on quality of life in terms of health. This paper describes how the NRSI is being evaluated in terms of these wider impacts.

## Introduction

The relationship between social class and child pedestrian fatalities has been known for over 20 years, perhaps being most clearly identified in the Black Report (Black *et al.*, 1980). Child pedestrian fatalities (1–15 years) by occupational class of the parent were last published in 1988. This showed that child pedestrians in the lowest social class were five times more likely to be killed than their counterparts in the highest social class. Further research suggests that the differential between social groups has widened (Roberts and Power, 1996).

The evidence suggests multiple causes of the pedestrian injury requiring multiple solutions (Christie, 1995). *Individual and household level factors* that are associated with increased risk of child pedestrian injury include: child psychiatric problems, gender, ethnic background, parental medical and psychiatric problems, maternal education, lone parenting, maternal age, the number of people in the household and number of children in the household, and accommodation factors such as tenure, overcrowding and household type. *Social and environmental factors* include the speed of traffic, housing type and density, kerb parking and road density, traffic volume, and lack of safe crossing sites and play areas. Different housing types also generate different child casualty rates. Often factors are *interrelated*. Combinations of factors and possibly interactions between them influence risk and increase the complexity. For example, both deprived households and disadvantaged areas increase injury risk for different reasons, Towner *et al.* (2004) illustrate this complexity in practical terms, listing the ways in which social and economic factors affect road traffic injury risk:

- lack of money (parents may not be able to buy safety equipment such as bicycle helmets or own older cars which do not have seat belts in rear seats);
- increased exposure to hazardous environments (lack of a garden or facilities for safe play, exposure to high volume and speed of traffic in inner city areas);
- the ability of parents/carers to supervise children (single parent families, parental maturity, awareness and experience, depression and family illness);
- children's attitudes and behaviour (risk-taking); and
- access to information and services.

Complex problems require complex solutions. The evidence (Crombie, 2002) suggests that the characteristics of successful initiatives for tackling inequalities in road traffic injuries are:

- comprehensive approaches that address broader problems;

- the inclusion of partners from across professions;
- engagement and buy-in of community;
- joint action at the regional level;
- the development of local information systems to identify patterns and evaluate progress;
- to include Education, Engineering and Enforcement strategies;
- addressing barriers to physical activity through transport;
- integrated guidance from different government departments;
- flexibility at the local (including local authorities) level, allowing joint funding and creative thinking; and
- local public service agreements identifying joint targets.

## Policy

To address the relationship between road traffic accidents and deprivation, the Government, in its Spending Review 2002, strengthened the DfT's Public Service Agreement (PSA) road safety target, adding an additional requirement to tackle social disadvantage. The revised PSA requires the DfT to 'reduce the number of people killed or seriously injured by 40 per cent and the number of children killed or seriously injured by 50 per cent, by 2010 compared with the average for 1994–98, tackling the significantly higher incidence in disadvantaged communities'. The NRSI is a response to this target.

## The Neighbourhood Road Safety Initiative

Taking child pedestrian casualties as an indicator, all English local authorities have been ranked in terms of casualty rate per 1,000 population and correlated this with the Neighbourhood Renewal Unit (NRU) list of authorities eligible for Neighbourhood Renewal Fund grant, as an indicator of the presence of social deprivation within the authority areas. A high degree of correlation is evident, with 23 of the 25 authorities (excluding the City of London) with the worst child pedestrian casualty rates also being within the NRU list of the 88 authorities with the most deprived areas. Child casualty rates have been used in particular because of the clear and strong links between deprivation and child pedestrian casualties, but authorities should reduce the road safety casualty levels of all those within their deprived areas.

In October 2002, the Government launched the first tranche (Tranche 1) of the NRSI (originally known as the Dealing with Disadvantage initiative). A cluster of 10 authorities within and close to the Greater Manchester area was identified on the basis of casualty rates and levels of deprivation. The authorities are Bolton

Metropolitan Borough Council (MBC), Blackburn MBC, Blackpool City Council, Bury MBC, Manchester City Council, Oldham MBC, Rochdale MBC, Salford City Council, Tameside MBC and Wigan MBC.

The DfT encouraged authorities to think holistically about their individual situations, seeking to treat root cause rather than symptom, with targeted intervention seeking to break road accident causal chains at any number of points. The DfT expected authorities to include a variety of solutions including a mix of engineering, education, enforcement and health promotion activities. It also encouraged authorities to work with one another to share experience and expertise, and to work in partnership with a range of local stakeholders. Bids were assessed against the criteria of a demonstrable understanding of the road safety problems facing the authority's disadvantaged communities; the direct relevance of proposals to those problems; the commitment and capacity of the authority to deliver on their proposals; and linkages to existing initiatives in the area.

On 20 June 2003, the Secretary of State announced that the 10 authorities would receive a total of £11.7 million to implement approved projects until March 2006. This included £3.5 million to set up and run a Neighbourhood Road Safety Team to co-ordinate collaborative projects across the 10 authorities.

Funding is available to the 10 authorities subject to their reaching milestones specified in partnership agreements between the individual authorities and the DfT. Funding for projects other than the highways improvement elements was subject to Parliamentary approval, and further partnership agreements were arranged once Parliament approved the Special Grant Report relating to these projects.

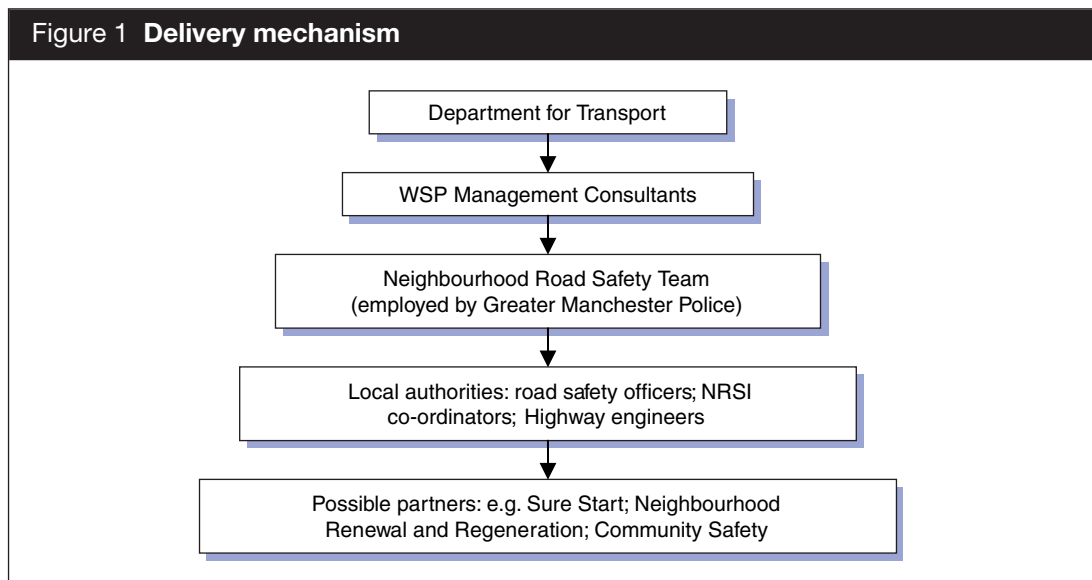
A further four authorities, known as Tranche 2, Bradford, Liverpool, Nottingham and Sandwell were invited to participate in the second tranche of the initiative and they joined the initiative in February 2004, and a further authority, Stoke, joined in April 2004 (see Table 1).

<b>Table 1 Tranche 1 and Tranche 2 local authorities</b>	
<b>Tranche 1</b>	<b>Tranche 2</b>
<ul style="list-style-type: none"> <li>• Bolton MBC</li> <li>• Blackburn MBC</li> <li>• Blackpool City Council</li> <li>• Bury MBC</li> <li>• Manchester City Council</li> <li>• Oldham MBC</li> <li>• Rochdale MBC</li> <li>• Salford City Council</li> <li>• Tameside MBC</li> <li>• Wigan MBC</li> </ul>	<ul style="list-style-type: none"> <li>• Bradford</li> <li>• Liverpool</li> <li>• Nottingham</li> <li>• Sandwell</li> <li>• Stoke</li> </ul>

## Delivery of the NRSI

A number of parties are involved in the NRSI, all of which are expected to work in concert (see Figure 1):

- the DfT;



- 15 local councils, not just their traffic and road safety departments but the councils in a corporate sense;
- WSP – consultants managing the performance of the councils on behalf of the DfT;
- a newly-formed Neighbourhood Road Safety Team (NRST) to act as a central source of expertise, advice and networking, principally for the Greater Manchester and Lancashire authorities, and to a lesser extent to the other five;
- the evaluation team led by the Centre for Transport Studies, University College, London; and
- the Child Accident Prevention Trust, providing responsive support to the local authorities and the NRST on specific issues outlined below.

A Steering Group was set up and governance was introduced comprising a Project Board to which the NRST are accountable.

## Broad-based approaches

The local authorities were encouraged to think about broad-based solutions such as:

- improving or creating accessible play areas;
- after school clubs;
- engineering measures, such as speed reduction measures;
- enforcement measures, such as ‘Watchman’, which comprises speed detection and speed activated warning signs; and
- education and publicity campaigns, such as Crucial Crew – a ‘multi-agency’ safety initiative aimed at primary schools; seat-belt wearing campaigns etc.

The budgets allocated to each local authority varied according to the proposed intervention mix and could vary by several hundred thousand pounds. Each authority was also allocated £50,000 to employ a co-ordinator.

In delivering these interventions the local authorities were encouraged to work in partnership with a number of agencies. A number of potential partners were identified, including:

- regeneration and neighbourhood renewal partners: especially with regard to the safety and accessibility of the physical environment;
- Sure Start: helping services development in disadvantaged areas alongside financial help for parents to afford childcare (up to 14 years old); and
- Community Safety: who provide local community safety schemes, e.g. parenting programmes, educational initiatives and mentoring programmes for young people, changing the physical environment through urban design schemes, installing CCTV, and improving security with locks, bolts and gates.

## The evaluation

### Overall objectives

The specific objectives of the evaluation are to assess the impact of the added value of the NRSI over and above what is going on already through multi-agency working, i.e. to assess what NRSI is adding, where and why, and also what would have happened anyway. In addition, this evaluation will identify the key factors/processes that encourage or inhibit the effectiveness of the initiative. The relationship of NRSI to other area-based initiatives targeting disadvantaged communities will be important. In addition, building on existing research and the evaluation of NRSI, to develop a more thorough understanding of the road safety problems of disadvantaged communities, in particular why this initial cluster of Tranche 1 authorities has a particularly poor record for road safety and how they may differ from other disadvantaged areas. This may assist in assessing the transferability of effective measures from the initial cluster of authorities to other disadvantaged communities. These objectives are being met by:

1. monitoring relative changes in health inequalities and quantifying the contribution of the initiative to local and national road safety targets;
2. measuring the wider impacts of the programmes, particularly on health and travel, implemented on local communities and on local professionals/service deliverers;
3. assessing the impact of local multi-agency partnerships on the delivery of casualty reductions, reductions in health inequalities and the wider local effects. Identify factors/processes that encourage and inhibit effective local partnership working;

4. building capacity amongst professionals delivering the NRSI on methods of monitoring, evaluation and evidence-based policy development;
5. undertaking an economic cost-benefit analysis of NRSI and the programmes implemented locally; and
6. assessing the value for money obtained from the NRSI grant, including the expenditure from other sources.

This paper describes the evaluation of the wider impacts of the NRSI, namely objectives 3 and 4 outlined above.

## **Evaluating the wider impacts of the NRSI**

### **PARTNERSHIP WORKING**

Working in partnership is central to the Government's agenda to encourage collaboration in delivering interventions at a local level. Since the Local Government Act 2000, local authorities are being encouraged to prepare community strategies to promote economic, social and environmental well-being of their areas. Each local area is required to have a Local Strategic Partnership (LSP) that brings together public, private, voluntary and community sectors, especially to address health inequalities. Partnership working is therefore a key tool in addressing road safety in disadvantaged communities as part of the NRSI.

Key partnership issues centre on cultural and organisational behaviour, not just on structures. The development and establishment of joint structures, policies and protocols are comparatively straightforward. The challenge is whether individuals and organisations can work in new ways that mean that partnerships are genuine and sustainable.

The evaluation is closely tracking the development, sustainability, culture and operation of the partnerships throughout the project. Baseline data have been collected from road safety officers and NRSI co-ordinators and are key to see what partnerships have been formed, such as local political and community leaders, local authority staff in a range of departments (education, leisure services, social services, housing, etc), the health sector, and voluntary agencies, community groups and business people. By carrying out the survey before, during and after the intervention we will be able to explore changes in the knowledge of, attitudes towards and working practices relating to partnerships, whether training and capacity building have taken place, and whether revised practices have become institutionalised and sustained. The sample is being obtained through the road safety officer and/or NRSI co-ordinator and by up to five other partners in each local authority.

In addition, the in-depth interviews are being undertaken among key individuals responsible for setting up, leading and managing the NRSI, including the DfT, WSP the management consultants, the NRST, and members of the Steering Group and Project Board.



## Quality of life

Broad-based road safety interventions may also improve quality of life for the community. For example, by providing access to after school activities and youth clubs for children may reduce the extent young people play or hang out in the street and, as a consequence, lead to reductions in exposure to traffic risk and anti-social behaviour and street crime. Improving the environment and reducing traffic speed may reduce feelings of lack of safety and community severance and may change the extent to which people move about locally.

In order to measure these wider impacts, surveys are being conducted among adults and children. The adults (aged 16 and over) were sampled from the NRSI wards within the selected local authority. It was a household survey involving face-to-face, semi-structured interviews to provide quantitative and qualitative measures. The survey was conducted by a fieldwork company and because of cost was carried out only in five local authority areas, namely Bradford, Blackburn, Oldham, Stoke and Wigan. Interviews were conducted with 200 people in each area, making a total of 2,000. The survey is being conducted 'before' and 'after' the intervention period to provide comparative data. The selection of local authorities was based on the following criteria:

1. intervention development by the local authority;
2. the level of funding from the DfT (local authorities to be selected to represent low, medium and high levels of funding allocations);
3. a mix of intervention measures (i.e. education, engineering, enforcement etc.);
4. innovation;
5. actual or potential partnership synergy with other area-based initiatives such as neighbourhood renewal, Sure Start etc.; and
6. the characteristics of local authority areas, such as Index of Multiple Deprivation (IMD) ethnic mix and the population of older people and children.

The questionnaire addressed the following issues:

- Mobility and accessibility:
  - quantitative information on mobility patterns; and
  - use of local facilities.
- Safety:
  - how safe they feel walking alone in the area in the daytime;
  - how safe they feel walking alone in the area after dark;
  - safety behaviour: seat-belt and cycle helmet wearing;

- perceived safety of the road in which they live;
- accident involvement; and
- awareness and impact of the NRSI.
- Quality of life:
  - view of social and leisure facilities;
  - view of facilities for young children up to the age of 12 and teenagers (13–17);
  - view of local transport;
  - perception of the level of parking in residential streets;
  - perception of the speed and volume of road traffic; and
  - perception of teenagers hanging around on the streets.

In order to look at the wider impacts on children, self-completion questionnaires were administered to school children aged between 9–14 years in all 15 areas. The schools with catchments in the NRSI wards were selected. Over 5,000 interviews have been completed. The survey is being conducted ‘before’ and ‘after’ the intervention period to provide comparative data. The questionnaire addressed the following issues:

- Mobility:
  - quantitative information on travel and recreation patterns.
- Quality of life:
  - how much they like living in their neighbourhood; and
  - use of facilities.
- Safety:
  - how safe they feel crossing the road where they live;
  - safety behaviour: seat-belt and cycle helmet wearing, pedestrian and cycle training; and
  - accident involvement.

# Conclusions

Changes in reported behaviour over the evaluation period will provide some understanding of whether people are travelling around more or less and the reasons for this, how they feel about local facilities, how safe they feel and reported road traffic accident involvement. The surveys will also inform whether there is an increase in secondary safety behaviour, such as increased seat-belt wearing or cycle helmet wearing. A key aspect of the data is that it will contribute to our understanding of the causal mechanisms of injury by helping to identify different patterns of travel and activities for different population groups, especially black and minority ethnic groups which are not routinely available. The travel data will also provide a denominator to look at exposure-based injury rates before and after interventions.

The final report is presently due in April 2008.

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# 4

## Traffic calming, childhood pedestrian injury inequality and politics

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### Introduction

This paper is based on a series of studies involving a considerable number of researchers from several universities. These are acknowledged at the end of the paper. The paper is also largely based on material which has been accepted for publication or is under review by scientific journals and so cannot be reproduced in full due to copyright agreements.

Across the Westernised world traffic-related deaths and injuries are a major public health problem (World Health Organization, 2004). A high proportion of childhood deaths are due to traffic and children are particularly vulnerable as pedestrians (Rivara, 1990; Murray and Lopez, 1996; Krug, 1999).

Over the last 20 or so years there has been a growth in interest in social inequalities in health. Childhood injury deaths show the largest of all inequalities in health and amongst the specific causes of injury producing such inequalities pedestrian injuries rank high. There is a considerable literature which demonstrates the magnitude of the inequality gap in childhood pedestrian injury (Avery and Jackson, 1993; Christie, 1995; Roberts, 1996; UNICEF, 2001; Lyons *et al.*, 2003). Not only is the gap between affluent and poor children very wide, but it is expected to increase in the future (UNICEF, 2001).

As a consequence of the increased focus on inequalities in health, several governments have responded by introducing aspirational targets to reduce inequalities, particularly

in the field of traffic injury prevention. Introducing targets on its own may not be sufficient to produce action which will lead to a reduction in injury inequalities.

A review of the literature on interventions to reduce health inequalities in childhood injuries by Professor Elizabeth Towner and colleagues on behalf of the Health Development Agency found scant evidence that interventions reduce inequalities (Towner *et al.*, 2005), but this is generally based upon a lack of evidence rather than evidence of a lack of effectiveness of the interventions.

The big problem with public health interventions, in general, is how small the research base is on testing interventions (Milwood *et al.*, 2001). There is a lot of research exploring factors which predict illness or injury but still very limited research on whether modifying these risk factors changes the incidence of illness or injury in real world settings.

The nature of evidence, and the degree to which it convinces, varies considerably by discipline and sector. Public health practitioners, particularly those from a medical background, tend to have a high degree of scepticism about research designs which are susceptible to bias, and particularly simple before and after comparisons. The Cochrane Collaboration ([www.cochrane.org](http://www.cochrane.org)) has taken an interest in injury prevention and has carried out a considerable number of reviews. However, by setting a very high threshold for research design, many studies are excluded from these reviews and they arrive at different conclusions to reviews carried out by other disciplines. For instance, a Cochrane review of area-wide traffic calming identified no randomised trials and included only 16 before and after trials, of which only four related to pedestrian injuries (Bunn *et al.*, 2003). The Cochrane study reported an odds ratio of 1.0 (no effect) for pedestrian injuries as a result of traffic calming. Closer inspection of the included studies showed that the majority dealt with separating traffic flows and not vertical deflections to slow traffic. Consequently, the absence of an effect on pedestrian injuries is not surprising. This result contrasts with that of Webster and Mackie which included a very large number of studies and reported an average drop of 70% in child pedestrian injuries in traffic calmed areas (Webster and Mackie, 1996). Most of these studies were excluded from the Cochrane review on methodological grounds. Where does this leave policy and practice? The vast majority of people in the transport sector believe the evidence that traffic calming work is persuasive, and as a result traffic calming has been widely introduced over the last 10–15 years. This analysis is supported by a logical framework, with studies showing that traffic calming slows traffic, other studies showing that slower speeds are associated with lower crash and pedestrian injury rates, and, thus, one could logically expect traffic calming to reduce pedestrian injuries.

Our interest lies in reducing the burden of injuries to individuals and society, and particularly to those who are disadvantaged and at high risk. Given the fairly widespread adoption of traffic calming by local authorities, our first study was designed to see whether there was social equity in the provision of this preventive intervention. This study is about to be published in *Injury Prevention* (Jones *et al.*, in press).

Briefly, the study involved a small area analysis of pedestrian injuries, particularly focusing on children aged 4–16, at electoral ward level in two UK cities. Each ward was assigned a deprivation fourth based on the Townsend Index of Material Deprivation and injury rates were compared across three three-year periods from 1992

to 2000 by deprivation fourths in the two cities. In addition, a drive and walk by survey of all roads in both cities was undertaken to measure the distribution of traffic calming features. Standardised surveys of travel to and from school were carried out with all final primary year and first secondary year pupils to look at travel modes by deprivation fourths. The results of the study showed that one city had invested much more extensively in traffic calming than the other and had particularly focused this work on the most deprived areas. In this city there was a substantial drop in absolute and relative inequalities in pedestrian injuries, with much smaller changes in the other city. Across both cities the incidence density of traffic calming at ward level was negatively correlated with the change in pedestrian injury rate. Less affluent children travelled to school on foot more than their affluent counterparts but there were no marked differences between cities. There were no other measurable changes in both areas which could explain the drop in pedestrian injuries in deprived areas of one of the cities. The most logical and likely explanation was the degree of traffic calming. However, it should be remembered that this is an  $n = 2$  before and after ecological design, a study design which many would regard as unconvincing. Nevertheless, it is the only evidence we have discovered so far that prioritising traffic calming in deprived areas is associated with a reduction in childhood pedestrian injury inequality.

The next question which came from this work was to try to understand why the distribution of traffic calming should be so different in the two cities. Discussion with traffic engineers, road safety officers and other council officers from environmental health identified factors which might be important, including influential champions who could gain a larger slice of the total council budget for road safety, influential council members who could effectively advocate for their communities, as well as the history of collisions in an area. It is very difficult to measure objectively how influential any given councillor might be, but the creation of a cabinet-style council provided an opportunity to test a theory. We hypothesised that influential councillors would be more likely to be elected to the cabinet than their counterparts. Using cabinet position as a categorical explanatory variable, we analysed the relationship of traffic calming density across all wards, adjusting for the historical pattern of injurious crashes and collisions. The results of this study confirm a strong association between the historical incidence of injurious crashes and traffic calming density. However, after adjusting for this factor, cabinet councillors had substantially more traffic calming in their wards. We have interpreted this as an indicator of the advocacy role elected politicians have for their own areas.

The third study, which is about to start, is based on these observations, and seeks to move from observation to intervention to protect vulnerable pedestrians in high-risk areas in deprived communities. It is a multi-site cluster randomised trial which aims to determine whether targeted information to councillors representing deprived wards with high pedestrian injury rates results in additional safety interventions in these wards.

The study has been funded by the Department of Health following the call for research after the Accidental Injury Task Force. It will take place in four regions of the country: the South West, East Midlands, Surrey and Wales. It is organised by the UK Child Injury Prevention Research Network – the Miskin Group ([www.miskin-group.org.uk](http://www.miskin-group.org.uk)) – and involves researchers from five universities (Swansea, Cardiff, West of England, Nottingham and Surrey) and the Child Accident Prevention Trust. The study will run until the end of March 2008 and the outcomes being measured are the additional provision of safety measures (engineering and educational) in

intervention wards relative to control wards, and interest and involvement in road and pedestrian safety schemes. It is a mixed methods study with both qualitative and quantitative components.

## Acknowledgements

As mentioned earlier this paper is based on three separate but linked studies. Different people have contributed to the various studies. The views expressed in this paper are those of the author alone. The following individuals have contributed to the design of some or all of these studies: Sarah Jones, Robert Newcombe and Stephen Palmer (Cardiff University), Nicola Christie (University of Surrey), Elizabeth Towner, Marianne Brussani, Richard Kimberlee (University of West of England), Denise Kendrick, Lindsay Groom, Carol Coupland (Nottingham University), Tinnu Sarvotham, Ceri Phillips, (University of Wales Swansea) and Michael Hayes (Child Accident Prevention Trust).

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# 5

## Illicit drugs and driving: prevalence and attitudes

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### Introduction

In 1999, the Scottish Executive commissioned the first Scottish study to examine the prevalence of, and attitudes towards, recreational drug use and driving. Since the first study was undertaken in 2000, there has been considerable additional research on the impact of both illicit (Walsh *et al.*, 2004; Huestis, 2002) and prescription drugs (DfT, 2003). The issue has also been taken up by other organisations with, for example, the BMA (2004) and RAC (2002) urging government research and action on driver impairment caused by both legal and illegal drugs. International research has identified drug driving as a common problem but one that is poorly understood by the public because of confusion about the extent of impairment, the legal status of drug driving, and the relative size and relatively closed nature of drug subcultures (Beirness *et al.*, 2003).

More generally, social attitudes around drug use continue to change in ways that are unfavourable to organisations seeking to deter drug use and driving. The public generally accepts cannabis use and recent changes in the treatment of the possession of cannabis appear to have led some people to believe that it is now legal to possess cannabis (MORI, 2001). ‘Recreational’ drugs are also an established and accepted part of youth culture and the dance scene in particular.

This study replicates and extends the earlier work conducted for the Scottish Executive Central Research Unit. This paper sets out the issues involved in the study and also discusses some limitations of the current study and indicates issues for further research.

# Prevalence and attitudes to drug use and driving

The current study has two main components: a survey of 1,000 drivers aged 17–39 years to establish the prevalence of illicit drug use and driving, and qualitative interviews with those who have driven under the influence of drugs within the past 12 months, done so longer ago or who have been passengers of drug drivers. Where the survey does identify drug use and driving, it will mainly involve cannabis. Problem drug use – heroin, cocaine – will be extremely rare. To shed more light on this aspect of drug use, a group of problem drug users recruited as part of the Drug Outcome Research in Scotland (DORIS) project will also be interviewed about drug use and driving.

The prevalence survey element of the study has three principal functions:

- to provide a reliable quantitative estimate of the proportion of drivers in the 17–39 age group who have driven while they were likely to have been impaired by drugs in the previous 12 months;
- to record details of drug driving incidents and to collect details of attitudes and behaviour that are associated with drug driving and more general driving risks; and
- to record general awareness and opinion of drug driving, the law and enforcement.

The survey is comparable with the 2000 survey in terms of its sampling and fieldwork approach, comprising a probability sample of 17–39-year-old drivers screened from the population resident in private households, with the questionnaire administered using Computer-Assisted Self-Interviewing. Lifetime use of each of the 22 drugs will be asked about. Of those ever used, use in the past 12 months will be asked about and, where any drug is reported to have been used, respondents will be asked if they have driven any motor vehicle on a public road within a defined period of using the drug. The time since ingestion will vary from half an hour for Amyl Nitrate to 12 hours for LSD.

This approach is well documented in the report of the previous study (Ingram *et al.*, 2001) and provides accuracy of  $\pm 1.4\%$  on a survey estimate of 5% prevalence of drug use and driving in the previous 12 months.

One of the key outputs from the study will be recommendations on approaches and campaign messages to tackle the problem of drugged driving. The starting point for this is to gain a full understanding of the causes of drugged driving – understanding what motivates people towards or fails to inhibit them from drug driving. We will examine four main reasons:

- Contrived compulsion – there is a ‘need’ to drive regardless of having consumed drugs. As has been found in research on drink driving (Anderson and Ingram, 2001), some drivers place themselves in situations where there are opportunities to become impaired but which also require them to drive.<sup>1</sup>

<sup>1</sup> The phrase ‘contrived compulsion’ was coined by author Michael Crichton to describe the narrative tradition that places characters who might not normally be heroes in circumstances where they are forced to act heroically (Crichton, 2000).

- Reward – driving under the influence of drugs is rewarded. This might be through the combined stimulus of the drug itself and either the fact of driving (i.e. stimulation by the fact that they are impaired and driving illegally) or their style of driving (i.e. stimulation by the drug and driving at speed). Again, this explanation has been found in other research and it seems reasonable to expect this in relation to drug driving.
- The absence of risk or censure – drug drivers might believe there to be little risk of detection or crash-involvement. Indeed, their own experience might be that having never been caught, there is little risk. They may experience little or no censure from their peers. There is evidence that drivers believe penalties for drug driving to be less severe than those for drunk driving (Beirness, 2003).
- Low awareness of impairment – although impairment by alcohol is now well understood and accepted by drivers, drug-driving is much more complex because of the range of substances that can lead to impairment (both legal and illicit substances), the combinations of substances and the differences in times over which the substances are effective.

We have noted many of these reasons in previous research and have hypothesised that drug driving, drunk driving, speeding and other driving violations are related expressions of more general psychological phenomena. The first is ‘sensation seeking’ behaviour – individuals seeking novel or intense sensations and being willing to take risks to achieve these experiences. Sensation seeking is well established in the psychological literature and has been applied to high-risk sports and drug use (Zuckermann, 1994; Stephenson *et al.*, 2003). We have found no application of it as an explanation of driving behaviour but the characteristics of risk takers and sensation seekers seems applicable, especially in this context given the strong link between willingness to take health risks by using illicit drugs and the likelihood that these characteristics will also extend to a willingness to drive under the influence. We propose to use a standard measurement instrument – Arnett’s Sensation Seeking Scale – to place respondents on a spectrum of sensation seeking in an effort to develop a more general explanatory framework for drug use and driving (Arnett, 1994).

Alongside sensation seeking, we hope to assess the extent to which drivers contrive to place themselves in situations where it is likely that they will use drugs and drive. This would be achieved primarily through the qualitative research by making a detailed study of the way in which drug drivers construct their accounts of drug driving. Reviewing our recent research on various aspects of driver behaviour, we believe there to be a pattern to the ways in which people recount their experiences of road safety violations which absolve them of responsibility. These are difficult to reconstruct from the verbatim comments used in the reports but they suggest that drivers, in effect, set up situations in which they are required to speed or drink and drive or, in this case, drive under the influence of drugs. For example, speeding drivers say they were late for a meeting but the question for us would be the extent to which drivers make themselves late or allow themselves to be late and use this to justify speeding.

In the context of drug driving we would be looking for accounts such as driving to a friend’s house, they have some drugs (usually cannabis). They engage in drug use as part of the social situation and for some reason must drive home. The situation is

presented as unusual or a 'one off'. In effect, we would be seeking the unifying themes among these various 'one-off' accounts of drug use and driving. Our hypothesis is that while sensation seeking might be the primary explanation for drug driving (and other violations) among young people, and young men in particular, contrived compulsion is likely to be a better explanation of drug driving among older drivers.

We believe that being able to establish a general explanation of drug driving and placing this within a spectrum of behaviours rooted in the same general psychology of sensation seeking or contrived compulsion will benefit the development of road safety campaigns.

## Limitations and the scope for further research

While the focus of the current study is on establishing the prevalence of drug use and driving among the 17–39-year-old population in private households in Scotland, there are a number of areas in which the study is limited and where additional and complementary research would contribute to deterrence-based campaigns.

### Willingness to drive after taking drugs

The study will provide an estimate of the prevalence and incidence of drug driving but there is research evidence (Robbe cited in DfT, 2003; Mixmag, 1994) that some drug users would be willing to drive while impaired if they thought the circumstances required it: if, for example, they felt they were less impaired than a friend or there was an emergency.

While willingness does not represent a measure of prevalence, it might represent a softer, attitudinal measure of the acceptance of drug driving and would indicate degrees of susceptibility and allow this to be related to other characteristics. To the extent that campaigns are aimed at addressing attitudes about the acceptability of drug use and driving, understanding the characteristics and views of those most likely to be persuaded to drive while impaired would help to target those campaigns more effectively.

### Drug use among older adults

Both the 2000 study and this study are based on drivers aged 17–39 years. This age range was chosen because the 2000 Scottish Crime Survey showed that the use of illicit drugs was highest in this age range and rapidly declined after the age of 39 years to an extent that made it not cost-effective to interview people over this age. This general pattern of drug use is undoubtedly true and the latest data from the 2003 Crime Survey (McVie *et al.*, 2004) confirms this: drug use is more common among young adults. However, we believe the data have been misread in two ways. First, the 40–65-year-old age group is treated as a single unit in terms of the

prevalence of drug use yet it is clear, when this group is broken down, that patterns of drug use differ substantially within this group and there is little difference in 'ever' use among drivers aged 40–45 years compared with those aged 30–39 years. Second, specifying the age range for this study in terms of the prevalence of drug use alone is mistaken because it ignores the relative size of the driving population in each age group and therefore understates the potential risk posed by drug users in these age groups among the driving population. This is illustrated in Table 1.

**Table 1 Estimating the number of drug drivers in each age group in the Scottish adult population**

	Driving population (approx)	% of drivers in age group	% age group using any drug in prior 12 months	Potential number of drugged drivers
17–19	35,000	1	32	11,200
20–24	175,000	5	34	59,500
25–29	280,000	8	22	61,600
30–34	420,000	12	12	50,400
35–39	490,000	14	5	24,500
40–49	875,000	25	3	26,250
50–69	1,190,000	34	1	11,900
	<b>3,465,000</b>	<b>99</b>	<b>109</b>	<b>245,350</b>

Table 1 does two things. First, it estimates the size of the driving population in each age group based on data from the Scottish Household Survey 2001/2002. This shows that adults outside the age range for the study represent the largest groups in the driving population. Second, it shows the proportion of each age group that reported having used any drug in the previous 12 months in the 2003 Scottish Crime Survey. Combining these gives an estimate of the number of drivers in each age group who might have used any drug in the previous 12 months. From this we can conclude that, although the prevalence of drug use is highest among people aged 17–24 years, this group is a small proportion of the driving population. The risk posed by drugged drivers aged 17–19 years might be low. Although only a small proportion of people aged 40–49 say they had used any drugs in the previous 12 months, this is a small proportion of a very large number of drivers – the estimated number of drivers aged 40–49 years who use drugs is very similar to the estimated number of drivers aged 17–19 years and is as large as the number aged 35–39 years. From the perspective of another road user, the risk is potentially the same from a driver aged 35–39 years as from one aged 40–49 years.

In terms of addressing the problem of drugged driving, the motivations, contexts and circumstances of older drivers might also be very different. We hypothesise (discussed above) that drug use and driving among young adults might be part of a more general phenomenon of 'sensation seeking' and is related to boredom susceptibility, thrill seeking and disinhibition. Among older adults we hypothesise that the general decline in drug use and the corresponding decline in self-reported drinking and driving, speeding, etc. reflects general lifestyle changes and we suggest that the residual problem of drug use and driving is more a problem of ignorance

and contrived compulsion. More specifically, we hypothesise that the dominant reasons among older drug drivers are very similar to those used to explain drink driving:

- ignorance of the law, impact and safe limits, and a belief that they are experienced enough to accommodate moderate impairment; and
- contrivance to place themselves in a position where they find they 'must' drive after using drugs.

For all of these reasons we feel that future campaigns would benefit from knowledge of the levels of drug use and driving among older drivers.

## Broadening the scope of the drugs asked about

Our current research is focused on estimating the prevalence of *illicit* drug use and driving, reflecting the focus of the previous study. However, research evidence suggests that although the use of illicit drugs is a serious problem, there is a potentially greater problem represented by impairment through the use of prescription drugs such as anti-depressants and over-the-counter medicines like anti-histamines and cold remedies. For example, Beirness *et al.* (2003) found in a survey of Canadian drivers that driving while impaired by the use of illegal drugs was rated as a more serious road safety problem than driving while impaired by prescription drugs or over-the-counter medicines. This study also found that the prevalence of driving while impaired by illegal drugs was the same as that of driving while impaired by prescription drugs. However, the proportion of drivers who had driven while impaired by over-the-counter medicines was 10 times that of cannabis and 7 times that of all illegal drugs.

## Conclusions

This research will provide a current measure of the proportion of Scottish drivers aged 17–39 years who have, in the past 12 months, driven a motor vehicle while under the influence of at least one illicit drug. It will also provide important information upon which the Scottish Executive and the Scottish Road Safety Campaign can build campaigns to inform the public and deter drivers from driving while impaired in this way.

Unfortunately, our expectations are pessimistic at this stage. We expect to find that drug driving has increased since 2000, when we found that 1 in 20 drivers had driven in the previous year while impaired by drugs. Our pessimism is based on a number of factors such as:

- the general increase in drug use recorded between 1996 and 2003 in the Scottish Crime Survey;

- increasing car ownership and use among young adults;
- increasing acceptance of cannabis use and, based on our research in the UK, an expectation that perceptions of the impairment effect of cannabis and the legal status of cannabis will have worsened rather than improved in the period since 2000; and
- increases in women's alcohol consumption and a narrowing of the gap between women and men in terms of other road traffic violations (Stradling *et al.*, 2003) leads us to expect some narrowing of the gap between women and men in terms of drug driving.

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# 6

## Comparing UK and European drivers on speed and speeding issues: some results from SARTRE 3 survey

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### Introduction

Driving speed (or more especially ‘driving too fast for the conditions’) is generally recognised as being one of the main contributory factors in traffic accidents (Treat, 1980; Taylor, 1999). A number of studies have examined the accident risk factor associated with driving speed, for example, Taylor *et al.* (2002) found that a 1 mph increase in speed was associated, on average, with a 5% increase in accident involvement – although this relationship did vary depending on a number of factors, such as the type of road, accident severity and traffic density (Taylor *et al.*, 2002). Understanding why drivers select the speed at which they drive is therefore an important factor in road safety.

There are many factors that have been shown to influence the speed at which a driver chooses to drive (Quimby *et al.*, 1999a, 1999b). Surveys of drivers caught speeding (Simon *et al.*, 1991) also reveal a variety of reasons that can be either temporary (e.g. ‘I’m in a hurry’, ‘I didn’t know the speed limit’) or more permanent (e.g. ‘I’m more skilled than other drivers so can drive faster and still be safe’, ‘This car is designed to be safe when driven fast’). The type of vehicle driven, the posted speed limit and the perceived likelihood of enforcement are also likely to be important in determining a driver’s choice of speed. A number of psycho-social factors have also been found to influence speed (e.g. the enjoyment of driving fast and speeding because of the pressure of work). Additionally, factors such as whether the driver is accompanied or not and the driver’s relationship with the passenger (e.g. peer-group friend or elderly relative) and the purpose of the journey have also been shown to influence driving speed.

Many of these various factors can be considered under the umbrella term of ‘attitudes’, and a number of studies have demonstrated the relationship between attitudes and behaviour (Elliot *et al.*, 2003). This means that a driver’s attitude to issues such as speed, risk, speed limits, enforcement and perceptions of their own and other’s driving behaviour are important in determining their behaviour and how safely they drive. There have been numerous surveys that have examined drivers’ attitudes to speed. This paper reports on the surveys that have been conducted by the pan-European SARTRE (Social Attitudes to Road Traffic Risk in Europe) research group and which are most relevant to speeding issues; and considers the results obtained for UK drivers as well as comparing these to those in other countries.

## The SARTRE surveys

‘SARTRE’ (Social Attitudes to Road Traffic Risk in Europe) is the mnemonic for the work of a consortium of road safety researchers that have periodically conducted attitude and reported behaviour surveys of European drivers. The consortium (which now comprises around 30 researchers) conducts a standardised survey on a representative sample of around 1,000 current drivers in each country. The surveys obtain attitudinal information on a wide variety of safety issues, such as speed, drink-driving, seat-belt wearing, regulations and countermeasure, in addition to a variety of safety related reported behaviours as well as their experience of police enforcement. The surveys also collect demographic information so that factors, such as age, gender and lifestyle, can be examined. A companion ‘contextual’ survey is also conducted in each country in order to obtain background information on things such as accident rates, speed limits, violation rates, size of penalties, and current (and recent) legislation that can be used to explain and understand some of the attitudinal and behavioural findings.

The majority of results reported here were obtained from the third SARTRE survey (hence SARTRE 3) that was recently conducted in 23 European countries. These included 14 countries that were existing members of the European Union (EU) (Luxemburg was the only member that did not take part), 7 ‘candidate’ – or applicant – countries who have all become members of the EU since the surveys were conducted, and Switzerland and Croatia. The first SARTRE survey (SARTRE Group, 1994) was conducted around 12 years ago in 15 European countries, including 10 members of the EU, while the second survey (SARTRE Group, 1998) – a 5-year ‘follow-up’ – was conducted in 19 countries. Although some changes have been made to the questionnaire employed for each tranche of the programme (removing some unproductive and ‘problematic’ questions, or adding questions, for example on new technologies for SARTRE 3), some questions have been repeated in all the surveys.

The information from these surveys meant that it was possible to analyse the findings in a number of ways. It is possible, for example, to make comparisons (‘benchmarking’) between individual countries or to compare individual results to a computed European ‘average’. Such comparisons can be made between both attitudes and a country’s road accident record in order to identify ‘good (and bad) practice’ so that individual countries can assess their own policies and performance

in promoting safety. It is also possible to monitor how things have changed over successive surveys; although not all countries have participated in all the surveys. The latest survey also provided an opportunity to compare the findings for individual EU and non-EU countries, in order to identify underlying economic, social or cultural factors that might lead to differences in road risk.

This paper focuses only on some of the findings that were obtained with regard to speed and speeding issues, and in particular refers to the results that are, in the opinion of the author, most relevant to the road safety situation in the UK. It should be noted that the contents of this paper may not reflect the thinking of the UK's Department for Transport – who part funded the research.

The survey included questions that obtained information on:

- drivers' perceptions of their speed and safety compared to other drivers;
- how often they and other drivers exceeded the speed limit;
- how 'often driving too fast' contributed to accidents;
- speed-related self-reported behaviours, such as driving through amber traffic signals and overtaking when they could 'just make it';
- existing speed limits and enforcement activity; and
- their enjoyment of speed.

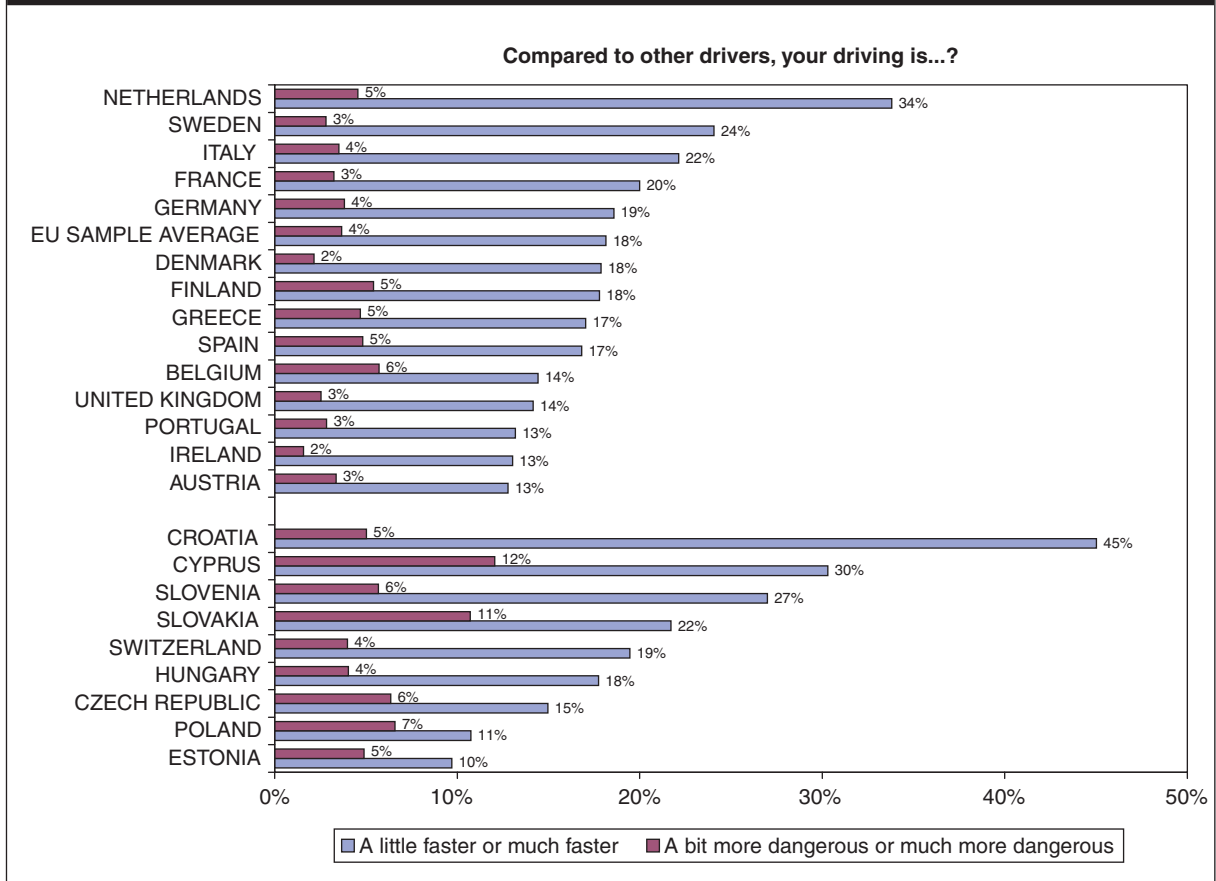
## Drivers' perceptions of their speed behaviour and safety

Amongst the factors that influence driving speed are likely to be how individual drivers judge their speed with respect to other drivers and how dangerous they considered their driving to be. Figure 1 shows the percentage of drivers in each country who responded that they drove faster (either a 'little' or 'much') than other drivers, together with the proportion of drivers who responded that they drove more dangerously (either a 'bit' or 'much') than other drivers.

When presenting these results it was decided to group the EU and non-EU countries. This meant that Switzerland was included amongst the non-EU countries (although in terms of economics, politics and transport infrastructure it is perhaps more similar to the other EU countries), and Croatia was grouped with the other applicant (now successful) countries although it has yet to apply to join. The countries are ordered firstly by whether or not they are members of the EU and secondly by the speed score for that country. The figures are all rounded to the nearest whole number; a sample average for EU countries was also calculated.

Figure 1 shows that, typically, European drivers are more likely to report that they drive faster than other drivers compared to driving more dangerously. While nearly one-fifth

**Figure 1 Percentage of drivers who report driving faster and more dangerously than other drivers**



(18%) of drivers in EU countries responded that they drove faster than other drivers, less than one in twenty (4%) reported that they drove more dangerously than other drivers. This suggests that, in general, drivers do not appreciate that speed is associated with risk when their own driving is concerned. While this was true for all countries (but to very different extents), the results also showed that there were major differences between countries in drivers’ perception of their own speed in relation to other drivers. For example while one-third (34%) of Dutch drivers reported they drive faster, only 14% of UK drivers did. The results also suggest that a very large majority of UK drivers think they drive more safely than other drivers. Only 3% of UK drivers (compared to an EU average of 4%) thought that their driving was more dangerous than other drivers.

## Self-reported speeding behaviour

While Figure 1 presents the results for driving ‘faster’ than other drivers, an important factor in speed choice – and safety – is likely to be how drivers rate their speed behaviour relative to the prevailing speed limit. Table 1 presents the results concerning how frequently drivers in each country reported exceeding the speed limit on different types of road.

**Table 1 Proportion of drivers reporting they exceed the speed limit on different types of road**

	Motorway	Main roads between towns	Country roads	Built-up areas
AUSTRIA	19	11	11	6
BELGIUM	27	17	14	12
DENMARK	46	34	14	4
FINLAND	17	11	10	6
FRANCE	22	14	10	7
GERMANY	20	15	17	7
GREECE	40	23	19	6
IRELAND	10	7	4	3
ITALY	24	26	15	12
NETHERLANDS	31	22	14	7
PORTUGAL	32	19	15	11
SPAIN	37	21	13	11
SWEDEN	35	27	14	5
<b>UNITED KINGDOM</b>	<b>26</b>	<b>13</b>	<b>8</b>	<b>4</b>
EU SAMPLE AVERAGE	28	19	13	7
CROATIA	25	18	21	6
CYPRUS	28	21	18	12
CZECH REPUBLIC	14	12	7	6
ESTONIA	13	25	20	12
HUNGARY	16	21	17	12
POLAND	12	13	11	7
SLOVAKIA	16	18	11	8
SLOVENIA	26	16	10	6
SWITZERLAND	32	21	18	4

Table 1 shows that there are very sizeable differences in self-reported ‘speeding’ behaviour for different types of road. While 28% of drivers in EU countries report driving faster than the speed limit (either ‘often’, ‘very often’ or ‘always’) on motorways, only 19% did so on main roads between towns and 13% reported doing so on country roads. There appears to be a widespread recognition that speeds should be low in built-up (residential) areas, since only 7% of drivers in the EU countries reported frequently exceeding speed limits in such areas.

The table again shows that there are very marked differences between individual countries. For example, for driving on motorways, nearly half of the drivers in some countries reported exceeding the limit speeding (either ‘often’ or more frequently) while in other countries the proportion was around the 10% level. Typically the differences between individual countries were less pronounced for slower roads.

Drivers in the UK in general – but not on motorways – report speeding less than the average EU driver, and only 4% report that they regularly speed in built-up areas, compared to the 26% who did so on motorways. These results show that UK drivers appear ‘sensitive’ to what they presumably perceive as different risk conditions. It would have been useful to have included a specific question about the ‘expectation’ of encountering speed enforcement on different types of

road. At the time of the survey there were no speed cameras on motorways in the UK; a situation that has now changed.

## Perceptions of other driver's speeding behaviour

It is also likely that a driver's general speed choice and speeding behaviour will be strongly influenced by how they view other drivers' behaviour. Figure 2 shows the proportion of drivers in each country who considered that other drivers exceeded the speed limit (either 'often', 'very often' or 'always').

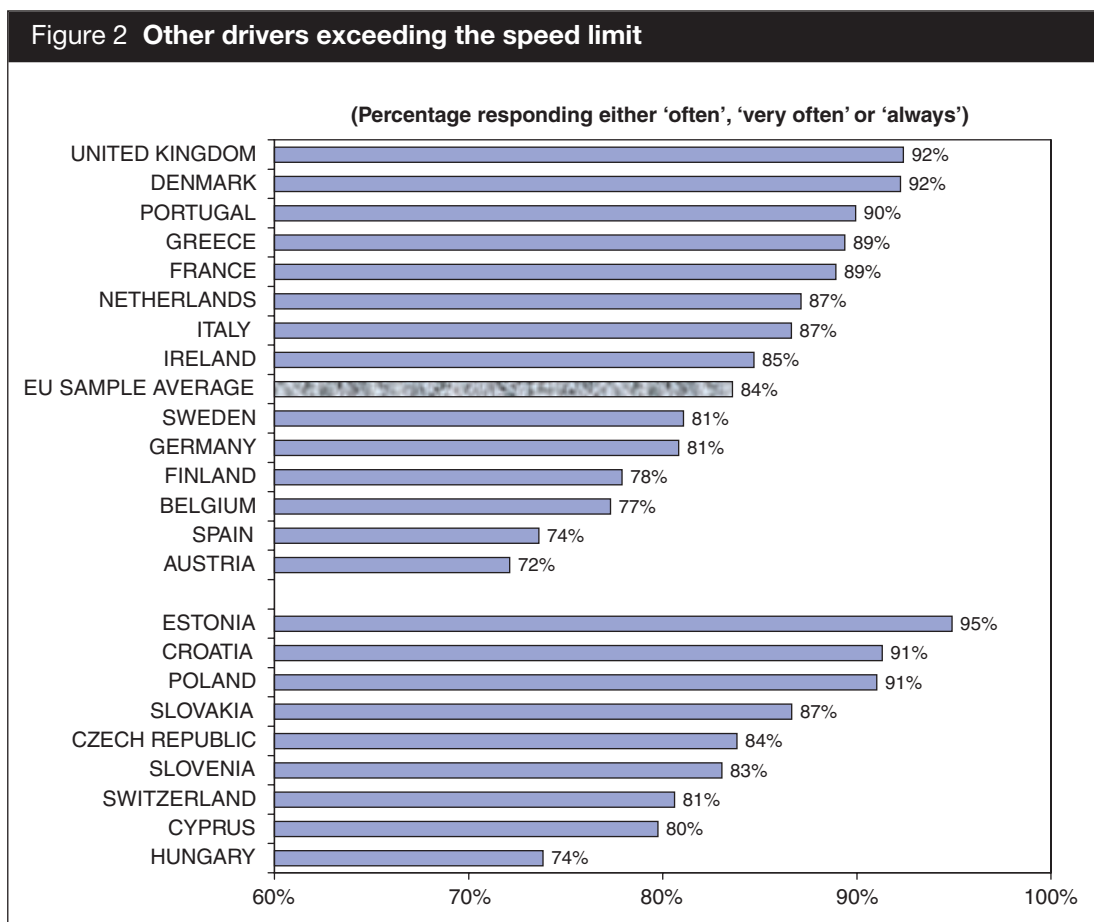


Figure 2 shows that a sizeable majority of drivers in all countries think that other drivers frequently exceed the speed limits – with an EU average of 84%. In fact, even in those countries with a low 'score', nearly three-quarters of drivers thought that other drivers were guilty of frequently speeding.

It is interesting that for this particular question, drivers in the UK (who typically tend to conform to more 'average' scores) in this case produce a more extreme score. While those countries, such as the UK, that conduct 'actual' speed surveys often find a high proportion of drivers exceeding the limit, the survey results may be influenced by a variety of psychological reasons. There will be greater justification for individuals

themselves to exceed the speed limit (i.e. break the law) if they consider that most other drivers are doing the same; these results probably also reflect a general feeling that they are better (or 'safer') drivers than other people. However, the results suggest that UK drivers may be more 'resistant' to reducing their speed because of the relatively high perception they have of other drivers' speeding behaviour.

It is interesting to reflect that while a significant number of drivers reported driving faster than average and that they consider that other drivers frequently exceed speed limits, they also claim that they do not speed themselves to any great extent, except when driving on motorways, which demonstrates a marked degree of ambiguity in such responses.

Whatever the reason for UK drivers being 'outliers', it is clear that this finding has very important implications for persuading drivers in the UK to reduce their speed and to drive within, or very close to, the speed limit.

## Enjoyment of driving fast

A number of research studies have demonstrated that psychological traits (e.g. 'sensation seeking') can influence speed behaviour (Quimby, 1997). The SARTRE survey included a question which asked drivers how much they 'enjoyed driving fast'. Figure 3 shows the proportion of drivers in each country who responded 'very' to this question.

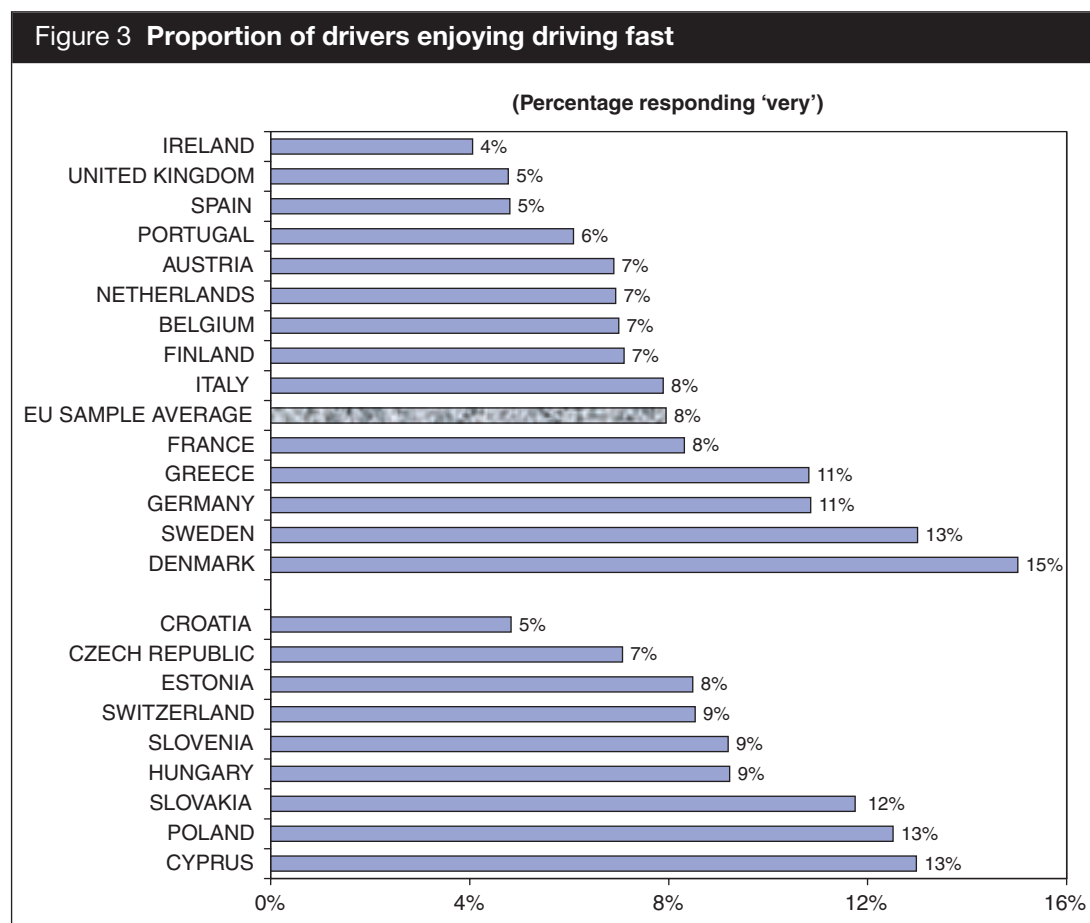


Figure 3 shows that, overall, only one in ten drivers reported that they very much enjoyed driving fast – the average for EU countries being 8%. Drivers in Denmark (15%) were most likely to respond that they enjoyed fast driving in contrast to drivers in Ireland (4%).

The result for UK drivers was that only 5% of drivers reported that they enjoyed driving quickly. While this result is perhaps surprising, it may be the result of drivers being concerned about being detected (by speed cameras or mobile police cameras) if they are exceeding the limit. However, while UK drivers may now have an increased expectation of being detected since the second SARTRE survey was conducted (because of the increase in the number of speed cameras), this finding has only changed by 1% (from 4 to 5%) over the period between the two surveys.

## Reported behaviours related to speed

It can be argued that driving speed (and speeding) are not necessarily, of themselves, always dangerous. More important is when drivers choose to drive too fast for the conditions, which can sometimes be less than the posted speed limit, when such behaviour can result in drivers getting into difficulties or expose themselves to unnecessary risks. The survey included two questions about self-reported behaviours that might be associated with excessive speed. Drivers were asked how frequently they ‘drove through amber traffic lights’ and ‘overtook when they thought they could just make it’.

Figure 4 gives the proportion of drivers in each country who reported that they drove through amber traffic lights (either ‘often’, ‘very often’ or ‘always’), while Figure 5 gives the corresponding results for overtaking when they can just make it.

Figure 4 shows that a significant proportion admits to driving through traffic signals when they are amber – and they are supposed to stop. ‘Only’ 12% of drivers in the UK report such behaviour, compared to an EU average of 18% and nearly one-third (30%) of Italian and Greek drivers, and 36% of drivers in Cyprus. Although this suggests that UK drivers are relatively safe compared to other European drivers, it does mean that not stopping for amber traffic lights is, worryingly, a relatively common event. The corresponding results for UK drivers in SARTRE 2 was 13%, suggesting that such behaviour has remained relatively constant – even though we now have an increasing numbers of ‘red light cameras’ in operation in the UK.

Figure 5, perhaps unexpectedly, shows that dangerous overtaking is admitted to much less frequently than driving through amber traffic signals. Again drivers in the UK reported such behaviour less than the average for other European drivers.



Figure 4 Frequency of driving through amber lights

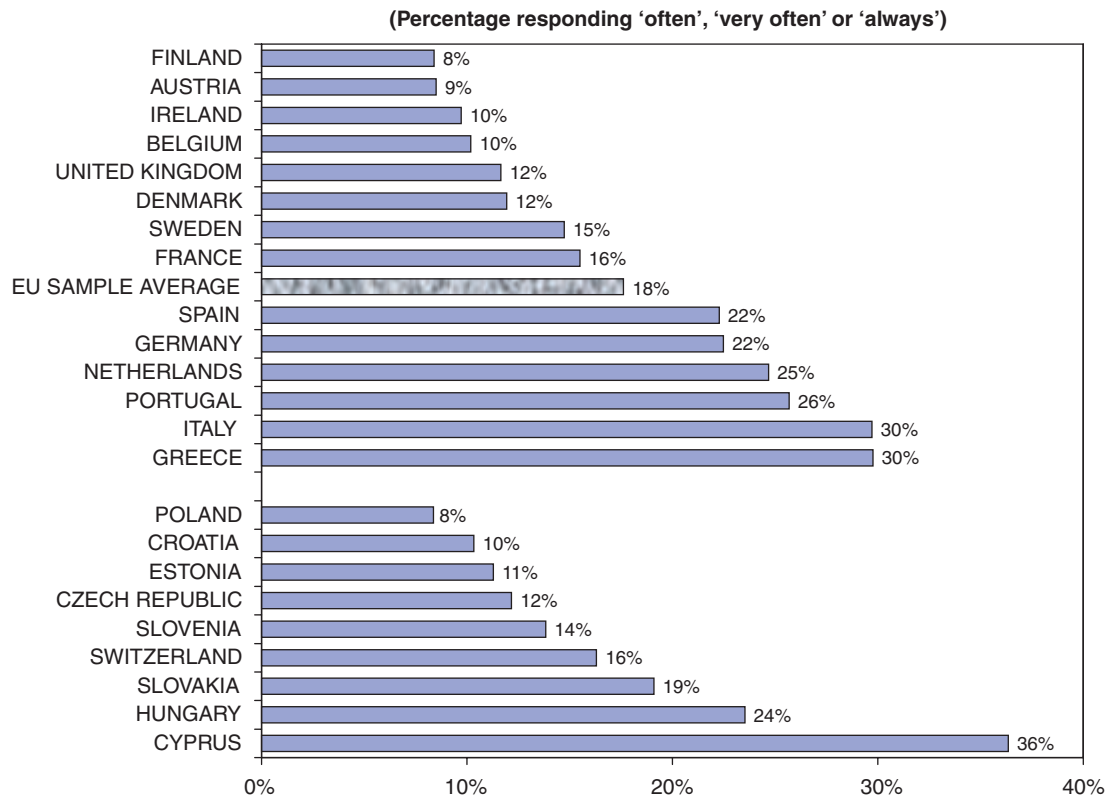
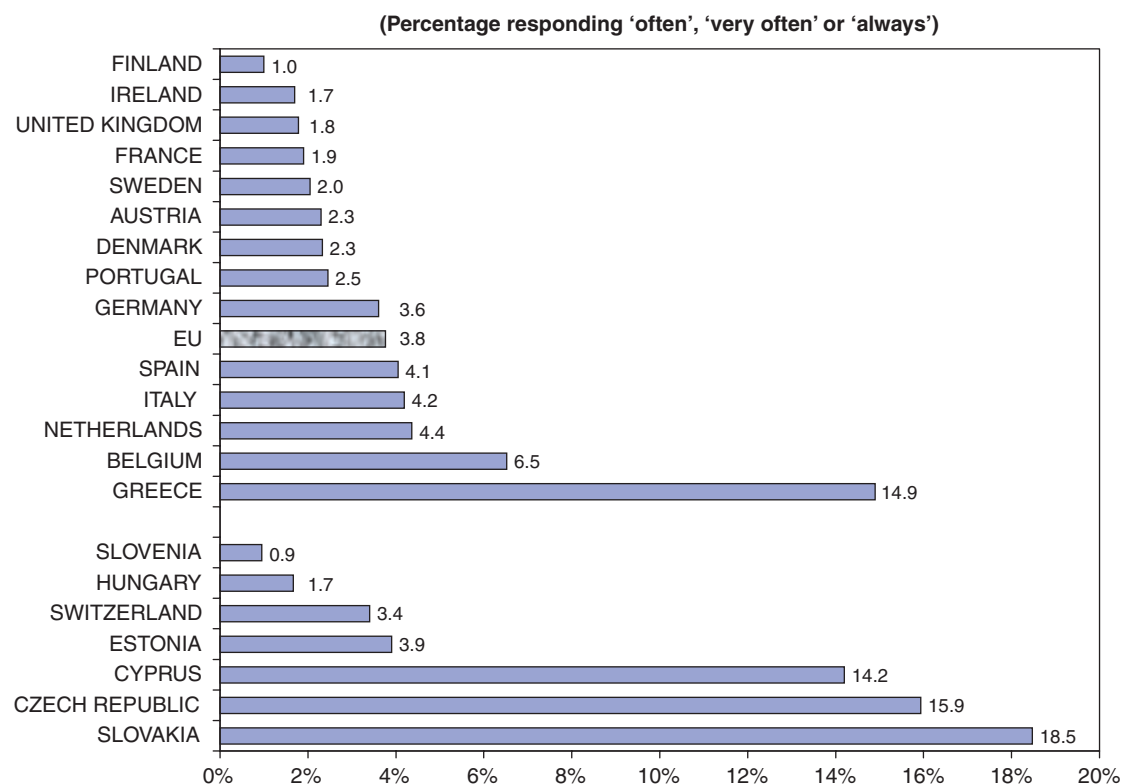
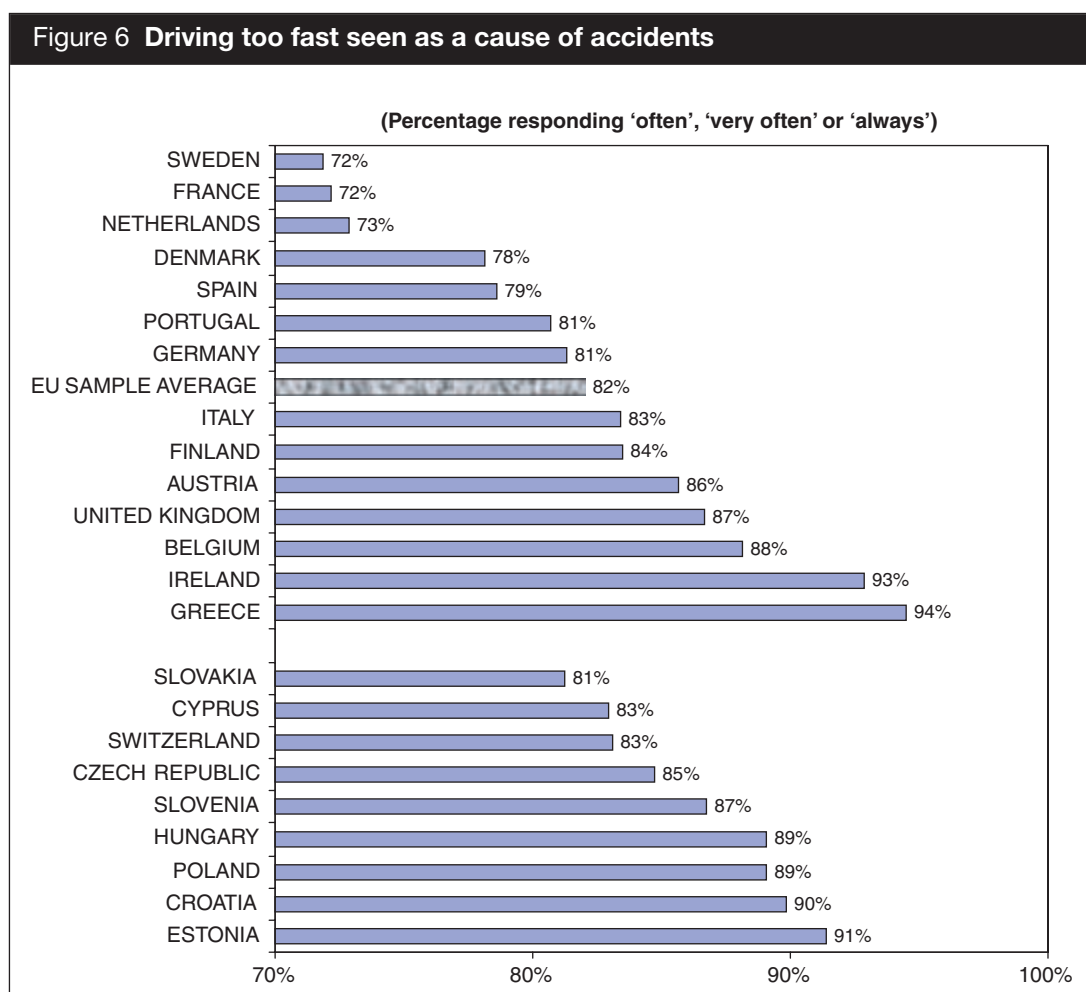


Figure 5 Frequency of overtaking when can they can 'just make it'



# Speed as a cause of accidents

Drivers' general attitudes to issues such as speed and speed limits – and their speed-related behaviours – are likely to be strongly influenced by their perception of the role speed plays in causing road accidents. The survey included a series of questions about how frequently a variety of possible accident contributory factors – including 'driving too fast' – caused accidents. Figure 6 gives the proportion of drivers in each country who responded that this factor was a contributory factor (either 'often', 'very often' or 'always').



The figure shows that 'driving too fast' is very widely recognised as being a contributory factor in accidents. Even in those countries with a relatively low score for this question (such as Sweden, France and the Netherlands), nearly three-quarters of the drivers recognised it as being a major cause of accidents; with nearly 90% of drivers in the UK responding this way.

Taken together with other results this finding suggests that a degree of cognitive 'dissonance' exists for drivers with regard to speeding.

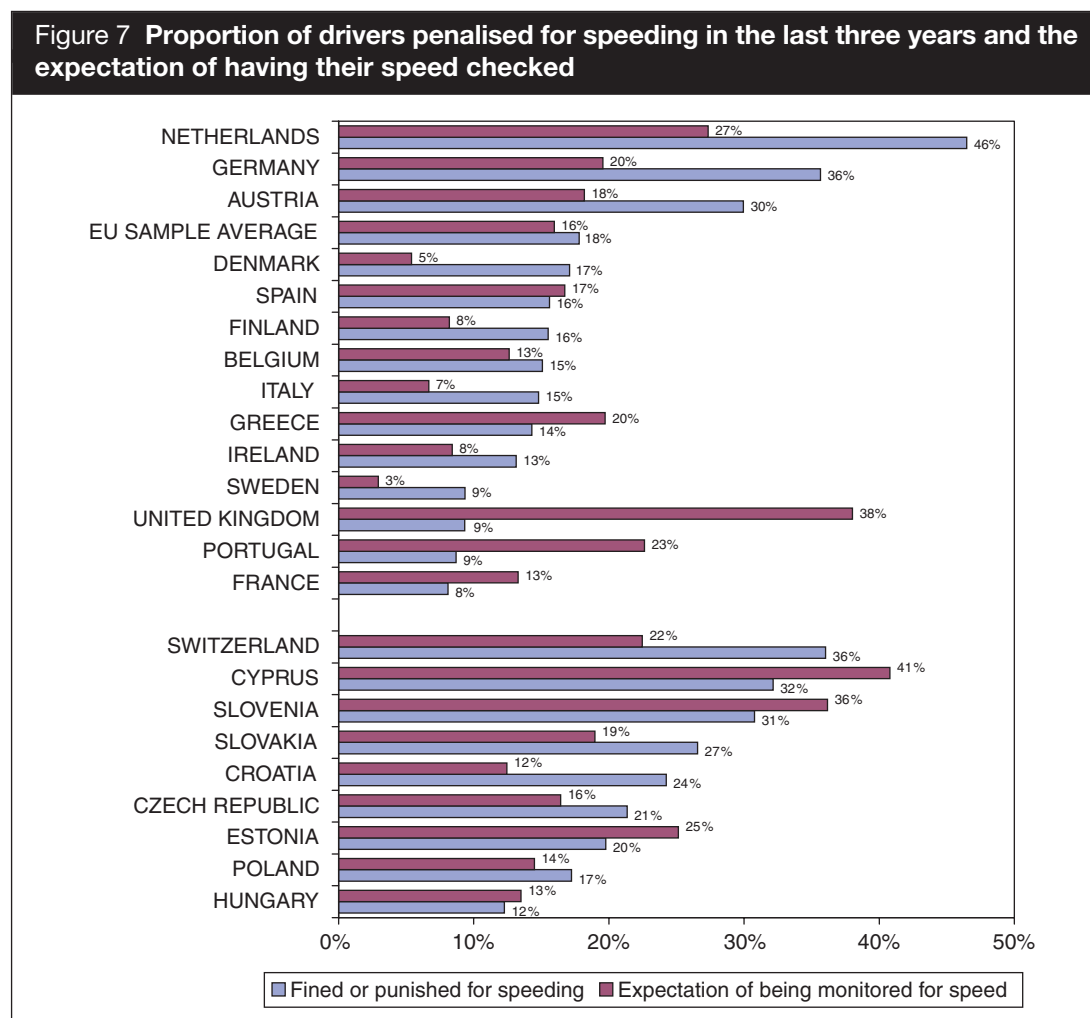
While they acknowledge that speed is a major cause of accidents, it appears that drivers do not think that the risks associated with speed apply to themselves – and that

they are not prepared to change their behaviour to take account of the risk – since they often report driving faster than other drivers, admit to frequently exceeding speed limits (outside residential areas) and quite often driving through amber traffic lights.

## Experience and expectation of speed enforcement

It was considered that the results obtained in the surveys were likely to have been influenced by the driver's personal experience of police, or speed camera, enforcement. For example, if they have been 'caught' speeding they may be less supportive of speed limits or police enforcement activity than if they have never been punished for speeding. Similarly, it is possible that a driver's expectation of being caught speeding may be an important influence on their attitudes and behaviour, if not more so, than their actual experience.

Figure 7 gives the proportion of drivers in each country who reported that they have been detected and punished for speeding in the previous three years plus the



proportion of drivers in each country who responded that they expect to have their speed checked (either 'often', 'very often' or 'always') on a typical journey.

Figure 7 reveals that a significant proportion of drivers reported being caught and punished for speeding in the previous three years. Nearly one-fifth of drivers in EU countries (18%), and even more than this in applicant countries, had been punished for speeding over this period. As might be expected there are considerable differences in drivers' experience of speed enforcement between individual countries. Amongst the EU countries a high proportion of drivers in the Netherlands (46%), Germany (36%) and Austria (30%) had been penalised in contrast to less than one in ten of the drivers in France (8%), Portugal, the UK and Sweden (all 9%).

The figure also presents the information on drivers' expectations of being 'monitored' for speeding on a typical journey. The perception of enforcement activity for speeding appears to be particularly high in the UK (38%) compared to other EU countries such as Sweden (3%) and Denmark (5%), perhaps reflecting the number of speed cameras in operation.

Figure 7 shows that in many countries there are very marked differences between drivers' actual experience and their expectation of being detected speeding. In some countries (such as the Netherlands and Germany) the drivers' experience of being 'caught' speeding (and punished) is markedly higher than their expectation; in contrast to countries such as the UK (and Portugal) where the drivers' expectation is markedly higher than their actual experience. From the safety point of view it is comforting that the 'expectation over experience index' (of 29%) is considerably higher in the UK than in any other country.

## Attitudes towards speed limits and enforcement

Another important factor that is likely to influence a driver's speed behaviour will be whether they think the posted speed limit – if they are aware of this by observing the speed limit signs – is sensible. For example, they may consider the speed limit on motorways to be too low, or even that the speed limit in residential areas (or near schools) is too high. Table 2 gives the proportion of drivers in each country who think the speed limit should be higher on different types of road.

Table 2 shows that, generally, there is considerably more support for higher limits on motorways than on other types of road. For example, while nearly half (44%) of drivers in EU countries support higher limits, only around one-in-ten did so for roads in built-up areas (7%) and country roads (11%). Again there were very considerable differences in the attitudes of drivers in different countries to higher limits. In general UK drivers were less supportive of higher limits than other countries – except for on motorways.

Such attitudes are likely to influence how drivers view enforcement activity on different types of road. While there will be general support for speed

**Table 2 Proportion of drivers preferring higher speed limits on different types of road**

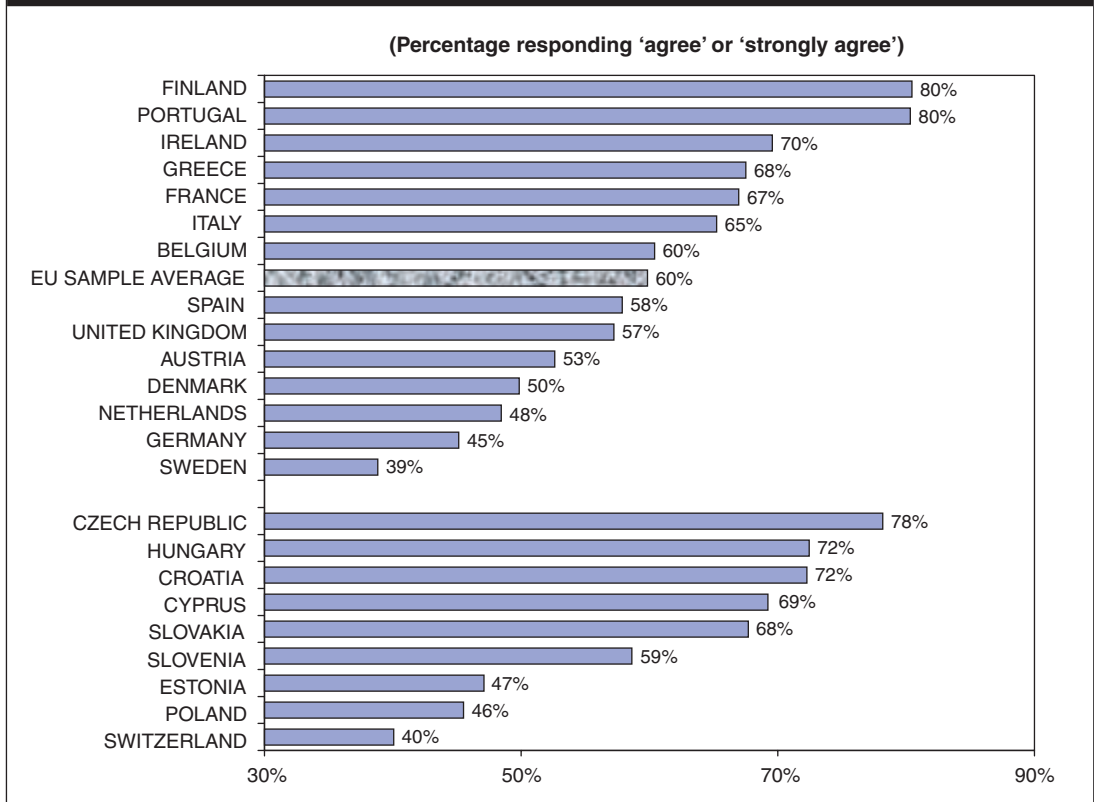
	Motorways	Main roads	Country roads	Built-up areas
AUSTRIA	38	15	9	7
BELGIUM	39	14	8	9
DENMARK	62	39	5	4
FINLAND	25	15	5	6
FRANCE	33	12	4	7
GERMANY	35	18	15	7
GREECE	47	21	16	3
IRELAND	34	14	3	6
ITALY	40	24	10	10
NETHERLANDS	53	23	8	6
PORTUGAL	48	18	11	5
SPAIN	53	27	15	12
SWEDEN	54	39	40	5
<b>UNITED KINGDOM</b>	<b>43</b>	<b>11</b>	<b>4</b>	<b>2</b>
EU SAMPLE AVERAGE	44	21	11	7
CROATIA	33	22	30	13
CYPRUS	42	22	14	8
CZECH REPUBLIC	42	27	13	20
ESTONIA	26	47	18	12
HUNGARY	69	16	53	3
POLAND	30	15	12	9
SLOVAKIA	49	31	20	9
SLOVENIA	40	18	12	15
SWITZERLAND	53	25	17	5

enforcement on lower speed roads, it is unlikely to be the case on higher speed roads.

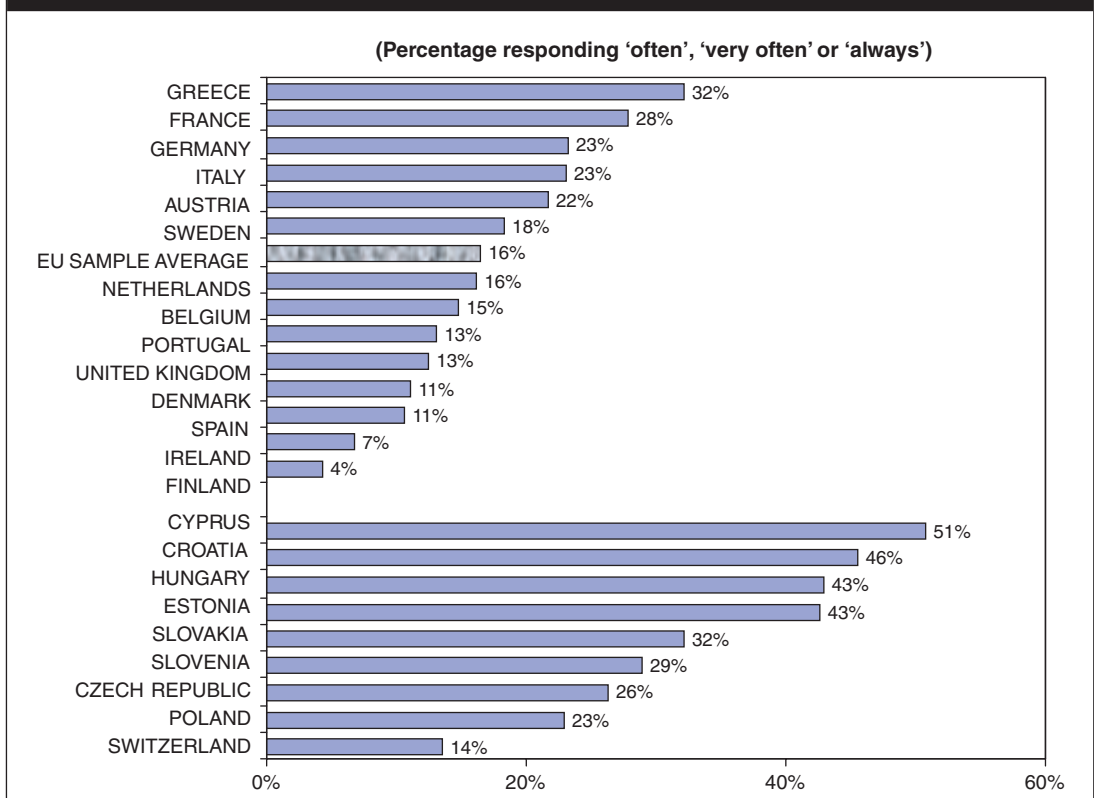
With regard to enforcement, drivers were asked if they would be in favour of more severe penalties for speeding offences. The findings are presented in Figure 8, which shows that there is very widespread support for having harsher penalties for drivers detected speeding. However the strength of this support does vary considerably between countries, with it being especially strong in Finland and Portugal (both 80%) while it is markedly lower in Sweden (39%) and Switzerland (40%). Figure 8 shows that drivers in the UK are generally slightly less supportive of more severe penalties than the average EU driver (57% compared to 60%). This may reflect the general ‘good’ attitudes of UK drivers and that penalties in the UK – which has a penalty points system (which can cause drivers to lose their licence simply for committing speeding offences) unlike many other EU countries – are already seen as being quite severe. ‘Speeding’ is not viewed as being as serious as other offences, such as drinking and driving, by UK drivers who are very supporting of harsher penalties for such behaviour.

However, while the results presented in Figure 8 suggest that there is considerable support within the driving public for penalising speeding, it should be recognised that in surveys of this type people often give socially acceptable responses that might bias the findings. Of relevance here are the responses to the question about whether drivers warned other drivers about the speed ‘traps’. Figure 9 shows the proportion

**Figure 8 Percentages of drivers supporting more severe penalties for speeding**



**Figure 9 Percentage of drivers who signal other drivers to warn them of a police speed trap ahead**



of drivers in each country who report that they warn other drivers (either ‘often’, ‘very often’ or ‘always’).

It shows that the proportion of drivers who warn other drivers about speed traps – suggesting that they do not approve of such police enforcement activity – tends to be markedly higher in applicant countries than in EU countries. In EU countries the practice was high in Greece and France and relatively low in Finland and Ireland; with around 13% of UK drivers reporting that they warned other drivers.

Table 3 shows the proportion of drivers in each country who support (either ‘very’ or ‘fairly’) different types of speed enforcement activity. It shows the degree of support for the use of speed cameras and enforcement conducted by public or private authorities.

<b>Table 3 Support for different speed management measures</b>			
	<b>Automated cameras</b>	<b>Public authorities</b>	<b>Private authorities</b>
AUSTRIA	54	55	18
BELGIUM	79	71	25
DENMARK	55	31	9
FINLAND	83	91	29
FRANCE	61	65	18
GERMANY	51	44	13
GREECE	60	60	18
IRELAND	87	54	22
ITALY	64	77	15
NETHERLANDS	71	66	28
PORTUGAL	83	80	31
SPAIN	52	53	17
SWEDEN	51	25	20
<b>UNITED KINGDOM</b>	<b>78</b>	<b>57</b>	<b>15</b>
EU SAMPLE			
AVERAGE	66	59	20
CROATIA	73	38	11
CYPRUS	63	49	30
CZECH REPUBLIC	65	39	20
ESTONIA	59	86	15
HUNGARY	69	30	10
POLAND	80	35	15
SLOVAKIA	72	47	21
SLOVENIA	68	33	14
SWITZERLAND	41	40	11

It shows that although there is very marked differences between drivers in individual countries, there is general support for the use of speed cameras (supported by 66% of drivers in EU countries) and enforcement by public authorities (59% for EU countries), although there is markedly less support (20% in EU countries) for private authorities conducting speeding enforcement. Drivers in the UK appear to be relatively supportive of speed camera enforcement, but not other types of enforcement. It may be that speed cameras at the time of the survey were supported in the UK because they were widely seen as promoting safety

(and not as revenue-raising devices), and they were seen as being fair in that they treated everyone the same.

## Discussion and implications

This paper presents some of the findings obtained by the pan-European driver attitude and behaviour surveys. They focus only on the results that are relevant to speed and speeding issues; and in particular consider the results obtained for UK drivers compared to those in other European countries.

The results have to be interpreted within the context that the road accident situation in the UK is amongst the safest in Europe; in fact the UK is recognised as being one of the three safest countries in Europe – and is one of the three ‘SUNflower’ countries (Sweden, UK and the Netherlands) being studied within Europe to identify good practice that might be adopted in less safe countries.

In general the result obtained for the attitudes and reported behaviours of UK drivers are typically ‘better’ (or safer) than in many other countries. While it is possible to speculate whether the attitudes produce safe roads, or safer roads lead to better attitudes, this situation means that, in general, other countries can learn more from what is done in the UK than practitioners in the UK can learn from other countries. In spite of this the UK is still setting challenging accident reduction targets and the results of the surveys do provide some pointers about some of the measures that might be introduced.

It is perhaps surprising that the results obtained for different countries are so varied and even more so that there was no clear-cut differences observed between EU and applicant countries. Similarly, there were no easily identifiable groupings observed for European countries (such as North vs South, East vs West, wine vs beer drinking; although in many cases UK and Irish drivers appeared to be very similar).

Similarly, the various answers did not lead to any specific pattern or groups of countries with common driver attitudes towards speed and speeding; although it is possible to identify a number of countries where the attitudes and reported behaviours are much more problematic than in others. However, the main focus of this report was to analyse the results with respect to UK drivers to see what lessons might be learned.

The results clearly indicate that drivers in the UK recognise ‘driving too fast’ to be a major contributory factor in accidents compared to drivers in most other countries. This is clearly a useful starting point; and it is interesting that the results suggest that drivers in many other countries, since earlier surveys, are moving towards this recognition. However, the results also suggest that drivers – including those in the UK – do not necessarily associate driving ‘faster’ (than other drivers) with driving more ‘dangerously’ – where their own driving is concerned. Drivers in the UK reported driving slightly slower than other European drivers and marginally safer (1% difference) than the average of EU drivers.



The results also show that drivers in the UK report exceeding speed limits slightly less frequently than other European drivers – although there were considerable differences between European countries for the results of this question. Importantly, the survey obtained self-reported speeding behaviour for four different types of road (from motorways to roads in residential areas). The results found that drivers in the UK reported very different amounts of speeding (driving faster than the speed limit) for different types of road and indicated that, while they exceeded the speed limits quite frequently on motorways, they very seldom did so in residential areas. While any speeding can be considered to be a serious safety problem, it is perhaps reassuring that UK (and other European) drivers appear to take account of different road conditions (and perhaps perceived risk) and set their speeds accordingly; and it is particularly comforting since the pedestrian problem (especially) for children is one of the current safety concerns in the UK. However, this finding also raises the issue of the need for more enforcement (either actual or ‘perceived’ – or both) or for increasing the speed limit on motorways in the UK. In this regard it is worth noting that drivers in the UK were, in general, much less supportive of having higher speed limits than many other European countries – although the strength of feeling for not having increased speed limits was much reduced for motorways.

One of the interesting findings of the surveys with respect to UK drivers was that they considered that a higher proportion of ‘other’ drivers drove over the speed limit most of the time than in any other country – one of the few examples of UK drivers giving ‘extreme’ results. This finding is important for at least two reasons. Firstly, it is likely to make drivers more resistant to reducing speeds themselves and driving within the speed limit if they consider that most other drivers are typically ‘ignoring’ speed limits. Secondly, it conflicts with the other results where a significant proportion of drivers report driving faster than other drivers (who are typically exceeding the speed limit) but that judge themselves to drive faster than the speed limit relatively infrequently. The results perhaps suggest that a significant proportion of drivers are intent on producing socially acceptable results (to ‘lie good’). In any case this perception of other drivers’ speeding behaviour is likely to strongly influence a driver’s general speed choice and needs to be targeted by suitable publicity and education to change such perceptions.

The survey also produced self-reported responses to two speed-related driving behaviours associated with risk. These were driving through amber traffic lights and dangerous overtaking (when you can ‘just make it’). Although the results showed that many drivers in the UK admitted to driving through amber lights (which is not illegal), very few actually reported that they engaged in dangerous overtaking to any marked extent. In both cases they reported engaging in such behaviours relatively less frequently than drivers in most other countries.

The results also show that only a small proportion of UK drivers ‘enjoy driving fast’ compared to the ‘average’ European driver; a finding that probably reflects the fear of being detected and punished if they drive fast – and over the speed limits.

In general UK drivers were relatively supportive of police enforcement activity for speeding offences – although such support was significantly less than with respect to drinking and driving. Firstly, UK drivers tended to be more supportive of higher penalties for speed offences and were positive about the use of speed cameras for enforcement purposes. They also tended to strongly favour other ‘new’ enforcement technologies, such as having speed limiting tachographs or ‘black boxes’ (to be used

by the police for enforcement purposes) fitted to cars, than in other countries. However drivers in the UK were much less supportive of speed enforcement by non-police bodies, such as public or private organisations. In spite of such support for police enforcement, it is perhaps worrying that over one-in-ten (13%) of drivers in the UK reported that they frequently warn other drivers about speed ‘traps’ – an indication that they do not support ‘secret’ enforcement activity by the police or do not think that speeding drivers should be punished. This compares to an EU ‘average’ of 16% – which ranges from a high of 32% (Greece) down to 4% (Finland) for individual countries.

Perhaps the most interesting result identified by the survey, with respect to drivers in the UK, was the difference between their ‘experience’ of speed enforcement (in the previous three years) and their ‘expectation’ of being checked for speeding on a typical journey. While in some countries the experience ‘score’ was higher than that obtained for the expectation question, in other countries the reverse was found. The difference between these two scores was bigger in the UK than in all the other countries surveyed. The direction of this difference was that the expectation of encountering speed enforcement was higher than the experience of being detected and fined for speeding; a ‘bias’ that is in the correct direction in terms of safety. UK drivers appear to have a very high expectation of being ‘caught’ speeding, a perception that have been generated by actually punishing relatively few (only 9% in the previous three years) compared to an average of twice this, about one-in-five, throughout Europe.

As a general concluding remark it can suggested that UK drivers have come out of the SARTRE surveys pretty well compared to drivers in most other countries with respect to speed and speeding. They tend to have more ‘positive’ (i.e. safer) attitudes and report that their behaviour is relatively safe compared to other drivers.

While this research has not shown a causal link between the attitudes and behaviours obtained by the surveys and the road safety records (good for the UK) of the participating countries, it does provide some clear messages about how the education, publicity campaigns and enforcement can be improved and used towards achieving improved road safety in the UK. Perhaps, also, the message for many other countries is ‘do it like they do in the UK’.

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# 7

## Why ride powered two-wheelers?

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### Introduction

The popularity of motorcycling within the UK continues to grow. According to Mintel, the market for new machines underwent rapid growth by 30% between 1998 and 2003 (Mintel, 2004). Department for Transport (DfT) figures also show a rise in the number of licensed bikes, rising by nearly 48% in a corresponding period of time (DfT, 2004a). Powered two-wheeler (PTW) traffic has increased significantly with a 49% rise in the 1998 to 2003 period. In 2003, around 5.6 billion vehicle kilometres were travelled by PTW vehicles in the UK (DfT 2004b).

With this rise in PTW ownership and distance travelled has also come a rise in the number of killed or serious injured (KSI) accidents. Between 1990 and 1996, the number of motorcyclists killed or injured on Scotland's roads steadily declined, but from 1997 onwards the casualty figures have increased year on year. 2001 saw 1,174 motorcycle casualties in Scotland, the highest figure since 1992. The relative risk of a motorcycle rider being killed or seriously injured per kilometre travelled was almost 50 times higher in 2003 than that for car drivers (DfT, 2004b).

The majority of these KSI accidents occur in non-built-up areas, mostly being loss of control type accidents on a single carriageway road with a 60 mph speed limit, and mainly involving bikes with an engine capacity of 500 cc or more (Sexton *et al.*, 2004). The Royal Society for the Prevention of Accidents (RoSPA), for example, report from a study of rural accidents in Cheshire that 67% were due to rider error, mainly involving losing control on a bend or mistakes while overtaking (RoSPA, 2001).

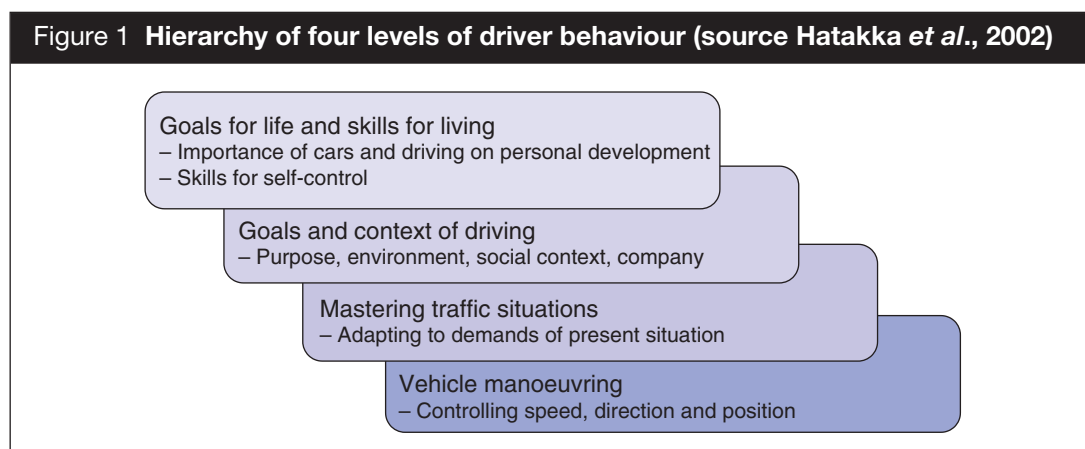
The high proportion of accidents that involve loss of control would suggest that many riders are, at times, riding beyond their riding skills. Mistakes while overtaking suggests a mismatch between rider goals and road-reading skills. Clearly some form of intervention is needed to bring the KSI for PTW under control. For such intervention to be effective it needs to be based on a better understanding of the goals of a PTW rider, and of how those goals relate to the risk of having a collision.

# Biker goals

Riders with less than six months' experience are more likely to be involved in an accident when compared to the rest of the riding population. These less-experienced riders are more likely to make decisions or manoeuvres that result in an accident. This suggests that rider experience is useful for developing skills in risk identification and anticipation of dangerous situations (ACEM, 2004).

Although there is no substitute for riding experience, training can help to bridge the gap between a novice and experienced rider, as well as improving the skills of the more experienced rider, and, on the face of it, skills training would seem to be the answer to reducing the KSI rate amongst PTW users. This though has not always proved the case, with research showing that those who undergo further skills training are often more likely to be at risk while using the roads (Rutter and Quine, 1996). This risk compensation effect was replicated in the findings of the evaluation of the BikeSafe Scotland scheme, where a number of those who undertook training said that they rode faster in non-built-up areas after the course (Ormston *et al.*, 2003; Stradling and Ormston, 2003). If skills training alone does not increase safety then how can rider training be used to reduce the KSI rate and improve PTW safety?

Hatakka *et al.* (2002) put forward a four-level hierarchy for the training of drivers that may also be applied to rider training. Figure 1 shows this hierarchy.



The lower two levels are concerned with gaining mastery over the vehicle by learning manoeuvring skills and how to adapt to the various demands of the road situation. The upper two levels of the hierarchy focus on the goals of driving and the goals of life. Most of biker pre-test training, such as the compulsory basic training (CBT) that is required before a rider is allowed to use a bike on the public road, is focused on the lower two levels, that of bike control and reading and reacting to the traffic situation. Post-test training, such as the BikeSafe schemes, where riders are assessed by police motorcyclists, concentrates on the reading of other traffic and riding accordingly, focusing mainly on the second lowest level of the hierarchy. It is the training schemes that focus on these levels that can increase the vulnerability of riders by raising confidence more than they enhance competence. This is not to say that training on these levels should not take place, as these riding skills are essential

for safe riding, but training schemes need to properly situate basic riding skills by placing a stronger emphasis on the goals and context of riding.

To design an intervention method that works, a clear understanding of the people concerned, and what motivates them, is needed. In this case, an answer to the question, ‘Why do people ride PTWs?’

Most current safety initiatives, like many models of mode choice, are founded on the assumption that the goal of the road user is simply to reach their destination safely so that they may then fulfil their trip purpose – work, shop, enjoy a social occasion. While it is true that transport joins up the places where people go to meet their obligations (Stradling, 2002, 2003), there is now a body of evidence showing that a transport mode may serve affective as well as instrumental functions (Steg *et al.*, 2001, 2002; Steg, 2004; Stradling *et al.*, 1998, 2001, 2004). Driving a car is a skill-based, rule-governed expressive activity involving ongoing, real-time negotiation with co-present, transient others in order to avoid intersecting trajectories.

PTW use may also be described as having an expressive function. Many recreational bikers go out just for a run, especially in the summer months, often without a specific destination in mind, except to eventually arrive back home. For this type of riding, while accomplishing a safe return is surely a consideration, the espoused goal of the trip will be found in the manner of riding, rather than the destination. Biking has inherited a strong image of the disconsolate rebel and the risk-taking, rule-breaking outsider, from the reincarnation and subsequent demise of the disenchanted Lawrence of Arabia as Leading Aircraftman Shaw, through Marlon Brando and Lee Marvin as the Wild Ones, Peter Fonda as Easy Rider, and Hunter S Thompson’s seminal depiction of Sonny Barger and his crew of Californian Hell’s Angels.

When asked in an earlier study why they ride, most bikers gave answers citing freedom and enjoyment (Broughton, in press). Some authors argue that riding a PTW can not be enjoyable due to the high level of risk involved, considering it ‘an extremely risky venture’ (Bellaby and Lawrenson, 2001), but there is a pervasive public perception that enjoyment is sought, and found, in the high levels of risk that riders face.

This paper reports two studies from a current programme of research on the relation between risk and enjoyment while riding.

## Study 1 – track day at Edzell

The relationship between risk, enjoyment and concentration while riding was explored in a study undertaken at the Edzell racing track in Scotland, on a day when the track was open for public bike use. After completing their circuits, riders were shown a map of the track and asked to indicate at which parts of the track they felt most at risk, where they felt the greatest enjoyment and where they had to concentrate the hardest.

Figure 2 shows the map of the Edzell track, along with its main features. A similar map was used in the study. A total of 69 riders completed questionnaires at Edzell and a summary of the data is given in Table 1.

Figure 2 Edzell Track

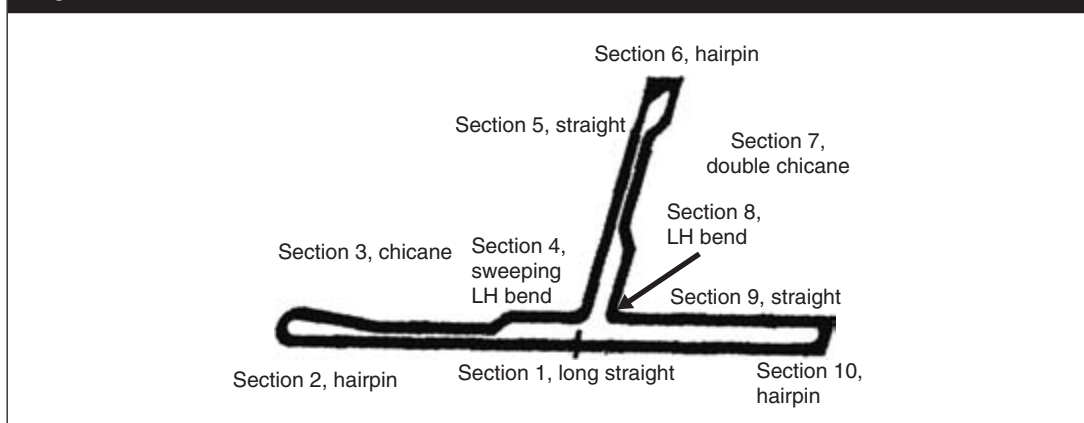


Table 1 Areas of greatest risk, enjoyment and concentration for Edzell track

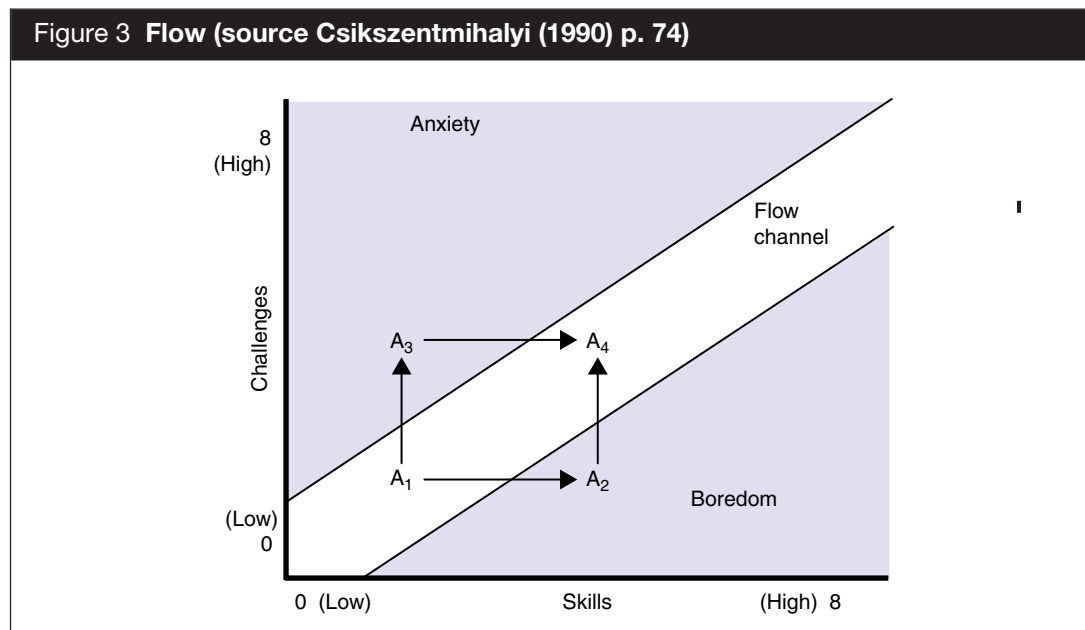
Track section	Risk (%)	Enjoyment (%)	Concentration (%)
1 – Long straight	3	11	5
2 – Hairpin	43	4	30
3 – Chicane	3	17	7
4 – Sweeping LH	6	20	5
5 – Straight	0	4	5
6 – Hairpin	17	4	9
7 – Double chicane	3	22	11
8 – LH bend	6	7	5
9 – Straight	0	7	5
10 – Hairpin	20	4	16

If enjoyment were enhanced by risk then it would be expected that there would be a positive correlation between risk and enjoyment, with respondents indicating the co-occurrence of risk and enjoyment at particular sections of the course. When the data are examined, Table 1 shows that the areas of greatest perceived risk were the three hairpin sections, with 43% selecting the Section 2 hairpin, 20% the Section 10 hairpin and 17% the Section 6 hairpin as their area of greatest risk. This is in contrast to the areas of greatest enjoyment, these being the Section 7 double chicane (22%), the Section 4 sweeping left hand corner (20%) and the Section 3 chicane (17%). The greatest concentration was reported for the Section 2 hairpin (30%), the same area as that perceived as the greatest risk.

One additional feature of the data is of interest: the spread of responses indicates that there were differences among individual riders as to which particular areas of the circuit they found the most risky, the most enjoyable and requiring the most concentration. This may vary with rider skill-set or rider goals or the interaction between them.

Examining each of the riders' individual answers, very little co-occurrence between risk and enjoyment was found, with only six respondents pairing the same section of track as affording them both the greatest risk and the greatest enjoyment. In contrast, the correlation between risk and concentration was higher, with 14 pairings, and there was a similar level of correlation between concentration and enjoyment.

These data show that risk and enjoyment are not necessarily related for most bikers, and that concentration bears a relationship to both risk and enjoyment. This would suggest that in track areas where concentration is heavily used, high levels of enjoyment are often found, and those areas of high concentration are very likely to be the areas where the rider is using their skill-set to, or beyond, the limit. This may be interpreted in terms of Csikszentmihalyi’s theory of flow (Csikszentmihalyi, 1990). Figure 3 shows the basic model of flow. This posits that where the skill level equals the challenge faced then flow can exist but that anxiety results where challenge exceeds the requisite skill and boredom where the skill level exceeds the challenge posed.



Csikszentmihalyi describes the flow state as ‘the Holistic Sensation that people feel when they act with total involvement’. When a person is in a flow state their attention is fully concentrated, and therefore they do not think about anything irrelevant or worry about life’s problems. As noted, many riders cite freedom as the main enjoyment factor of riding (Broughton, in press) and, in part, the description of flow as absorption in the act could describe this freedom.

So is it the case for all riders that their enjoyment from riding comes from matching their riding skills to the challenge that is presented by the roads and other environments where they use their bikes? How do risk and enjoyment interact?

## Study 2 – risk/enjoyment ratings of road scenes

An experiment was devised that explored the relationship between risk and enjoyment by asking PTW users to rate six pictures of various road conditions for risk and enjoyment using five-point Likert scales between 1 (low) and 5 (high) (Figure 4). A total of 96 riders completed the questionnaire. The relationship between risk and enjoyment was then classified by using self-learning pattern recognition software and three distinct patterns were discerned. The average risk/enjoyment profile for each type is shown in Figure 5.



Figure 4 Risk/enjoyment profiles for three types of riders

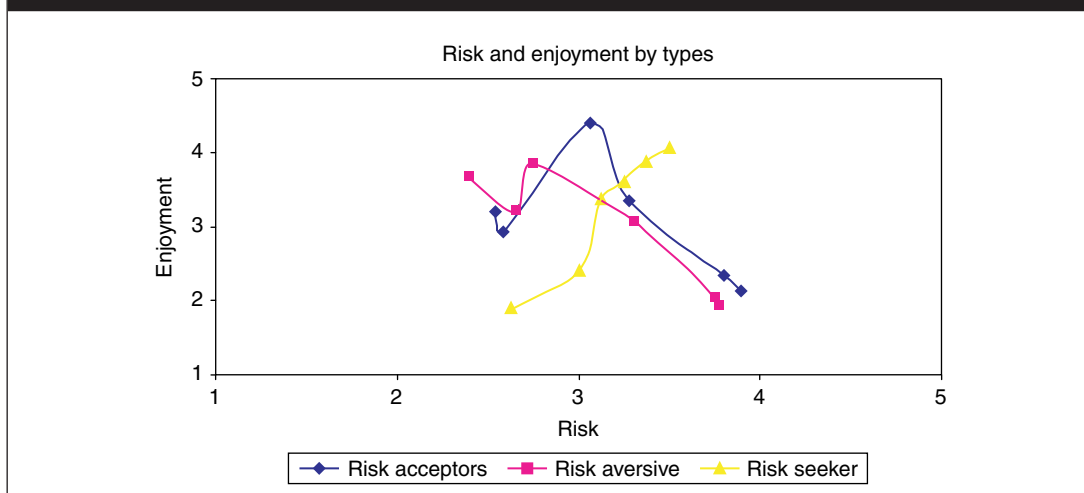
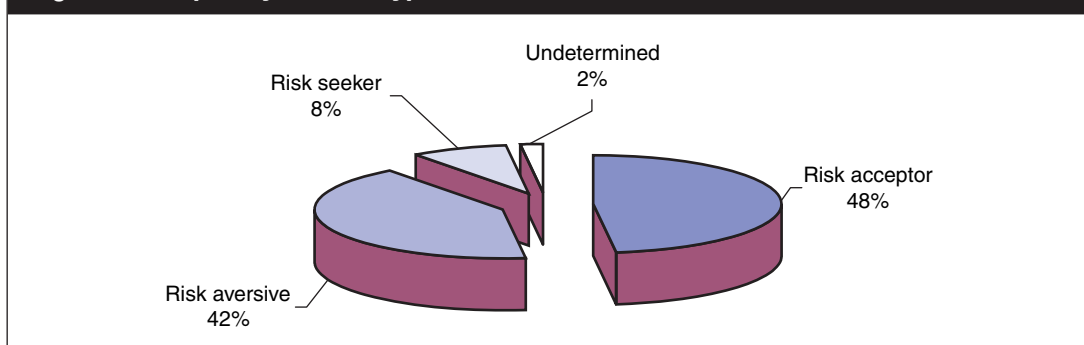


Figure 5 Frequency of rider types



The three types of rider risk profiles were identified as:

- *‘Risk averse’*: enjoyment at low perceived risk. As rated risk gets higher than rated enjoyment declines. These riders enjoy riding most when the perceived risks levels are low. They enjoy the freedom that the apparent lack of risk affords.
- *‘Risk acceptors’*: enjoyment at mid-range perceived risk. As risk increases so does enjoyment until a peak of enjoyment is reached. Then, as risk continues to rise, enjoyment falls off rapidly. These riders are happy to accept a level of risk to enable them to enjoy their riding, but once this level has been exceeded then the activity becomes less enjoyable.
- *‘Risk seekers’*: Enjoyment at high perceived risk. As the risk increases so does the enjoyment. It may be for this class of rider that there would a threshold where the risk becomes too high to give them enjoyment, but this threshold point is considerably higher than for the other rider types and was not captured in the set of six stimuli used here.

Figure 5 shows the breakdown of how many riders fall into each group, revealing that there is roughly the same number of risk-averse riders as there are risk acceptors (42% and 48% respectively), with only 8% falling into the risk-seeking

category. 2% of the sample were not categorised by the pattern recognition algorithms.

Harre (2000) identified five types of risk state in adolescent driving:

1. habitual cautious driving;
2. active risk avoidance;
3. reduced risk perception;
4. acceptance of risk as a cost; and
5. risk seeking.

Those who are in the risk-averse grouping would either be habitual cautious riders or those who actively seek risk avoidance, but given the nature of biking and its reputation for being a dangerous activity, it would be hard to see that a large proportion of the riders would be actively avoiding risk – else why ride at all? Hence it is assumed that the majority of the risk-averse group would be habitually cautious riders.

Those who are ‘acceptable riskers’, that is, looking for enjoyment out of the biking experience, but that enjoyment would not come at all risk-costs, would come from the ‘acceptance of risk as a cost’ state. These are those who ride despite the risk, not because of it, because of the enjoyment that they get out of riding by using their bike control skill sets to the fullest. For this group of riders the risks involved are a cost that they are willing to accept in order to gain the enjoyment that they seek.

Conversely, risk seekers will go out of their way to feel at risk, and they will consider this risk appealing and desirable. The risk seeker is not to be confused with the acceptable risker, despite similarities. The risk seeker will ride with little margin for error, but will do this to feel at risk, while the acceptable risker may, outwardly, do the same type of riding, but to the acceptable risker he is in control, he is testing his skills and therefore he does not feel significantly at risk.

As the data collection method used self-assessed, or perceived, risk, it is not possible to identify, and therefore see how, riders with reduced risk perception fit in.

There is also the possibility that some riders may sit on the boundaries of a particular group, or that they may temporarily change group due to other factors, such as mood. This may have consequences that relate back to the theory of flow and the emotional enjoyment that is gained due to a flow state being entered into. Intense emotion can cause a rider to become distracted from the task of controlling his machine, and intense emotion has also been shown to be present in many accidents (Rothe, 1986).

Peer pressure, or presumed peer pressure, can also affect the way someone rides, and this may be a problem for male riders who ride as a group, as males prefer male friends who were non-heroic risk takers, and any non-heroic risk-taking signals that a male sends out is more likely aimed at fellow males (Farthing, 2005). The motorcycling media also affect the ways that people ride bikes, making it seem

the norm for man and machine to be pushed to its limits, as seen from this quote taken from the Motorcycle Action Group website:

*Encourage media to adopt a more responsible reporting, a change of emphasis from “get out and have a go” to know you/your bikes parameters and get there safely* ([www.mag-k.org/content/issues/position\\_statements/bikesafe\\_2000.html](http://www.mag-k.org/content/issues/position_statements/bikesafe_2000.html))

How do these three rider groupings, ‘risk averse’, ‘risk acceptors’ and ‘risk seekers’ fit with the theory of flow? For flow to exist there must be a match of skill levels to the challenge faced – how is this met for each of the rider groupings?

## Risk averse

Risk-averse riders will not take undue risks, or push their bike control skills to the maximum by riding in a fast or hard manner. They will, however, still use their riding skills to match the challenge that they face. These skills will be ones of road craft, such as ensuring that the bike set-up is correct before entering a corner and using good anticipation skills to avoid putting themselves into a situation of risk. By concentrating hard on the use of these skills, the rider will still be in a position to experience flow as the ‘anticipatory skills’ used will match the challenge they face.

## Risk acceptors

Risk acceptors acknowledge that for them to use their skills to a level where they can gain enjoyment then a level of risk has to exist, and that level will increase as they seek a flow experience. These riders know their own skill sets, and when they find themselves riding outside that envelope their enjoyment drops off rapidly. These riders enjoy their riding, up to a position where the cost, measured in the potential consequences of the risk levels that they face, is no longer worth risking. For these riders it is the bike control skills that are used to match the challenge.

## Risk seekers

The risk seekers generally believe that their skill levels are such that they are able to ride their machines to the limit of the bikes, whereas the real limit would be, in most cases, their skills. These riders believe that the thrill they get from riding is doing it faster, harder and, in their minds, better than anyone else. They have an elevated view of their own skill level and this will drive them to take risks that most riders would see as unacceptable.

Thus this research proposes that there are three types of attitude to risk for riders, each type of rider has a different way of getting enjoyment out of riding, and therefore would have different sub-goals activated as reasons for riding. The main goal, of riding for enjoyment, would be consistent across all types, but how that enjoyment is found and how it relates to risk would vary by type. Any intervention scheme designed to reduce the KSI of PTW users should consider what the rider’s goals, and sub-goals, are and therefore develop an intervention method that works (Broughton, in press).

# Conclusion

The evidence presented shows that there is a complexity to PTW users and their attitudes to risk. The topology presented provides the first step of an attempt to find the answer to the question ‘Why ride?’ Further research is currently being carried out, looking more closely at this subject so that a model of rider typologies with respect to risk, enjoyment and flow can be formulated.

What the research does show is that despite most riders stating that they ride for pleasure and enjoyment, the way in which that pleasure is achieved varies depending on where in the typology they stand. As they all may have the same goal, that of enjoyment, their sub-goals are different and this must be taken into account with any intervention scheme that is implemented. For example, those who are risk averse may not benefit as much from anticipation skills training as those from the other two groups, and conversely extra bike control skills for the more risky groups may only encourage them to ride harder (Ormston *et al.*, 2003; Stradling and Ormston, 2003), and for these groups peer resistance skills may be more useful (Broughton, in press).

This research is seeking to understand the goals and motivations of riders, the most vulnerable of all road users (DfT, 2004b), and with that understanding it will then be possible to put in place methods that can make a real difference to the PTW KSI, without removing the enjoyment of riding.

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# 8

## Research to inform future speed policy

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### Context

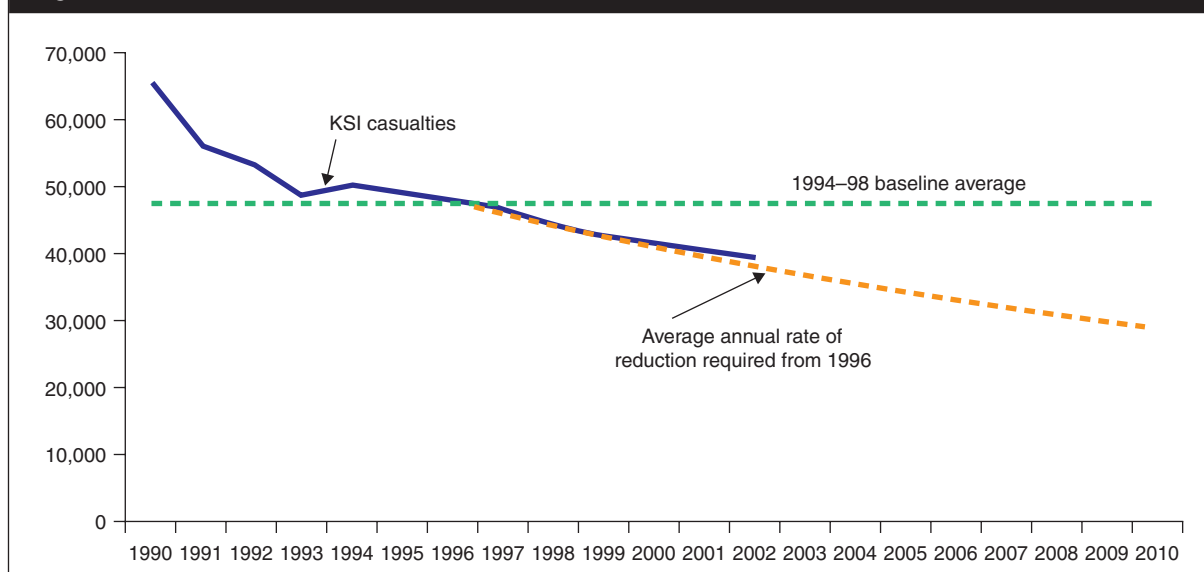
The first three-year review of the Government's road safety strategy and targets for 2010 indicates that progress towards meeting the targets is good.

Figure 1 shows progress for killed or seriously injured (KSI) casualties against the KSI notional trajectory and the baseline average for 1994–98. As can be seen, the KSI casualties are on a downward trend where the average annual reduction in the number of KSIs over the last five years has been 3.3%. Despite this, the number of casualties is still slightly above the line which represents the notional trajectory. It has been estimated that the reduction in KSI casualties is currently 2.4% less than that needed to coincide with the trajectory. This means that, on the one hand, more time will be needed for existing measures to bear fruit but, on the other hand, that more work and new initiatives will be needed by all partners in road safety for the target to be comfortably achieved by 2010.

However, this aggregate assessment on progress needs to be considered against the different trends in casualties of different severities and road-user groups because progress is not uniformly downward. Attention needs to be focused on the areas in which progress is slower than forecast by the statistical models used to set the targets.

One such area is fatal casualties. The statistics indicate that there has been a continuing decline (about 18% below the baseline) in the number of people seriously injured. However, since 1998 the annual reduction in fatalities has stalled with the trend levelling off at about 4% below baseline. This means that the historic picture of fatality trends following those of serious injuries is no longer occurring because deaths are failing to fall (see DfT, 2004, paras 30 et. seq.). Part of this diversion in trends may be an artefact of the reporting and recording of serious casualties in STATS19, and research is in progress to address this issue.

Figure 1 KSI casualties: 1990–2002 (Source DfT 2004)



There are indications that pedestrian and cyclist fatalities are broadly in line with their KSI trends. The excess deaths are coming from car occupants and motorcyclists with occupant fatalities at 1% below baseline and motorcycle casualties 30% above baseline. However, early indications from work by Broughton (2004) show that motorcycle fatalities are following exposure while car occupant fatalities are back to the baseline level and the fatality rate has fallen only gradually, and may have levelled off. Indeed, for older cars the fatality rate is rising. There are disproportionately many deaths amongst young male drivers (peaking at age 20–24 years), with 41% of all dead drivers being in the 16–29 age group.

The predominant road type for driver fatalities is A class non-built-up roads, where half of them occur, but the fastest increases have occurred on built-up roads and motorways.

## Development of research questions

Speed management is one of the 10 central themes in the Government's road safety strategy and is at its most effective with input from education, training and publicity, engineering, and enforcement. Safety cameras have an important part to play in speed management strategies and have been found to be effective at the locations they operate.

The three-year review, the three-year evaluation report of operation of safety cameras (Gains *et al.*, 2004), and that of trends in fatal accidents (Broughton, 2004), have brought together sufficient information on fatal and serious accidents to provide the Department for Transport (DfT) with a number of questions that would benefit from being answered by a structured programme of research into speed management.



The DfT commissioned a set of short thinkpieces from leading academics in the road safety field and these were presented and discussed at a workshop held in London on 13 October 2004 comprising a group of academics, key stakeholders, and policy makers.

Through the thinkpieces and workshop, the DfT was seeking clarity on what should be the research questions and objectives for such a research programme, together with a brief and broad specification for work which might be part of this programme.

Some of the questions it was hoped would be addressed by the thinkpieces and the workshop were as follows:

- Is the strategy of focusing on speed enforcement in urban areas the right one, or, because of the poor performance of rural roads, should effort be focused here? If so, what form should it take?
- How can inappropriate speed on rural roads be tackled?
- Are there cost-effective engineering solutions?
- What strategies do drivers adopt around cameras?
- What do we know of casualties and speeds away from safety camera sites?
- Do drivers think it is safe to speed where there are no cameras?
- Are downstream speeds at camera sites faster than speeds before camera installation at that site?
- Is there evidence of the migration of accidents from camera sites?
- What are the most effective strategies for changing driver attitudes and modifying behaviour, and how can speed awareness courses contribute to this?
- How can drivers be made aware of the relationship between speed and accident risk?
- What are the relative roles of enforcement and education/publicity?

## A research programme to inform speed management

The research identified as needed falls into five main categories:

- understanding the mechanisms of change in accident occurrence and speed behaviour brought about by speed enforcement by cameras;

- the role of the road environment;
- the role of the media and others in raising awareness of the relationship between speed and accident risk, and how to influence this risk;
- the role of education and enforcement; and
- research to support safety camera partnerships.

In each of these areas the role of research into individual differences in driver behaviour is recognised.

To move forward, a multi-disciplinary research programme has been developed which is affordable and delivers answers within an appropriate timescale to some of the fundamental questions that are needed to inform effective and acceptable speed management programmes.

Prioritising the research is difficult but in terms of the DfT's immediate and medium-term needs, the projects described under the following headings have been identified to provide information to fill currently identified gaps.

## **Under the mechanisms of change in accident occurrence and speed behaviour brought about by speed enforcement by cameras**

Perhaps the most fundamental of the research needs is that which can clarify the questions of:

- is there evidence of migration of accidents from camera sites?
- what do we know of casualties and speeds away from camera sites?
- how can the contribution of regression to the mean (RTM) to observed reductions in casualties at camera sites be estimated?

## **Interaction between speed choice and the road environment**

More work is needed in understanding how drivers interact with the road environment, including its surface, markings and geometric characteristics, in terms of speed choice in both urban and rural areas.

Research is needed which investigates the circumstances in which the speeds chosen by different kinds of driver and rider on different kinds of road contribute to accident

occurrence in order to inform the development of ways of encouraging them to moderate their speed while continuing to enjoy their use of their vehicles. This could lead to the identification of features of the road and roadside which could be modified affordably to encourage choice of appropriate speeds and to reduce the severity of injury in those speed-related accidents which nevertheless still happen.

## **Relationship between penalties for speed offences and driver behaviour**

Although there has been an increase in the number of speed offences, there is no discernable upward trend in disqualifications arising from the totting up of points on drivers' licences. The implications are potentially important as it could be a marker for a real change in drivers' speed behaviour.

It would be useful to investigate the distribution of the penalty points resulting from camera operation among those licence holders who have acquired them, and the distributions of the time intervals between the changes in the number of points on the licences of those who acquire points on more than one occasion, and of the time elapsed since the last acquisition of points.

## **Improved driver information on speed and accident risk**

There appears to be a mismatch between the actual level of risk from inappropriate or excessive speed and a driver's perception of the risk. The public needs to be better informed about the role of speed in accidents as a prerequisite for the acceptance of the message that speed reduction is important everywhere and not just at camera sites. More effective strategies are needed which inform the public of the basis for speed management and enforcement policy in order to modify driver behaviour in relation to speed choice and attitudes to speed limits and their enforcement.

## **Research to support Safety Camera Partnerships**

The dissemination of research findings is an important part of the duties of all researchers and sponsors of research. However, accessibility of the findings to Safety Camera Partnerships and to the public is a major issue. Partnerships need to have at their fingertips the latest research in order to keep abreast of the developments in this area in order to be able to fulfil their role of development and implementation of safety camera deployment strategies.

The public needs to be better informed about the role of speed in accidents as a prerequisite for the acceptance of the message that speed reduction is important everywhere and not just at camera sites.

Issues for partnerships include:

- criteria for site selection and should these be different for rural and urban sites as well as for mobile and fixed sites?
- should sites be selected on total number of accidents, KSI accident or only on excess speed?
- what is the principle behind the use of the camera, is it a hazardous location treatment or is it there to influence speed choice over a wider area?
- which is the best operational strategy in terms of the number of days of operation at a time, randomly allocated or on a fixed schedule, overt or covert?
- how does one decide which cameras are still working to reduce casualties even though the accident numbers may be zero or one per annum?
- how can partnerships be more integrated into speed management strategies?

Most of the information exists but it needs bringing together in an appropriate form.

## Conclusions

The research programme is important to developing further the knowledge base on speed management. This in turn will help to develop better accident prevention countermeasures, including those that improve the communication to the public of important road safety messages.

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# 9

## Driving by the seat of your pants: a new agenda for research

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### Abstract

Recent research has discovered that driver ratings of feelings of risk do not necessarily co-vary with ratings of statistical risk. However they do co-vary very closely with ratings of task difficulty. If these findings can be interpreted in terms of the ‘somatic marker hypothesis’ (Damasio, 1994), then a whole new agenda for research on driver behaviour suggests itself.

### Introduction

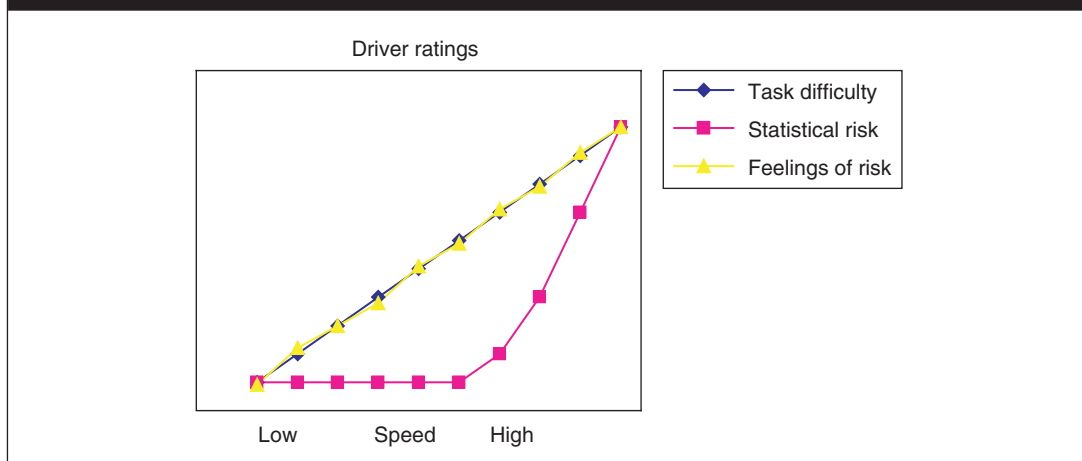
#### **Task-difficulty homeostasis**

The Task-Capability Interface Model provides a framework for operationalising the concept of task difficulty in terms of the degree of separation of task demand and driver capability (Fuller, 2000, 2005). Where demand is high and capability is low, task difficulty is high. Where demand is low and capability high, task difficulty is low. Furthermore, equivalent levels of difficulty may be represented by pairings of high demand and high capability or low demand and low capability. Associated with this model is the hypothesis of task-difficulty homeostasis, the idea that drivers drive in such a way as to maintain a level of difficulty within a preferred range. Based on the goals of a particular journey, self-appraisal of capability and effort motivation, a driver ‘selects’ a range of difficulty which s/he is prepared to accept and drives in such a way as to maintain experienced difficulty within that range. Manipulation of speed is the primary mechanism for achieving this, although undertaking or dumping

other tasks secondary to the primary driving task may be used on occasion. In a series of recent studies exploring this hypothesis (Fuller *et al.*, in press), we asked drivers to view video sequences of road segments viewed from the perspective of the driver. Each road segment was presented at a number of different speeds. We asked drivers, amongst other things, to imagine that they were driving each road segment and to rate it in terms of task difficulty but also in terms of statistical risk of loss of control (and crashing) and in terms of risk perception (i.e. feelings of risk). We expected that task difficulty would relate to speed in a systematic way: for any given segment, the higher the speed, the greater the task difficulty. We expected ratings of statistical risk to be independent of speed until speed approached a critical point where task demand approached the upper boundary of driver capability. Around this point we expected ratings of statistical risk to take off. Finally, we expected that feelings of risk would track these ratings of statistical risk.

The first two of these hypotheses were strongly confirmed by the evidence, as shown schematically in Figure 1. Task difficulty is very highly correlated with speed, and there is no relationship between statistical risk and speed at lower speeds. Only after some threshold is reached, which incidentally is higher than the speed at which drivers feel comfortable, do ratings of statistical risk begin to rise and relate to further increases in speed. The third hypothesis however, and much to our surprise, was not confirmed. Feelings of risk were systematically related to speed, even at lower levels, thus departing radically from ratings of statistical risk which were consistently zero at these levels. In fact, feelings of risk correlated with speed in the same way as ratings of task difficulty. Put another way, they tracked ratings of task difficulty almost perfectly: the correlation was of the order of 0.97.

Figure 1 Task difficulty ratings, statistical risk ratings and feelings of risk ratings of a road segment at different speeds



If drivers use perceived task difficulty as the criterion for determining the level of task demand they prefer to take on, the question arises as to how difficulty is represented and sensed by our information processing systems. If we view driving as a control task in a dynamic system which constantly tends towards disequilibrium, then feedback regarding impending loss of control may be a key determinant of task difficulty. Such feedback may relate to a decoupling of responses and intended outcomes (in terms of goals); that is, the driver may make a response to achieve a particular outcome or goal, but the response does not achieve the intended goal – it has no effect (e.g. braking in order to slow down having no effect because of entering into a skid instead). A further determinant may be the rate of information flow. When this exceeds the rate-capability of the information processing system,

either in terms of take-up or analysis, it will serve to decouple input from the decision-making process. Decisions, if they are made under these circumstances, will be based on only partial rather than complete information. An example might be a driver seeing a brief opportunity to overtake and initiating the manoeuvre without first checking her/his rearview and wing mirrors. An intriguing question follows. Is it the case that impending loss of control through such decoupling processes is what is sensed as an increased feeling of risk? Could this be why task difficulty and feelings of risk are so highly correlated?

What makes this question so intriguing is that it gives a role to feelings in decision making which has largely been ignored in the decision-making literature. However, an early proponent of the importance of affect in decision making was Zajonc (1980). To quote Slovic *et al.* (2002), Zajonc ‘... argued that affective reactions to stimuli are often the very first reactions, occurring automatically and subsequently guiding information processing and judgement. If Zajonc is correct, then affective reactions may serve as orienting mechanisms, helping us navigate quickly and efficiently through a complex, uncertain, and sometimes dangerous world’ (p. 4). More recently, Damasio (1994, 2003) and others have provided cogent argument and compelling evidence in support of a key function of affect in decision making.

## The somatic marker hypothesis

Damasio (2003) concludes that emotions provide a natural means for the brain and mind ‘to evaluate the environment within and around the organism, and respond accordingly and adaptively’ (p. 54). Damasio suggests that stimuli with which some feeling is associated can elicit attention and thought can then be focused on those stimuli, thereby enhancing the quality of decision making. Emotional signals ‘mark options and outcomes with a positive or negative signal that narrows the decision-space and increases the probability that the action will conform to past experience’ (p. 148). The emotional signal is not generally a substitute for reasoning. However, when we immediately reject an option that would lead to certain disaster, reasoning may be ‘almost superfluous’. Because emotional signals are body-related, Damasio labelled this set of ideas ‘the somatic marker hypothesis’. Slovic *et al.* (2002) refer to a similar set of ideas as ‘the affect heuristic’. Through learning, somatic markers become linked to stimuli and patterns of stimuli. When a negative marker is linked to an image of a future outcome, it sounds an alarm.

Damasio has found that certain types of brain lesion specifically exclude access to feelings associated with objects, events and scenarios. At the same time they degrade decision performance: ‘The powers of reason and the experience of emotion decline together, and their impairment stands out in a neuropsychological profile within which basic attention, memory, intelligence, and language appear so intact that they could never be invoked to explain the patients’ failures in judgement’ (Damasio, 1994, pp. 53–54). Damasio (2003) has also outlined a plausible and coherent neurological model which could sustain this entire process. Experimental studies of decision making in normal individuals (Slovic *et al.*, 2002; Loewenstein *et al.* 2001) clearly demonstrate the interplay between emotion and reason, with the unambiguous and perhaps surprising conclusion that affect is more or less essential to rational action.

The role of affect in decision making is illustrated by a study by Slovic *et al.* (2002) in which participants were asked to evaluate the attractiveness of purchasing new

equipment for use in the event of an airliner crash-landing. They hypothesised that saving 150 lives was a somewhat diffuse positive outcome, having only a weakly positive affect, whereas saving 98% of something was more convincingly good and would have a much stronger positive affect. In one condition, participants were informed that the equipment would make it possible to save 150 lives that would otherwise be at risk in such an event. In a second condition, participants were told that the equipment would make it possible to save 98% of the 150 lives that would otherwise be at risk. The results confirmed their hypothesis. Rated support for the purchase of the life-saving equipment was significantly higher in the 98% of 150 condition than in the 150 condition, even though more lives are saved in the latter condition. It was also higher than the 150 condition when participants were told that the equipment would make it possible to save 85% of the 150 lives that would otherwise be at risk.

Now it might be suggested that this line of thinking simply brings us right back to the threat-avoidance model, as proposed in 1984 (Fuller, 1984), which argued that driver behaviour was motivated by the avoidance of threat (potential aversive stimuli) and that safety was challenged where the requirement for an avoidance response was not detected or when motives to delay avoidance prevailed. Does the somatic marker hypothesis do any more than unpack the concept of 'threat' in terms of its associated feelings, translating the potential aversive consequences of an event into its affective psychological substrate? Or does the somatic marker hypothesis take us even further back, to the experimental study by Taylor (1964), who argued that drivers adapt their speed according to the level of anxiety they feel (as well as an attempt to maintain a constant level of anxiety when driving)? It appears, however, that the somatic marker hypothesis does go beyond these two conceptualisations in asserting that affective responses to present and anticipated stimuli do more than inform response choice (as in reinforcement theory and as in Taylor's view). Affective responses also capture attention to pertinent stimuli and prioritise their further processing. Damasio openly admits that it is still too early to have complete confidence in the somatic marker hypothesis. However if it is further validated, it creates a new agenda for driver behaviour research or, at the very least, creates a new set of priorities for that research.

## New agenda for research

One clear prediction from the somatic marker hypothesis is that individual differences in the affective response to particular scenarios should be associated with different decisions in relation to those scenarios. Thus if we take speed choice as an operationalisation of decision making, drivers who are more emotionally reactive to dynamic road scenarios, representing various degrees of threat (or impending loss-of-control), should opt for lower speeds than drivers who are less reactive.

A further prediction from the hypothesis is that attentional selectivity should be affected by somatic marker strength. We might operationalise this selectivity in terms of prioritisation and dwell time for particular stimuli in the environment, measured for example in terms of visual fixation patterns. Do maps of points of varying degrees of attention reflect the affective profiles of those points?



If these kinds of study confirm the somatic marker hypothesis, a number of further questions immediately suggest themselves. At a fundamental level we might ask if there are key elements of the dynamic road and traffic environment which act as powerful somatic markers, for example rapidly looming stimuli, converging stimuli (with the driver's trajectory), the rate of stimulus change in peripheral vision, or the level of g forces acting on the vestibular system or, as suggested earlier, the sense of an impending loss of control. Is it possible that in general there may be the equivalent of an inverse square law of affect intensity in driving, with feeling intensity growing in proportion to the inverse square root (or other expression) of the time-to-line crossing or to collision, for example?

Are there stable individual differences in emotional reactivity? If there are, this could mean that the same situation would ring alarm bells somewhat differently for different individuals. Some may be relatively so deaf that an impending hazard has to be right on top of them before they are able to hear it, so to speak. These persons would unwittingly be in a condition of delayed avoidance (Fuller, 1984). Larsen and Diener (1987) review evidence which strongly suggests that affect intensity is a stable individual difference characteristic defined in terms of the typical strength of an individual's responsiveness. Are such differences related to gender? According to Fujita *et al.* (1991), women report experiencing negative and positive affect more intensely than men. They asked 100 students to complete the Affect Intensity Measure (Larsen and Diener, 1987) which consists of 40 items which measure how intensely participants feel emotions and yields both a positive and negative affect intensity score. Females scored higher on both positive and negative affect intensity. This naturally leads to the hypothesis that male-female differences in risk taking may be mediated by differences in emotional reactions to those risks. Perhaps males crash more because they feel less. Can the same be said in relation to age differences? Loewenstein *et al.* (2001) speculate age-based differences in risk taking may be 'affectively mediated', in particular that they may be the result of possible differences in the vividness of mental simulations of behaviour at the moment of decision making.

Are such differences related to developmental sociopathy, which Damasio cites as another example of a pathological state in which a decline in rationality is accompanied by a diminution or absence of feeling? Or are such differences related to the disposition of the individual to engage in denial processes, which enable dealing psychologically with painful, unpleasant experiences by ignoring their existence. This can be effective in the short term in enabling us to continue everyday activities without interference from disturbing emotional reactions triggered by the painful experience. However if used in the context of driving, denial of the negative affective associations to particular decision options would distort attentional processes and the quality of decision making. According to the somatic marker hypothesis, such denial processes must work against the individual making informed decisions about the risk to life and limb to himself or herself as well as to others.

Can somatic markers generated by the unfolding road and traffic scenario be drowned-out by, or misattributed to, other feelings? For example, can feelings of anger, or of sensation and thrill, or of stress displace the somatic marker indications which would otherwise inform decision making? Is this what we mean by blind, when we talk about blind rage? Deffenbacher *et al.* (2003) have shown that high anger drivers are between 1.5 and 2.0 times more likely to engage in risky non-aggressive driving, such as exceeding the speed limit and not wearing a seat belt.

We already know that extraverted individuals are more likely to seek enhanced external stimulation. Does this then mean that they may be more likely to accept higher levels of somatic arousal and, other things remaining equal, because of this be more likely to find themselves approaching a situation where the task demand exceeds their capability? Related to extraversion is the dimension of sensation seeking which, like extraversion, is also considered a constitutional characteristic of the individual (Zuckerman, 1979). Evidence supports the prediction that individuals high in sensation seeking are more likely to speed, overtake and adopt shorter headways. They are also over-represented in traffic crashes (Jonah, 1997). Are these effects mediated by a displacement of somatic marker indications? Are the whispers of affect drowned out by screaming sensation? Combining some of these possibilities, Dahlen *et al.* (2005), in a questionnaire study of 224 undergraduate drivers, found that both the propensity to become angry while driving and the degree of sensation seeking predicted risky driving, minor losses of vehicle control and loss of concentration while driving.

What about factors that might suppress sensitivity to somatic markers, such as a state of depression, or the effects of depressant drugs such as alcohol? Is the drug-related impairment in driving associated with alcohol in part mediated by this process (i.e. loss of sensitivity to the consequences of one's actions)? Is it possible to become desensitised to somatic markers, as suggested by Näätänen and Summala (1976) and others? Does such desensitisation explain in part the over-representation of professional racing drivers in collisions on the public highway?

Are there implications of the somatic marker hypothesis for driver education and training? Damasio argues that somatic markers are acquired through experience, under the control of an internal preference system and under the influence of an external set of circumstances. The internal preference system consists of 'mostly innate regulatory dispositions, poised (poised?) to ensure survival of the organism' (Damasio, 1994, p. 179). The external set of circumstances includes 'events relative to which individuals must act; possible options for action; possible future outcomes for those actions; and the punishment or reward that accompanies a certain option, both immediately and in deferred time, as outcomes of the opted action unfold ... The interaction between an internal preference system and sets of external circumstances extends the repertory of stimuli that will become automatically marked' (Damasio, 1994). This sounds remarkably like the description of an affect-conditioning history. And indeed he goes on to state: 'When the choice of option X, which leads to bad outcome Y, is followed by punishment and thus painful body states, the somatic marker system acquires the hidden, dispositional representation of this experience-driven, noninherited, arbitrary connection' (p. 180).

Harrison (2005) has recently shown how easy it is to condition behaviour change to consistencies in traffic contingencies – specifically delaying entry into a junction when approaching motorcycles are present. It would be really useful to extend this research in two directions, first to determine changes in affect related to the key discriminative stimuli here and, second, to determine any changes in attentional preference arising out of the conditioning process. We may then begin to get a rather more complete picture of the relationship between learning and attentional processes.

Learning of appropriate affective responses to potential outcomes on the roadway may be an important element in learning how to drive safely. In a field study of patterns of visual fixations by novice and experienced drivers, Underwood *et al.*

(2003) have shown that on rural roads, two-fixation transitions by novices typically terminated in just one zone, the road far ahead, whereas those by experienced drivers terminated in five different parts of the scene. On a dual carriageway, experienced drivers also showed more extensive scanning, particularly in the horizontal plane. Underwood *et al.* characterised this as experienced drivers being more sensitive to whatever traffic conditions prevail. They conclude that the monitoring of other road users arises as a result of experience and that novices have relatively little ability to switch the focus of their attention as potential hazards appear. The somatic marker hypothesis offers the possibility that these learned differences in visual scanning between novice and experienced drivers may be the result of learned affective responses to events on the roadway, such as fast-moving vehicles merging from both left and right in the dual-carriageway situation.

Is it inappropriate (or absent) affect, then, that mediates in part the difference between inexperienced and experienced drivers, where the experienced driver has learned that such-and-such a negative outcome is possible in a given scenario. Of relevance to the notion of possibilities in a given potentially threatening scenario, Loewenstein *et al.* (2001) cite a number of studies which show that under conditions of uncertainty, feelings of fear appear to have an all or nothing characteristic, that is sensitive to the *possibility* rather than the *probability* of negative consequences. In these experiments, which concerned anticipatory emotion, participants experienced a series of countdown periods at the end of which they received, with some stated probability, a painful electric shock. Physiological responses to the impending shock were correlated with expectations about shock intensity – but not the probability of receiving the shock (except where the probability was zero). Loewenstein *et al.* conclude that the mere thought of receiving a shock is enough to arouse individuals, but the precise likelihood has little impact.

A further question relates to how such an emotion conditioning process relates to responses to violations of the traffic code. Does the prevalence of speed violations simply reflect that such violations are not associated with negative affect? What are the implications for training using a simulated or virtual road and traffic environment – and for that matter, research? What are the implications for the design of media safety campaigns which aim to modify road-user behaviour?

And given the variability of individuals' conditioning histories, is this perhaps in part why decision making in safety sensitive industries, such as commercial aviation, has moved forcibly, albeit unwittingly, away from reliance on somatic markers towards standard operating procedures: prescriptive rules for dealing with each contingency experienced? In areas such as aircraft maintenance, where the affective consequences of inappropriate actions must be extremely weak, if they exist at all, a reliance on standard operating procedures must be even more important for maintaining system safety. Thus it is a breach of standard operating procedures which then becomes the somatic marker which informs decision making.

In the control of driver behaviour, the use of enforcement as a deterrent may well operate through the same process. Thus, for example, speeding *per se* may not generate appropriate somatic markers to deter the behaviour, but the possibility of an unpleasant and punishing encounter with the police may produce just such an effect.

# Conclusion

From the forgoing discussion it can be seen that the somatic marker hypothesis has the potential to provide a unifying explanation for a diverse set of empirical findings in the domain of driver behaviour, including our finding that feelings of risk track ratings of driving task difficulty and speed almost perfectly. It also raises a number of new questions regarding the role of affect and emotional conditioning in attention and decision making. This makes the experimental evaluation of the somatic marker hypothesis of some importance in the contemporary research agenda. It may be noted that one author has already begun to develop a model of driver decision-making based fundamentally on the somatic marker hypothesis (Vaa, 2004). The implication is that if we want to understand driver decision-making more clearly, we need to take into account not just thinking but also feeling.

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# 10

## Why do drivers break the speed limit?

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### Introduction

Speed choice is regarded as one of the clearest factors involved in crash involvement. The arguments supporting this are a matter of logic and empirical evidence. As a matter of logic it is clear that the more energy involved in a crash the more opportunity for injury. It is also argued that as speed increases, then there is less time to react and the probability of a crash increases. At an empirical level the relationship between speed choice and crash involvement emerges from a combination of sources. Those who are observed on the road to drive faster have more accidents (Wasielewski, 1984). Those who self-report that they drive faster are more involved in accidents (French *et al.*, 1993) and those who choose faster speeds on a video assessment are more involved in speed-related accidents (Horswill and McKenna, 1999). It has also been found that if the legal speed limit goes up, then the casualties increase (Rock, 1995).

Given the connection between speed choice and accident involvement, it might be wondered why drivers break the speed limit in such large numbers? Gabany *et al.* (1997) argue that factor analysis reveals five factors that are involved in why drivers break the speed limit. They labelled these (a) thrill, (b) time pressure, (c) inattention, (d) ego gratification, and (e) disdain of driving. Conceptually the latter two factors were the most difficult to interpret. For example, the ego gratification factor included items that appeared similar to the thrill factor. For example, one item was 'Speeders get a thrill from breaking the law'. The disdain of the driving factor included items that appeared similar to the time-pressure factor. For example, the disdain of the driving factor included the item 'Drivers speed because every minute counts'.

The factors generated by Gabany *et al.* (1997) were based on judgements of why people believed other drivers broke the speed limit. They were not based on what drivers themselves offered as reasons for their own speeding, nor were they based on judgements made by drivers who admitted that they did speed. In the present investigation the judgements were made by those who had been caught speeding and were asked to rate what factors were involved in their own speeding. Two groups of

speeding drivers were assessed: those who had broken the speed limit by a small margin and those who had broken the speed limit by a large margin. Since it is possible that the factors involved in breaking the speed limit are different across these two groups, comparisons were made. The overall aim is to understand why drivers break the speed limit. The first two factors offered by Gabany *et al.* (1997) thrill – and time pressure – are commonly thought to have a significant impact on driving behaviour. Adams-Guppy and Guppy (1995) examined the role of time pressure and Jonah (1997), while not explicitly considering the role of speed limits, has reviewed the evidence of the importance of thrill seeking in risky behaviour. While it is likely that thrill seeking and time pressure will result in faster speeds and hence greater law breaking, it is not clear how much speeding behaviour can be accounted for by these factors.

A primary aim was to explore the factors that drivers offer as being important in their particular driving offence. A secondary aim was to determine if the factors offered by drivers were situation-specific versus general aspects of their driving behaviour. For example, it is possible that time pressure is a random transient factor that influenced speeding behaviour only in this specific offence and is not characteristic of general behaviour. Alternatively, it is possible that the driver generally perceives himself/herself to be under time pressure. An attempt was made to assess this distinction in two stages. The first stage considered whether the specific reason offered by the driver predicted their accident involvement. If it did predict their accident involvement, then this would be consistent with this factor, reflecting a more general aspect of their driving. This was then further assessed by entering a more general factor into the regression and only adding the specific factor at a later stage. If the specific factor no longer is able to predict accident involvement, then this is consistent with the specific factor being a sample of a more general behaviour. For example, drivers rated the extent to which they were enjoying speed at the specific time of the offence. If this specific thrill factor predicted accident involvement, then this would be consistent with the view that ratings related to a specific driving offence reflected more general behaviour. If a general thrill-seeking measure was entered into the regression and the specific thrill-seeking measure no longer predicted accident involvement, then again this would be consistent with the view that the specific sample of experience reflected a more general approach to driving.

## Method

### Participants

A total of 9,196 drivers who attended a low-speed awareness course provided answers and a total of 274 who attended a high-speed course did likewise.

### Procedure

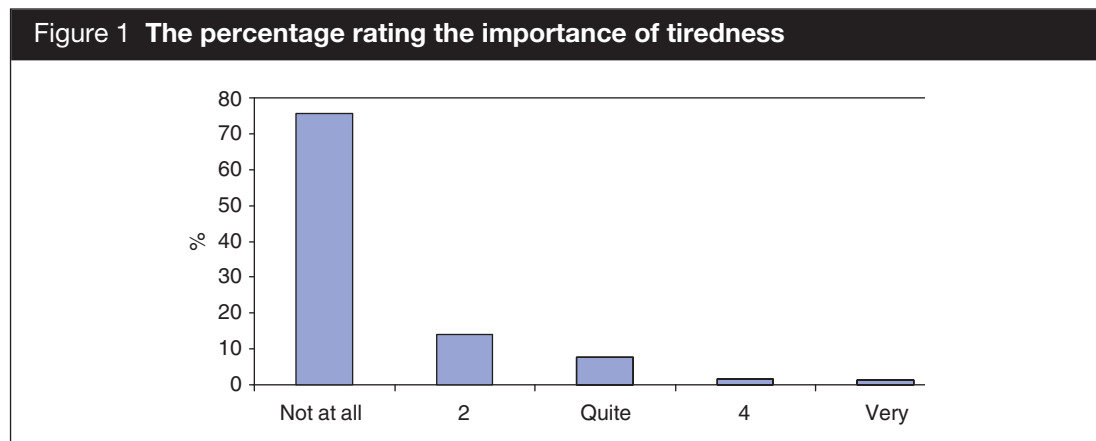
The questions were presented as part of a computer assessment and training session that provided feedback to the driver on their personal Driving Risk Profile. The overall session took between 40–50 minutes and covered a broad range of topics including demographics, self-reported speed, driving violations, fatigue, driving experiences and personality. Digitised video tests were also included that assessed speed choice, close following and hazard perception. On finishing the assessment, drivers received a

four-page printout providing (a) feedback on their attitudes and ability, and (b) safety messages tailored to their personal responses. The next session was with a trainer who involved all participants in the discussion, which was designed to cover both perceived barriers to enforcement (e.g. should the police enforce the speed limit, and is this just a money making exercise?) and how speed is connected with accident involvement. The latter is illustrated through examining the personal speed choices of the participants.

The key questions for the present investigation were presented as part of the first session, in which drivers were asked to indicate whether at the time of the offence they were (a) tired, (b) concentrating totally on their driving, (c) upset or annoyed before the driving offence, (d) enjoying going fast, and (e) in a hurry. Their responses were anonymous and were registered via a computer. They rated the importance of each factor on a five-point scale with the following labels: 1 (not at all), 3 (quite) and 5 (very).

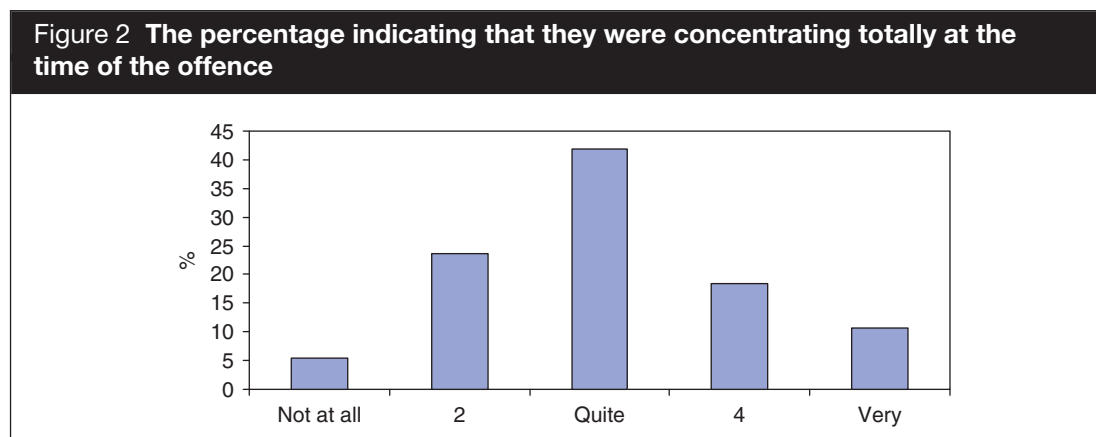
## Results

The extent to which tiredness was rated as an important factor can be seen in Figure 1.



An alternative method of describing these results is to combine ratings 1 and 2 and to define this as having little impact. On this basis we can conclude that 89% indicated that tiredness had little impact on their speeding offence.

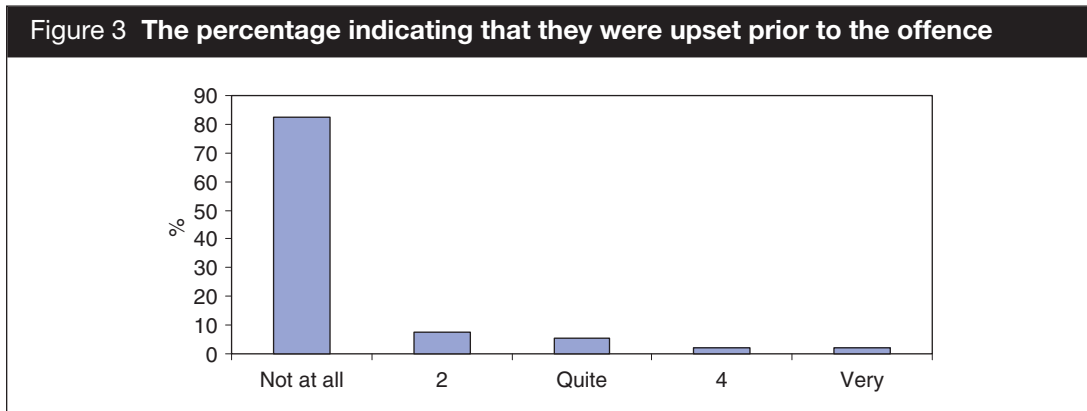
Figure 2 illustrates the role of concentration.





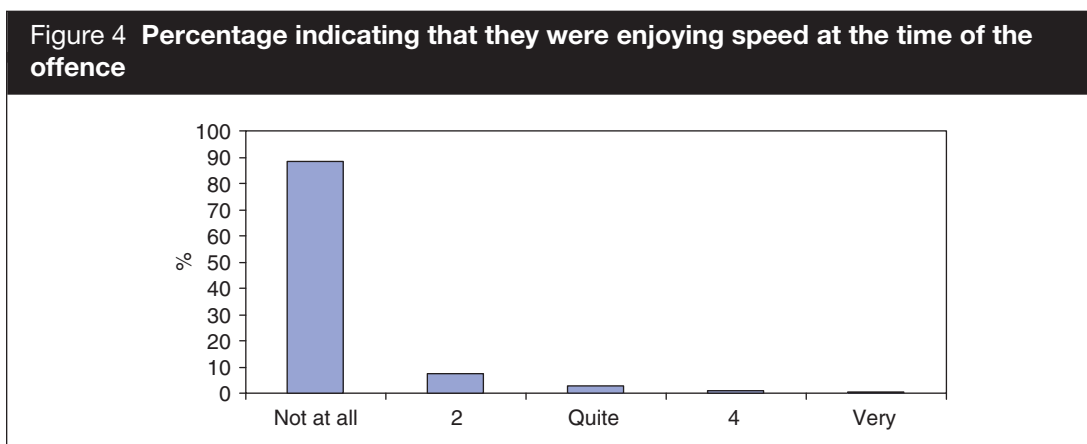
Combining categories 1 and 2 reveals that 29% indicated that they were not concentrating totally on their driving at the time of the offence.

Figure 3 indicates the percentage who were upset or annoyed prior to the speeding offence.



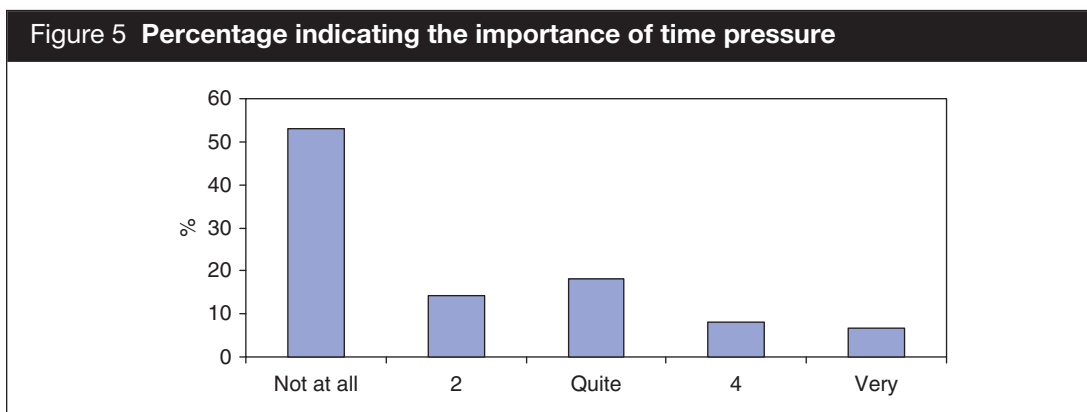
Combining categories 1 and 2 reveals that 90% indicated that annoyance had little impact on their speeding offence.

Figure 4 describes the rated importance of enjoying speed at the time of the offence.



Combining categories 1 and 2 reveals that 96% indicated that enjoying speed had little influence on their speeding offence.

Figure 5 demonstrates the role of time pressure.



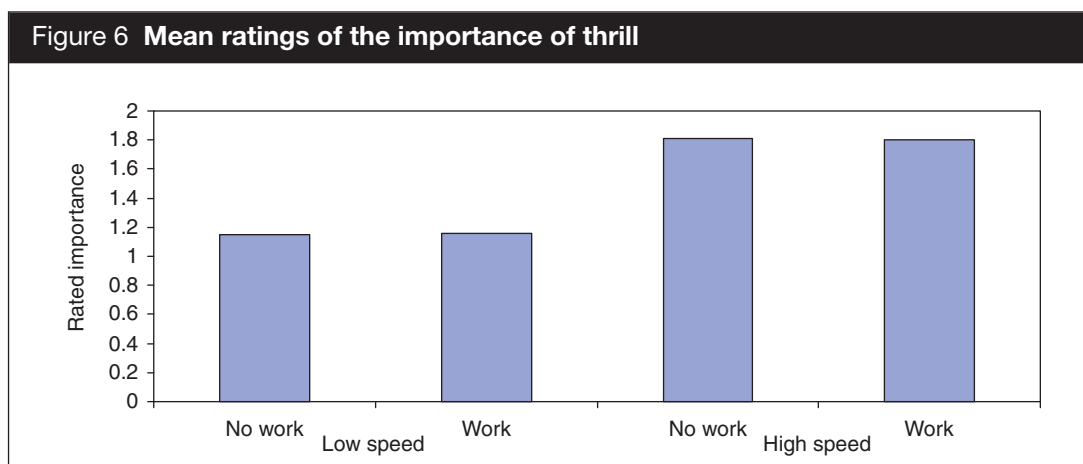
Combining categories 1 and 2 reveals that 67% indicated that there was little time pressure at the time of their speeding offence.

## Comparison of high versus low speed offenders

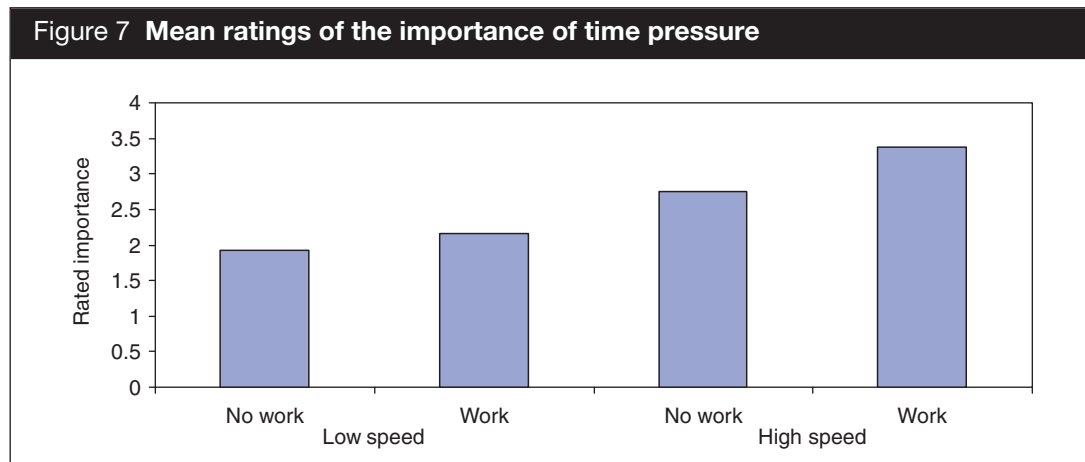
In order to determine whether the various factors were rated to the same extent across speeding groups, comparisons were made between those who have broken the speed limit by a small margin versus those who have broken the speed limit by a large margin. It was found that there was no significant difference between the two groups in their ratings of the role of tiredness ( $t(9468) = 0.23, p = 0.82$ ). There was a significant difference in concentration such that those who had broken the speed limit by a large margin were more focused on their driving ( $t(9468) = 3.99, p < 0.001, \text{Cohen's } d = 0.24$ ). There was a significant difference in the level of annoyance such that those who had broken the speed limit by a large margin were more upset prior to breaking the speed limit ( $t(9468) = 3.61, p < 0.001, \text{Cohen's } d = 0.22$ ). There was a significant difference in enjoying speed such that those who had broken the speed limit by a large margin indicated that they were more often enjoying the speed when they were caught ( $t(9468) = 20.7, p < 0.001, \text{Cohen's } d = 1.24$ ). There was a significant difference in time pressure such that those who had broken the speed limit by a large margin reported more time pressure ( $t(9468) = 12.1, p < 0.001, \text{Cohen's } d = 0.73$ ). Overall, it can be seen that there are two factors where the differences are not small: thrill and time pressure.

## Further analyses of thrill and time pressure

In order to explore the thrill and time pressure factors further, these have been split into high- and low-speed groups and into whether they were caught speeding while on work-related driving, thus forming four groups. In considering the role of thrill, a one-way ANOVA (ANalysis Of VAriance between groups) confirmed that there were differences amongst the groups ( $F(3,9466) = 143.3, p < 0.001$ ) and Tukey's post hoc test indicated that the two low-speed groups were not significantly different from each other but were significantly different from the two high-speed groups which were not different from each other (see Figure 6).



In considering the role of time pressure, a one-way ANOVA confirmed that there were differences amongst the groups ( $F(3,9466) = 70.7, p < 0.001$ ) and Tukey's post hoc test indicated that all groups were significantly different from each other (see Figure 7).



While the overall ratings of the importance of thrill remains low (on average drivers rate it as of little importance), the ratings for time pressure are greater and, for those who have been caught speeding at a high level and who were engaged in work-related driving at the time of the offence, the average rating indicated that time pressure was quite important.

## The relationship between ratings and accident involvement

In order to determine whether the factors operating at the time of the offence reflected transient versus enduring influences on driver behaviour, a series of logistic regressions were carried out to determine if the factor operating at the time of the offence could predict accident involvement.

A direct logistic regression was performed on accident involvement as outcome and age, mileage and tiredness at the offence as predictors. According to the Wald criterion, all three were significant including tiredness at the offence (Wald = 8.3,  $p < 0.01$ ). To determine whether the tiredness at the offence factor could account for variance not accounted for by a more general measure of frequency of driving tired, a hierarchical regression was carried out. The general measure of frequency of tired driving was entered first with age and mileage. The specific measure of tiredness at the offence was entered as a predictor in the second block. The general measure of frequency of tired driving was significant according to the Wald criterion (Wald = 34.3,  $p < 0.001$ ) and interestingly the specific measure of tiredness at the offence entered in the second block was no longer significant (Wald = 2.2,  $p > 0.05$ ). This pattern of results is consistent with the view that the specific rating of tiredness at the time of the offence reflects a more general measure of driving tiredness.

A direct logistic regression was performed on accident involvement as outcome with age, mileage and whether the driver was concentrating at the time of the offence as predictors. According to the Wald criterion, all were significant including the level of concentration at the time of the offence (Wald = 5.7,  $p < 0.05$ ). To determine whether concentrating at the time of the offence could account for variance not accounted for by a more general measure of lapse of attention, a hierarchical regression was carried out. The general measure of lapse of attention was entered first with age and mileage. The specific measure of concentration at the time of the offence was entered as a predictor in the second block. The general measure of lapse of attention was significant according to the Wald criterion (Wald = 33.24,  $p < 0.001$ ) but the specific measure of concentration at the time of the offence was no longer significant (Wald = 0.58,  $p > 0.05$ ). This pattern of results is consistent with the view that the specific rating of level of concentration at the time of the offence reflects a more general measure of driver attention.

A direct logistic regression was performed on accident involvement as outcome with age, mileage and level of annoyance prior to the driving offence as predictors. According to the Wald criterion, all were significant including the level of annoyance prior to the driving offence (Wald = 6.4,  $p < 0.05$ ). To determine whether the level of annoyance at the time of the offence could account for variance not accounted for by a more general measure of emotional volatility, a hierarchical regression was carried out. Although the Driving Risk Profile does not contain a general measure of emotional volatility, two measures were employed: general level of aggression and using the vehicle as an emotional outlet. The general measures were entered first with age and mileage. The specific measure of level of annoyance prior to the driving offence was entered in the second block. According to the Wald criterion, both the general measure of aggression and the emotional outlet measure were significant (Wald = 10.7,  $p < 0.001$ ; Wald = 36.0,  $p < 0.001$  respectively) but the specific measure of annoyance prior to the driving offence was no longer significant (Wald = 2.6,  $p > 0.05$ ). This pattern of results is consistent with the view that the level of annoyance prior to the driving offence reflects a more general measure of driver behaviour.

A direct logistic regression was performed on accident involvement as outcome with age, mileage and whether drivers were enjoying speed at the time of the driving offence as predictors. According to the Wald criterion, all were significant including enjoying speed at the time of the driving offence (Wald = 17.4,  $p < 0.05$ ). To determine whether enjoying speed at the time of the offence could account for variance not accounted for by a more general measure of thrill seeking, a hierarchical regression was carried out. The general measure of driver thrill seeking was entered first with age and mileage. The specific measure of thrill seeking at the time of the offence was entered as a predictor in the second block. The general measure of driver thrill seeking was significant according to the Wald criterion (Wald = 33.24,  $p < 0.001$ ) and interestingly the specific measure of enjoying speed at the time of the driving offence remained significant (Wald = 11.2,  $p < 0.001$ ). This pattern of results is consistent with the view that enjoying speed at the time of the offence reflects a more general measure of driver behaviour that is not completely captured by the driver thrill-seeking measure.

A direct logistic regression was performed on accident involvement as outcome with age, mileage and time pressure at the time of the driving offence as predictors. According to the Wald criterion, while age and mileage were significant, the role of

time pressure was not significant (Wald = 2.2,  $p > 0.05$ ). This result is consistent with the view that time pressure may be a random transient factor. Although other interpretations are possible, the result is not consistent with the view that time pressure at the time of the offence reflects a more general form of behaviour that is related to accident involvement.

## Discussion

From the general literature, and perhaps intuitively, we might anticipate that factors such as enjoying speed and time pressure would be important factors in breaking the speed limit. We know from the work of Gabany *et al.* (1997) that people believe that these factors are considered as important factors in breaking the speed limit. However, when drivers who have actually broken the speed limit are considered, the majority did not cite any of these factors as having a major impact on their speeding offence. This is well illustrated by the fact that 96% of drivers who had broken the speed limit reported that enjoying speed had little impact on their speeding offence. The role of time pressure was less clear cut but again the majority of drivers reported that they were not under significant time pressure at the time of the offence. There was some evidence that drivers were not concentrating totally on their driving at the time of the offence.

There were differences between the low- and high-speed groups. However, apart from enjoying speed and time pressure, these differences were small. Although the high-speed group reported that enjoying speed was a more important factor in their speeding offence, the overall level of importance of enjoying speed remained low. Time pressure did play a more significant role for a relatively small group of high-speed drivers who were engaged in work at the time of the offence. This latter result does raise a question as to what role workplace policies and pressures might play in drivers' speed choices. Where workplace policies and pressures are condoning, ignoring or encouraging speeding, a question arises as to what actions might be expected. This in turn raises at least two further questions. The first is whether companies have in place a mechanism for knowing whether their drivers are breaking the speed limit and, second, does society have a clear mechanism for informing companies that their drivers have been breaking the law in company time.

In designing countermeasures such as propaganda, training and speed awareness courses, the present results suggest that we should avoid assumptions that the majority of speeding can be accounted for by simple factors such as thrill seeking and time pressure. Breaking the speed limit is endemic at this point in time and no simple factor accounts for the majority of speeding. In the absence of clear data we might speculate that habitual behaviour may play a role. Almost one-third admitted that they were not totally paying attention at the time of the offence. If we were to reverse this, then 29% indicated that they were concentrating totally on their driving, thus leaving a substantial proportion who were not concentrating totally on their driving.

Although factors such as thrill seeking could not readily account for the majority of speeding, they were not irrelevant to driving in general. Drivers' ratings of the

importance of tiredness, level of attention, level of annoyance and enjoying speed at the time of the offence all predicted their accident involvement. Although these were measures that were relevant to a specific point in time and space, namely the speed offence, it seems likely that this specific sample of behaviour is representative of their more general driving behaviour and, hence, the relationship with accident involvement. Time pressure did not fit this pattern and, hence, the importance of time pressure at the time of the driving offence was not a significant predictor of accident involvement. More general measures of driving while tired, attention lapses, emotional volatility and thrill seeking were available as part of the Driving Risk Profile and all of these measures were predictors of accident involvement. When these more general measure had been taken into account, then the specific measures relevant to the driving offence could not account for any additional variance in accident involvement (with the exception of speed enjoyment). The fact that the specific measures could not account for additional variance in accident involvement is consistent with the view that the factors rated by the drivers in relation to their speeding offence were factors that were relevant to their driving behaviour and that the general measures in the Driving Risk Profile could account for this variance. The fact that enjoying speed at the time of the offence could predict accident involvement even when a general thrill factor has been taken into account is interesting. One speculation would be that there may be knowledge that the law is being broken and this may constitute a factor that is different from simply enjoying speed.

## Conclusion

While people believe that factors such as thrill seeking and time pressure can account for breaking the speed limit, there is not much evidence of support from the majority of drivers who have broken the speed limit. Level of attention may play more of a role. Although factors such as thrill seeking, tiredness, level of attention, and being upset prior to the speeding offence may not provide an unambiguous account of speeding, they are not irrelevant to driving in general. Although each of these ratings were concerned with a specific time and place (the driving offence), all of these ratings predicted accident involvement.

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# 11

## A multiple case study of work-related road traffic collisions

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### Abstract

We have completed four projects for the Transport Research Laboratory (TRL)/Department of the Environment, Transport and the Regions (DETR)/Department for Transport, Local Government and the Regions (DTLR) on right-turning accidents, overtaking accidents, young drivers' accidents and motorcycle accidents. Our latest project, completed recently, looked at work-related road traffic accidents. This paper reports findings relating to 2,111 police case reports involving work-related road traffic accidents (over 1,000 of them in detail) from three Midland police forces. Nearly 90% of the sample was found to contain six main classes of vehicle being used in a work-related capacity. These were: company cars, vans/pickups, lorries/large goods vehicles (LGVs), buses/coaches, taxis and emergency vehicles. Various differences were found in accidents involving drivers of each class of vehicle. Other types of work-related accident were also examined, e.g. accidents involving workers on, or near, the road. The implications of these findings are discussed.

### Introduction

According to both the Royal Society for the Prevention of Accidents (RoSPA, 1998) and the Trades Union Congress (TUC, 2004), traffic accidents while at work are the single biggest cause of employment-related fatality in the UK. Research carried out over recent years has suggested that drivers who drive for business purposes are at an above average risk of accident involvement relative to the general driving population. Research by Broughton *et al.* (2003) compared company car drivers with a sample of non-business drivers, matched for factors such as age, gender, annual mileage and percentage of annual mileage done on motorways. Drivers who drove more than



80% of their annual mileage on work-related journeys had about 53% more accidents than similar drivers who had no work-related mileage. High-mileage high-risk work-related drivers were found to admit to undertaking long journeys after a full day of work, driving under time pressure to reach specific destinations, and performing potentially distracting tasks while driving, e.g. mobile phone conversations, and eating or drinking on the move.

Research work already carried out in the School of Psychology at Nottingham (Chapman *et al.*, 2000) has indeed found that employees who differ in employee status and business mileage requirements show important differences in self-reported driving behaviours, accident frequency, and in the types of accidents reported. Company drivers who drove a car that could be described as a 'perk' car (received as part of a remuneration package), and sales staff driving company cars, appeared to be at a particularly increased risk of accident. Staff driving their own vehicles on business mileage allowances and staff driving liveried vehicles appeared to have an accident rate much closer to that of the general driving population. Chapman *et al.* comment that these findings highlight the importance of understanding that company car drivers are not a single homogenous group.

Research by Bomel Ltd (2004) showed how organisational culture in the workplace is important in terms of levels of work-related road accidents. They examined company vehicle drivers in both small and large companies, driving mainly company cars and LGVs. There was a key relationship shown between safety culture, driver attitudes and accident liability. LGV drivers (particularly those transporting hazardous loads) had more safety measures applied to their driving than equivalent company car users, and safety management systems were sometimes found to be lacking in smaller companies when compared with larger companies. Cross-company comparisons showed that the lowest accident rate (and highest positive scores on a driver attitude scale) were shown by a company with 'clear driving standards and rules, excellent driver training, and a policy to report and try and learn from all driving incidents'. The company with the worst accident rate (and most negative driver attitudes) had 'no formal driver training, unclear rules/reporting requirements, and relatively ineffective lines of communication'.

## Method

Our method relies on the human interpretation of the full sequential nature of the accident story in each individual case, which is where the technique of qualitative human judgement methodology proves more useful than more traditional statistical methods applied to aggregated data. Full details of our method can be found in previous reports and papers (e.g. Clarke *et al.*, 2004).

The data were entered into a FileMaker Pro database customised to handle the information and search parameters required for this project. Data are entered describing the relatively objective facts of each case: time of day, speed limit, class of road etc. A 'prose account' is also entered for each case giving a step-by-step description of the accident. These accounts give a detailed summary of the available facts, including information from witnesses that appears to be sufficiently reliable. A minimum set of possible explanations for each accident is recorded from a standard checklist adapted

and developed from a previous study (Clarke *et al.*, 2004). The ultimate aim of the database was to build a library of analysed cases stored as a series of case studies.

Taking just the most detailed, or 'A' class, cases, the next step was to consider simple behavioural countermeasures which could have made a substantial difference to the outcome of each accident in turn, either by preventing it or reducing its severity. A list of 23 possible behavioural strategies for avoiding typical accidents was drawn up using established texts such as *Roadcraft* and *The Highway Code*, together with prior knowledge of the data.

## Results

A total of 2,111 work-related road accident files were examined. There were 1,009 (48%) of the most detailed 'A' grade type. There were 103 fatal accidents (4.9%) and a further 249 (11.8%) involving serious injuries to a driver/worker.

There were 15 types of vehicle (including 'miscellaneous or other') entered into the database. Six classifications of vehicle were found to be the most commonly involved in work-related road traffic accidents. These were: company cars; vans/pickups, lorries (heavy goods vehicles (HGVs)/LGVs of all weights); buses (public commercial vehicles (PCVs)); taxis (including Hackney carriages and minicabs); and emergency vehicles (EVs). These top six vehicle categories covered over 88% of the sample as a whole.

## Blameworthiness ratios

All cases were assessed by coders as to the blameworthiness of any participants in the incident. Drivers could be rated as either 'to blame', 'at least partly to blame' or 'not to blame' in any given accident, and there are also codings for pedestrian fault, unforeseen mechanical failure and miscellaneous others. Table 1 shows the blameworthiness ratios for drivers of the six main types of vehicle that we have identified, i.e. the number of accidents where the driver is rated as at least partly or fully to blame, divided by the number of accidents caused by all other factors, most usually another road user/driver. Here, a ratio of 1.0 indicates that the driver is equally likely to cause an accident as he/she is to become the victim of an accident caused by another. The ratio for all work-related drivers in the sample is also shown, for comparison.

**Table 1 Blameworthiness ratios (in order of magnitude) for six types of work vehicle in road accidents**

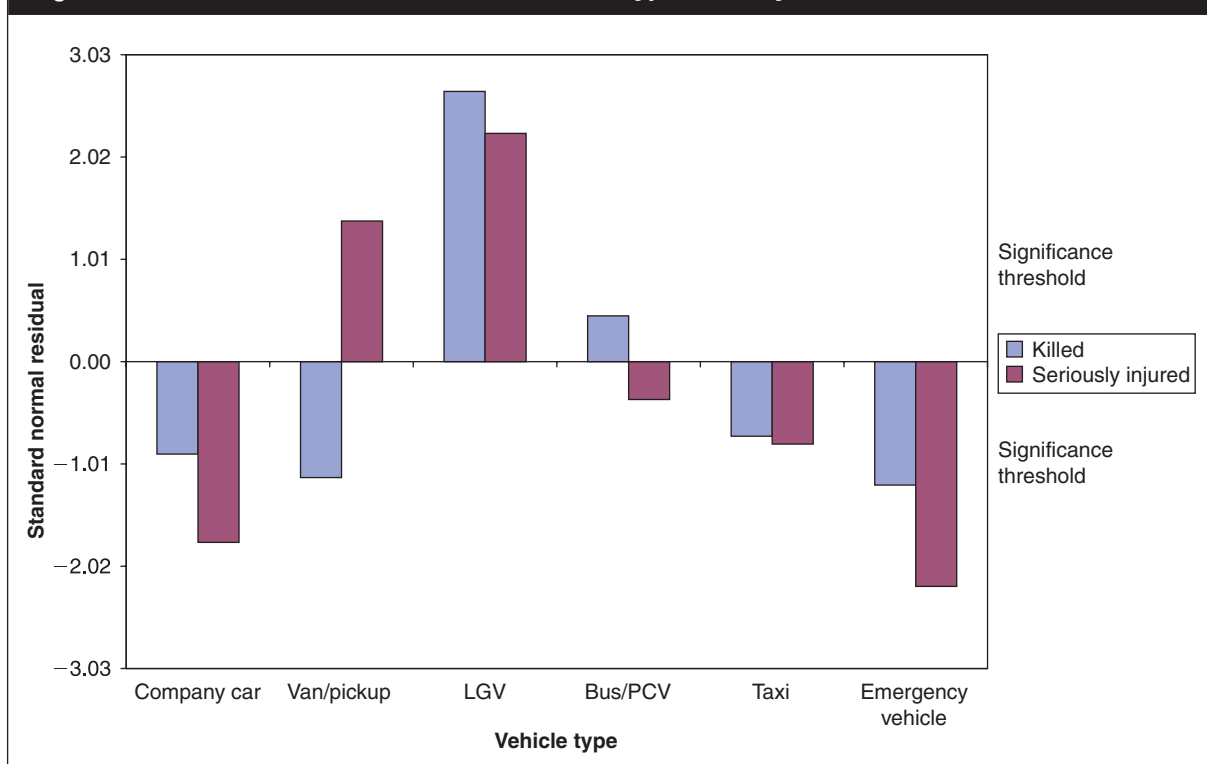
Vehicle type	Blameworthiness ratio
Lorry/LGV	2.46
Van/pickup	2.08
Company car	1.18
Emergency vehicle	0.90
Taxi/minicab	0.70
Bus/PCV	0.56
All work-related drivers	1.39

Work-related drivers, when considered as a whole, were seen to have an elevated blameworthiness ratio, i.e. were more likely to actively cause accidents than become involved as blameless or passive participants. However, splitting the sample into groups by concentrating on vehicle types reveals that there were important differences between different driver groups. Only the top three classes of vehicle had drivers that were coded as being at least partly to blame in more than 50% of the accidents that they were involved in. The last three classes of vehicle suffered proportionally more accidents primarily caused by other road users.

## Accident severity

An initial examination of the severity of accidents in the sample showed that LGVs were more likely than other vehicle groups to be involved in fatal and serious accidents. To examine the effect of vehicle class,  $O - E/\sqrt{E}$  was computed for cells in a table, where 'O' is the observed figure and 'E' the expected figure. This can be treated as a standard normal residual. This measure is based on the  $\chi^2$  statistic and attempts to provide an induced exposure measure by finding combinations of a 'row' feature and 'column' feature which are considerably over-represented in the data, even when mere coincidences have been allowed for (Colgan and Smith, 1978). For each cell,  $O - E/\sqrt{E}$  is calculated and the resulting figure is evaluated against the square root of the upper 5 percentile point of the appropriate  $\chi^2$  distribution divided by the number of cells in the table. Here, a figure exceeding  $\pm 1.01$  is approximately equivalent to a significance level of  $p < 0.05$ , and the null hypothesis is that there is no interaction, i.e. differences between accident severity are unaffected by vehicle, and vice versa. Figure 1 shows the clear over-representation of LGVs using this analysis.

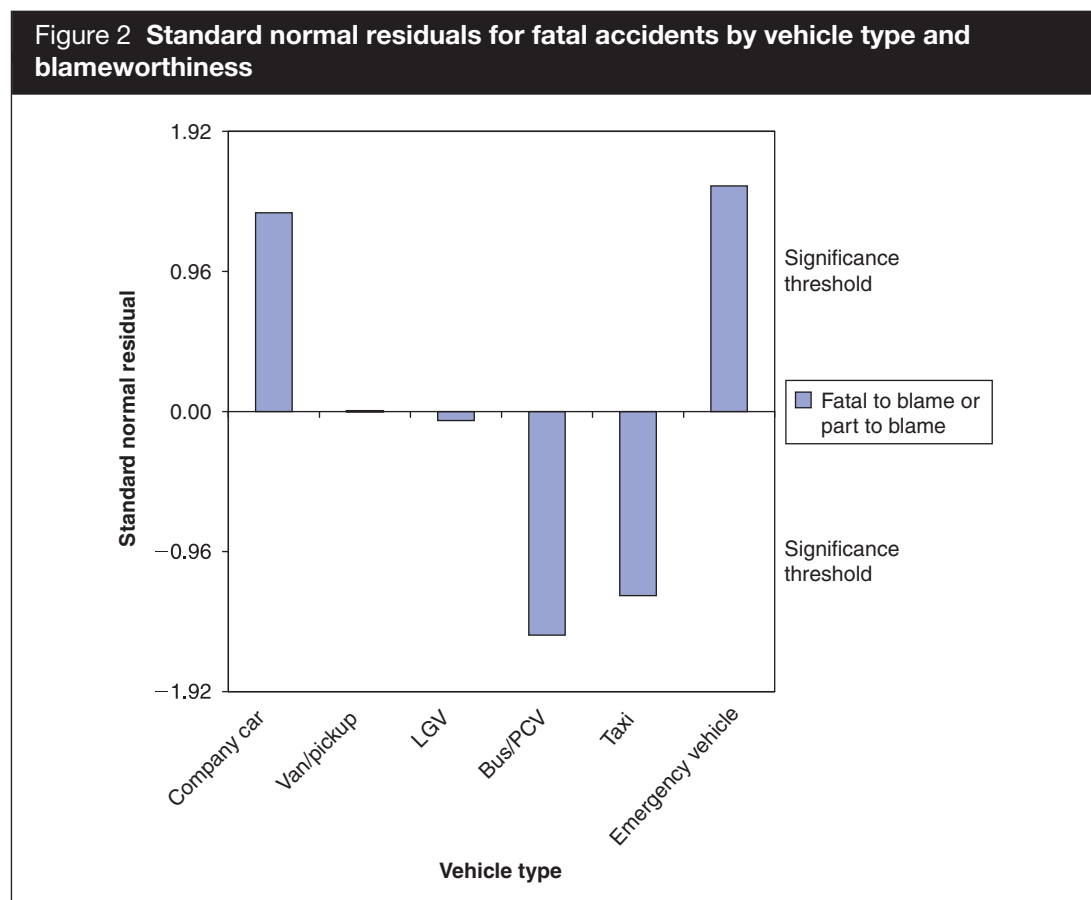
Figure 1 Standard normal residuals for vehicle type/severity of accident



Such a finding is hardly surprising, and could be expected to occur as a result of LGVs' large mass increasing the severity of any crash they are involved in. However, when blameworthiness is taken into account, a different picture emerges. In fatal

accidents where LGV drivers are considered at least partly to blame, the majority of cases appear to occur as a result of poor observation and distraction. The most common result is running into the rear of other vehicles, causing either a fatal crushing injury to another vehicle occupant or to the LGV driver themselves. Such accidents occur mostly on motorways or dual carriageway A class roads. About a quarter of fatalities caused by LGV drivers involve breaking the speed limit; these include cases where the driver is breaking the applicable limit for a vehicle of that class, as well as those ignoring posted speed limits. There was evidence of fatigue or illness in around a fifth of fatalities caused by LGV drivers. Two fatalities were caused by overloading or insecure loads. One fatal case showed the lengths to which some drivers will go, in terms of perceived time pressure and willingness to circumvent safety protocols: a driver had disabled his speed limiter, which also disabled his anti-lock braking system (ABS), prior to his journey. He had also removed the number plate fixed to the trailer to avoid speed detection (which he claimed was common practice). He was paid for working a 45-hour week, so it was presumably in his interest to finish his work as quickly as possible. A seizure of his past tachograph records found 65 other speeding offences.

However, over half of the fatal LGV accidents were found to be cases where the LGV driver was *not* to blame. Running the standard normal residual analysis again on fatal cases alone, and taking blameworthiness into account, showed that there were only two groups of drivers significantly more likely to have a hand in causing fatal road accidents, rather than becoming involved as blameless participants: company car drivers and emergency vehicle drivers. Figure 2 shows the standard residual analysis.



It is important to realise that (fortunately) overall numbers of fatal accidents are quite small, so these results should be treated with some caution. Nevertheless, an examination of common patterns in company car fatal accidents shows that over half

of them involve excessive speed on the driver's part. There was only one case of excessive alcohol consumption; two cases where driver fatigue played a part; and one case where a driver was distracted by using a hands-free mobile phone.

With drivers of emergency vehicles, the majority of the fatal accidents caused involved excess speed, as might be expected. In half of them, another driver's behaviour had also contributed to the accident in some way, including a driver who had clearly failed to observe a speeding police car using emergency lights that was about to overtake her vehicle as she turned.

## Explanatory factors in work-related accidents

An explanatory factors list with 64 items was used to categorise each accident in the sample. This list was summarised further into seven 'background' factors, and eight major 'behaviour' factors. Table 2 shows the results of a standard normal residual analysis of these factors in all 'at fault' accidents, across the six major vehicle types. Significant figures ( $p < 0.05$ , threshold value  $\pm 1.07$ ) are highlighted in bold.

Table 2 Explanatory factors in accidents: standard normal residuals across six vehicle types						
	Comp. car	Van	LGV	Bus	Taxi	Emer. Veh.
<b>Background</b>						
Slippery roads	<b>1.07</b>	0.16	-1.45	-0.57	-2.22	0.32
Vehicle defects	-1.44	-0.70	<b>1.50</b>	0.08	0.10	-0.39
Unusual handling	-2.07	-1.80	<b>3.96</b>	-0.04	-1.01	-1.29
Load problems	-2.53	0.89	<b>2.55</b>	-1.25	-1.23	-1.58
Alcohol	<b>1.35</b>	0.46	-1.19	-0.20	-0.17	-1.39
Fatigue/illness	0.18	-0.12	<b>2.36</b>	-1.67	-0.43	-2.10
Time pressure	-2.94	-2.50	-3.51	-1.74	0.04	<b>15.63</b>
<b>Behaviour</b>						
Close following	-0.23	-1.04	<b>1.67</b>	<b>1.83</b>	-2.21	-3.44
Excess speed (limit and conditions)	<b>1.32</b>	-0.22	-1.90	-2.70	-1.21	<b>1.79</b>
Poor observation (all categories)	<b>1.94</b>	<b>3.52</b>	<b>2.20</b>	<b>3.00</b>	<b>4.50</b>	-1.68
Failure to signal	0.13	-1.43	-0.08	<b>3.06</b>	-0.30	-0.81
Gap judgement	0.91	0.00	-1.48	-0.53	<b>1.30</b>	-0.75
Distance to stop judgement	-3.24	-2.79	-3.45	-1.10	-2.04	-2.23
Failure to check load	-1.09	-0.34	<b>1.75</b>	-0.54	-0.53	-0.68
Deliberate recklessness	-0.78	0.30	-0.62	-0.72	<b>3.50</b>	-0.91

Company car drivers had more of their accidents on slippery roads, or while under the influence of alcohol, or while speeding, than would be predicted by chance, when compared with drivers of other vehicles used for work purposes. Over half of the accidents on slippery roads also involved excessive speed, so there appeared to be a large overlap in these two groups.

Lorry drivers, in contrast, had a higher proportion of close following, fatigue/illness accidents, and accidents resulting from the type of load/handling problems one might expect with this type of working vehicle.

Bus drivers showed a higher proportion of close following and failure to signal accidents. In the failure to signal group, however, another driver shared blame with the 'at fault' bus driver in the majority of cases.

Taxi drivers were the only group that showed over-involvement in accidents caused by deliberate recklessness, or failure to correctly judge gaps in traffic before making a manoeuvre. However, the 'reckless' sub-group was very small, and contained such anomalies as a taxi driver having his vehicle stolen after a violent dispute (i.e. the reckless driver was actually the former passenger).

Emergency vehicle drivers were the only group that showed over-involvement in accidents involving time pressure and excess speed, but this is hardly surprising, given the type of driving this sub-group has to engage in out of necessity.

Every group of drivers with the exception of emergency drivers showed an over-involvement in accidents with an observational failure component. It was decided to examine this factor further to see if there were any specific differences in more detailed sub-types of observational failure among the six groups.

Some evidence of differences in observational failures among the driver groups was found. Van and pickup drivers were found to have had significantly more ( $p < 0.05$ ) accidents where they failed to take account of a restricted view. When the cases were examined, the largest category proved to be cases where heavy or queuing traffic had somehow contributed to blocking a driver's view of other traffic.

Van and pickup drivers were also found to be more likely to have had accidents where they failed to notice another driver's signal. These cases tended to involve either running into the rear of a vehicle that the van/pickup driver had failed to notice was slowing and/or indicating to turn, or alternatively attempting to overtake such a vehicle and subsequently colliding with it.

Bus/PCV drivers were found to be more likely than drivers of other vehicles to have had accidents relating to a failure in continuity of observation. This typically occurred in right of way violations (ROWVs), where a bus pulled out in front of other vehicles without the driver re-checking the road in a particular direction, for example. An excerpt from a police interview with an accident-involved driver illustrates this:

*Police: 'At what point did you see the vehicle?'*

*Driver: 'I didn't see it until she hit me; I was concentrating on the traffic coming the other way. I assumed the road was clear and I carried on then next thing I hear a bang.'*

It is possible that bus drivers have a higher than average exposure level to this kind of collision, given that they often drive set routes around cities during which they must perhaps make many more junction manoeuvres than (say) a company car user, so perhaps this finding is not overly surprising.

Taxi drivers had a disproportionate number of accidents where they failed to look in the relevant direction at all. Most commonly this involved U-turning in the road

in front of a vehicle that is about to pass them, or reversing without enough rear observation and hitting pedestrians or other vehicles. This finding is (again) probably related to the type of manoeuvring (U-turns and reversing) that taxi drivers are most likely to do more of in their regular driving than drivers of other vehicles.

Although emergency vehicle drivers did *not* show an overall over-involvement in observational errors as a causal factor, in comparison with other groups of driver with observational errors as a sub-group, they did seem to be over-represented in two accident groups with an observational error component. The first of these was classified as ‘failing to take account of a restricted view’. Nearly all these cases also involved travelling through a red light at a traffic light controlled junction while on an emergency call and failing to see a vehicle using the junction at the time, most commonly as it would have been masked by a vehicle that had already stopped and given way for the emergency vehicle. The second of the accident groups comprised cases where a driver had failed to notice another driver’s signal. However, all these cases were ‘combined fault’ accidents, and the observational failure had been on the part of another accident-involved driver, rather than the emergency driver, even though the emergency driver had been determined to be at least partly at fault in addition.

## Fatigue as a factor in accidents

Driver fatigue is often found to be a major cause of work-related road accidents, but only 2.6% of the whole sample showed fatigue as a possible causal factor. An attempt was made to find sleep-related cases by use of Horne and Reyner’s list of sleep-related criteria for accidents (as detailed in Flatley *et al.*, 2003), but no more cases were found. However, the blame ratio for fatigue accidents in the sample was 3.6, i.e. work-related accident involved drivers appeared more than three times as likely to cause a fatigue-related accident than become the passive victim of another driver’s fatigue. The largest vehicle category in fatigue accidents was lorries (LGVs). There was some evidence of a peak in LGV fatigue accidents in the early hours of the morning, and early in the afternoon. ‘Early hours’ accidents occurred most often on motorways, perhaps because low traffic densities and monotonous driving could be contributing to boredom and associated fatigue at these times (Flatley *et al.*, op.cit).

## Vehicle defects

Accidents resulting from vehicle defects were quite rare, and only accounted for around 1.5% of the sample. The two main categories of vehicle that were prevalent in this group were LGVs and vans/pickups. The most common defect found was with braking systems. There was also evidence in some cases of confusion as to who exactly was responsible for vehicle maintenance.

There were also accidents in this small group of cases that showed more obvious signs of a lack of maintenance, including wheel sheer-off, worn brake linings and failures of brake air-lines. Two fatal cases, however, both showed that poor maintenance can also include the way brakes are adjusted for vehicle load, even though they may be working efficiently in other respects. Other accidents in this group included one remarkable case where an LGV had no trailer brakes at all, as the trailer air-lines were not connected, and another where an LGV was involved in an accident whilst being used in contravention of a prohibition notice.

## 'Non-driving' work-related accidents

Twenty-one cases in the database involved workers who were not driving themselves at the time of the accident, but who were working on or near the road. Two-thirds of these accidents involved workers who were run over or otherwise injured by other drivers while performing the various duties their jobs require. Most of these cases involved carelessness on the part of the other road user, but a minority also showed a reckless disregard by road users for people working on the highway, as in the following case.

Story:

*It was the middle of the afternoon on a fine day in early Summer. A lollipop lady (1) (F,55) was working in the road. Some children had just crossed and she was just leaving the road when the driver of a Rover 214 started forwards and almost collided with the lollipop lady. The lollipop lady shouted at the driver (F,50), who shouted back, and the lollipop lady approached the car to talk to the driver. As she got near, the driver slapped her face and then drove off. Even though the lollipop lady stood in front of the car and was pushed out of the way by the car, the driver didn't stop and left the scene. She was traced and charged with dangerous driving and assault.*

Cases that involved carelessness rather than recklessness tended to involve drivers failing to see stationary vehicles, such as delivery or recovery vehicles, in time to stop, or drivers who failed to give sufficient clearance to workers unloading or loading vehicles at or near the side of the road. Some drivers' lack of knowledge of basic traffic law was also quite surprising. One driver hit a delivery person with her car, but thought that the incident did not qualify as a reportable accident because there was no damage to her car.

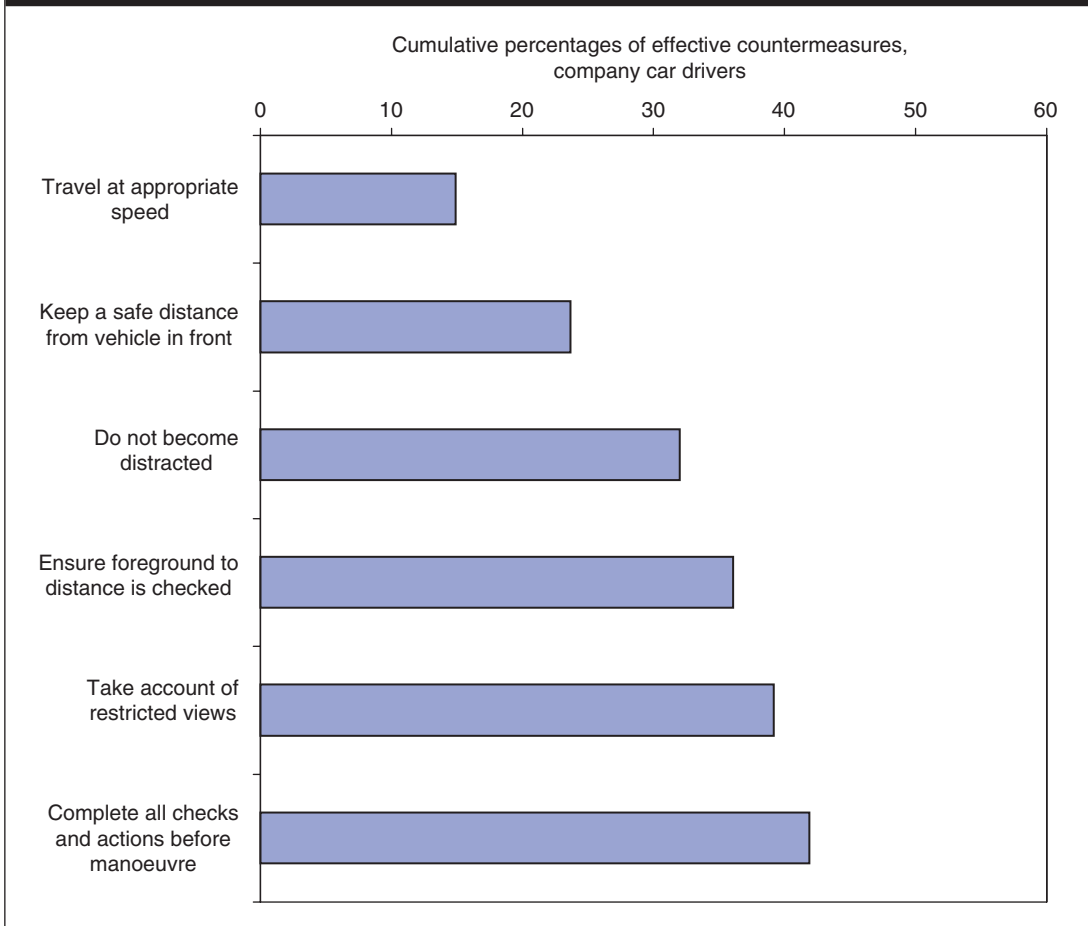
## Countermeasures

A list of 23 possible behavioural strategies for avoiding typical accidents was drawn up using established texts such as *Roadcraft* and *The Highway Code*, together with prior knowledge of the data. The countermeasures were concerned solely with simple driver behaviours and did not extend to road/vehicle engineering factors that were outside the scope of this study. Each case in the database was coded for the countermeasures that might have either prevented the accident or reduced the severity of it. Countermeasures were not meant to be either exotic or counter-intuitive, and dealt with mainly obvious measures that would be understood by most competent drivers. The top five countermeasures for the three classes of vehicle and driver with peak blameworthiness are shown in Figures 3–5. In each of these figures, the top five countermeasures are shown by cumulative percentage in order to show their effectiveness on a particular class of vehicle-related accidents, considered as a whole. (Note Figure 3 appears to show six in the top five, as the final two items share joint fifth place.)

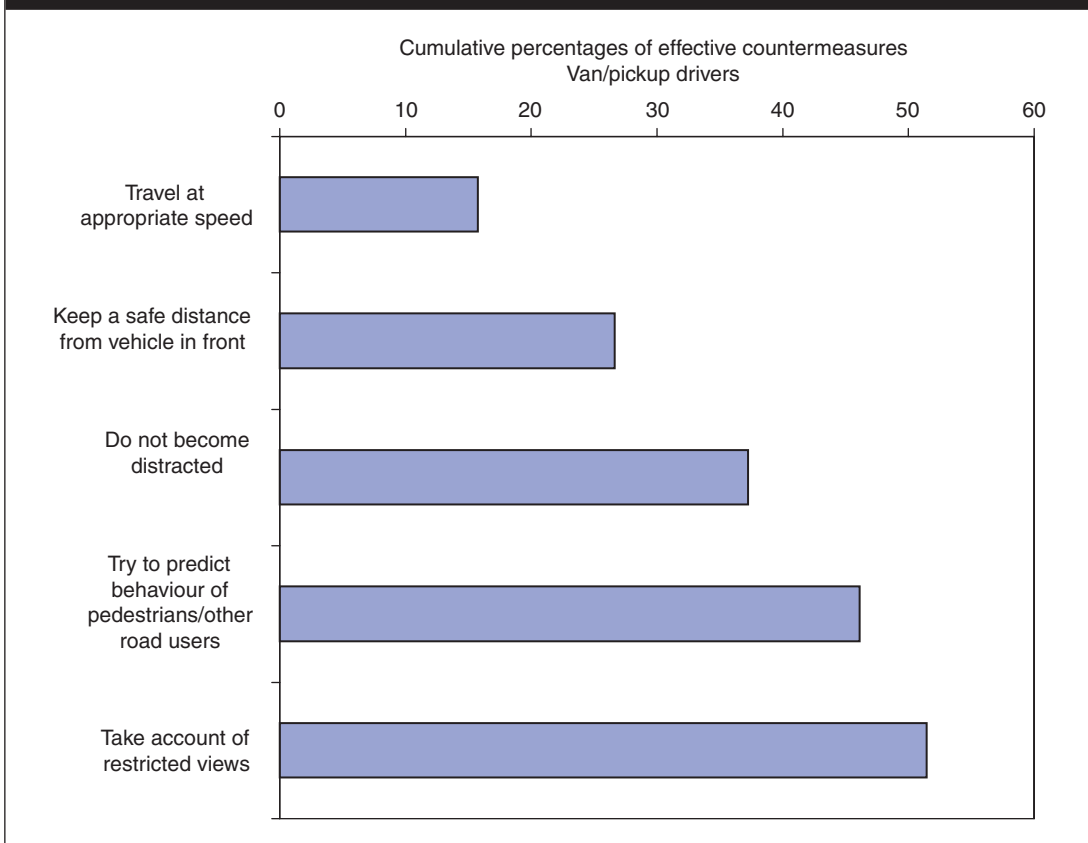
It can be seen that the top five effective countermeasures vary between the three vehicle types in the way that might have been predicted by the errors and violations that were shown for each class of driver earlier. The key themes that would improve safety in all these driver groups are speed control, maintaining safe following

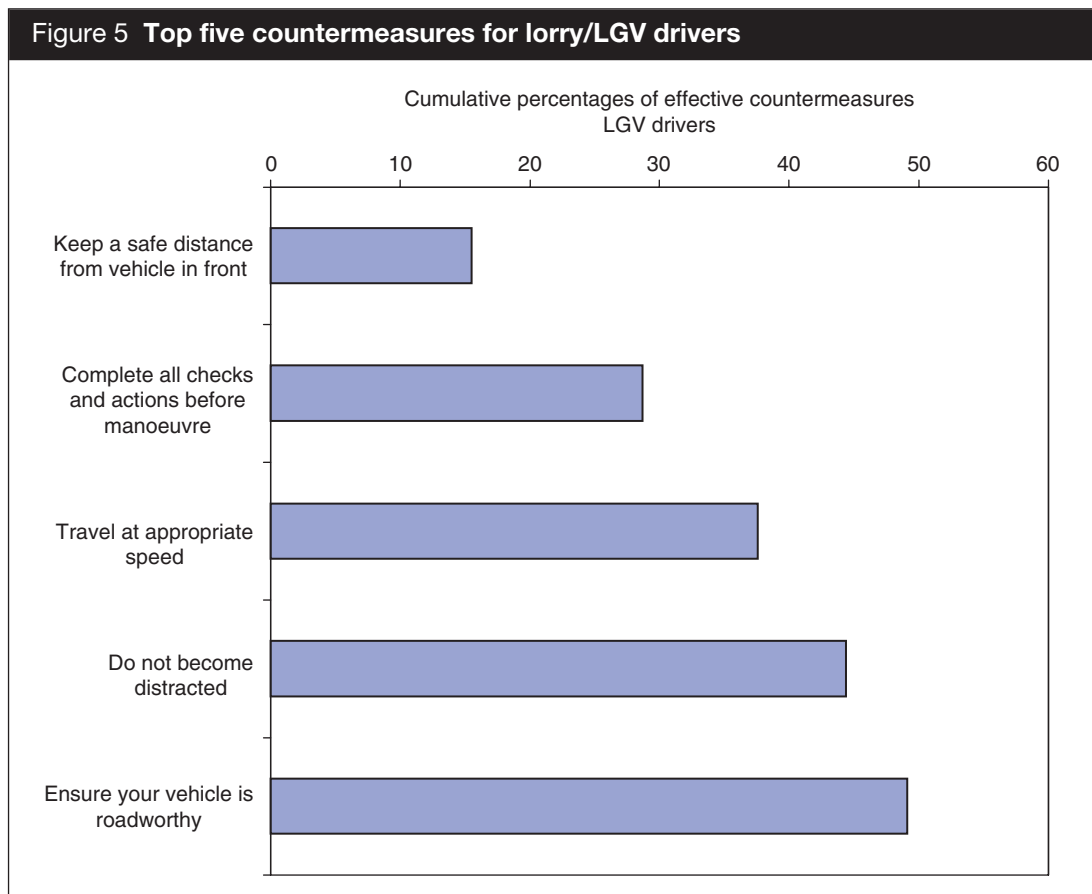


**Figure 3 Top five countermeasures for company car drivers**



**Figure 4 Top five countermeasures for van/pickup drivers**





distances and avoiding distraction. The scope for improvement, however, differs quite widely between vehicle types, before diminishing returns set in.

## Discussion

### Vehicle types in work-related accidents

The majority of work-related road traffic accidents involved the drivers of six main types of vehicle. These were: company cars; vans/pickups; lorries (HGV/LGVs of all weights); buses (PCVs); taxis (including Hackney carriages and minicabs); and emergency vehicles (EVs).

The results from blameworthiness ratios showed that work-related vehicle driving seemed, in many cases, to involve drivers having accidents caused by other motorists. Three of the vehicle groups (taxi, bus and emergency vehicle) had blameworthiness ratios below 1.0, which implied that these drivers were more likely to be passive victims of other road users' mistakes and violations than they were to be perpetrators of such mistakes and violations.

This form of analysis proved particularly pertinent when examining various sub-groups of accidents. With fatal accidents, for example, we found that lorries/LGVs were significantly more likely to be involved in fatal collisions, and showed factors such as distraction, fatigue, speed and time pressure. However, over half of LGV-related

fatalities were actually caused primarily by other drivers. When overall fatalities were analysed using blameworthy cases only, the group most likely to cause fatal accidents appeared to be company car drivers. These cases most often involved excessive speed as a causal factor.

There were a variety of findings across the vehicle sub-groups. Table 3 (below) summarises the main points.

**Table 3 Summary of work-related road accidents by vehicle type**

	<b>Blame</b>	<b>Age/sex</b>	<b>Severity</b>	<b>Location – over-represented on ...</b>	<b>Over-represented contributory factors</b>
Company cars	More to blame than not	Peak at 31–35 years, mostly male, some females	More fatalities if driver to blame	Rural unclassified (60 mph limit)	Excess speed; poor observation; excess alcohol; slippery roads
Vans/pickups	More to blame than not	Peak at 21–25 years, mostly male, few females	No effect	Urban unclassified roads, rural B class roads, and rural unclassified roads (mixed limits)	Poor observation (restricted views and other drivers' signals)
LGV/lorry	More to blame than not	Peak at 26–30 years, nearly all male	More fatalities regardless of blame	Rural A roads (60 mph) and motorways (70 mph)	Poor observation; close following; fatigue; load problems and vehicle defects
PCV/bus	Other parties more to blame	Peak at 46–50 years, nearly all male	No effect	Urban roads, all classifications (30 and 40 mph)	Poor observation (at junctions); close following; failure to signal
Taxi/minicab	Other parties more to blame	Peak at 26–30 years, nearly all male	No effect	Urban roads, all classifications (30 and 40 mph)	Poor observation (U-turns and reversing); gap judgement
Emergency vehicle	Other parties more to blame	Peak at 26–30 years, nearly all male	More fatalities if driver to blame	Urban roads, all classifications (30 and 40 mph)	Excess speed; time pressure

## Company cars

It can be seen (from Table 3, above, and Table 2 previously) that company car drivers had different background and behavioural factors appearing in their accidents when compared with drivers of virtually any other vehicle. They were the only group (aside from emergency drivers) where excess speed was over-represented significantly as a causal factor. LGV drivers (as an example of a comparison group) showed more 'background' factors such as load problems, vehicle defects and driver fatigue.

Excess speed can be considered as a behavioural or 'attitudinal' failure (e.g. by Clarke *et al.*, 2002). Unfortunately, driver interview quotes from this study were found to be

generally unrevealing with regard to attitudes. It may be, for example, that the ‘perk’ or ‘sales’ cars referred to by Chapman *et al.* (2000) are driven differently due to the reduced personal cost of any predicted accident. As one company car driver explained in a rare moment of candour to another driver who had shunted his car, and who wished to exchange details: ‘Why? It’s a company car – I don’t give a s\*\*t.’

Unfortunately, there is a lack of information about the exact type/use of company car involved in these excess speed collisions, so it is difficult to comment further. The sub-group of vehicles in these cases mostly contains average mass-market saloon cars, with the occasional luxury high-capacity model, but we have no further information beyond the fact that their drivers say they are company cars.

## Fatigue, safety culture and vehicle defects

Although only a relatively small number of cases with driver fatigue as a causal factor were found, it is possible that a large number of such accidents have been logged as being caused by distraction or other observational failures. This would lead to an unquantifiable level of underestimation of the fatigue factor. Drivers are seldom willing to admit to having fallen asleep at the wheel, perhaps because they are unlikely to recollect having done so (Horne and Reyner, 1995). In addition, there are other ways in which fatigue can affect driving which are beyond the remit of this study. For example, shift workers who use their own car to commute are not (by the definitions used in this study at least) driving in a work-related capacity. Nevertheless, their work may be affecting their chances of having a fatigue-related accident. A study by Folkard (1999) showed that the risk of being in a single-vehicle accident at 3am was 50% above baseline after four successive nightshifts, for example. We cannot comment on this phenomenon any further, as we only have evidence of such drivers hitting other work-related drivers, which proves to be a very small pool of cases. This small number does include one fatal accident involving a night-shift worker killed when he fell asleep at the wheel on his journey home and was hit by an LGV, after drifting out of control into the path of the lorry.

Some attitudes towards working time and fatigue were shown by various drivers in the sample, which gave a limited insight into this aspect of safety culture. There is, for example, a case on record where the tachograph of an LGV showed the driver had only had 5.5 hours rest in the last 33.5 hours, and the vehicle had also covered 149 km with no records being made in the preceding week. The driver also admitted that he had disabled the speed limiter on the truck to enable it to go faster. Another case involved a driver who caused an accident after becoming fatigued and ill through working a regular 75-hour week. He was not covered by driving hours regulations as he was a company car driver.

More seriously there is evidence, albeit in a minority of cases, that drivers can perform such actions as deliberately falsifying tachograph records, disabling safety equipment such as speed limiters and ABS systems, and removing trailer registration plates when they think it will be financially advantageous to do so.

Vehicle defects are likewise not a common cause of accidents overall, but where they are a factor, a worrying failure of safety culture in some organisations is revealed.

One case in particular highlighted the 'grey areas' that can exist with regard to which company in a leasing agreement is liable for aspects of vehicle maintenance.

## Other types of work-related accidents

People working in the road seemed to come to grief in road accidents primarily due to a lack of care shown by other road users, who sometimes seemed fairly ignorant of basic road traffic law (or alternatively, were aware of it, but chose to ignore it). The perception seemed to be that pedestrians were not expected to be in the road, and some drivers would do little to ensure their safety when they were.

## Conclusion

To a striking degree, this sample of work-related accidents shows the same characteristics as a general sample of all accidents. In other words, we find that work-related accidents are not fundamentally different in their causal structure to any other road accidents, except in certain tightly defined conditions; an example would be the risks engaged in of necessity by emergency drivers.

Some work-related drivers, principally those driving company cars, vans/pickups or LGVs, appeared to be more to blame in their accidents: these are drivers who drive above average mileages and are exposed to a variety of internal and external stressors and motivations that may explain this finding. Their errors and violations did not appear markedly different from those of the general driving population; they may merely have had more opportunities for committing them. The solution here may involve driver training, but consideration must also be given to altering organisational and work structures that may be shaping these drivers' attitudes and behaviour.

Perhaps more surprisingly other work-related drivers, principally those driving buses, taxis and emergency vehicles, suffered more accidents caused primarily by other road users. Their problem was therefore predominantly one of exposure to dangerous environments. This was very marked, for example, in the case of taxi and minicab drivers, whose work puts them on the road at the same time as young, reckless and intoxicated drivers, intoxicated pedestrians, and even customers that sometimes assault them. Defensive driving techniques may be a partial solution with this kind of driver, but they can only go so far in accident prevention terms if the behaviour of other road users is not also addressed.

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# 12

## Work-related road safety: age, length of service and changes in crash risk

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### Introduction

Age and experience are known to be major factors in road traffic collisions (Maycock *et al.*, 1996) and are commonly used as predictors of crash frequency (Evans and Courtney, 1985). But age and experience are difficult to separate when investigating crash risk (Brown, 1982; Ryan *et al.*, 1998; Mayhew and Simpson, 1990; Bierness, 1996). Experience is closely related to age but independently influences crash risk. For age, mileage-adjusted crash risk declines with age but then rises for drivers over 65 (Maycock *et al.*, 1991). This is thought to be due to physical and cognitive declines in older people and to increased risk-taking in younger drivers (Chipman *et al.*, 1992; Clarke *et al.*, 1998; McGwin and Brown, 1999). For experience, even limited driving experience has a major effect on road safety. For example, there is a disproportionately higher crash rate during the first year of driving, particularly in the first few months after licensure (Sagberg, 1998). For age and experience, Mayhew *et al.* (2003) found larger decreases in crash risk amongst younger novices compared with older novices during the first few months of driving. This was interpreted as due to greater initial risk-taking amongst younger novices, with on-road driving experience facilitating a more rapid learning rate compared with older novices. They suggest that this was an appropriate point at which to provide training intervention. There is reasonable literature on the effects of age and experience on accident involvement, but little is known about whether these effects can be generalised to professional drivers, especially since professional drivers differ substantially from the general population of drivers.

Crash risk is greater for drivers who drive for work, even when taking into account increased mileage (Broughton *et al.*, 2003). Bus drivers are a special group of professional drivers that differ markedly from the general population of car drivers in a way that is likely to affect their crash risk in many ways. Most bus drivers are already experienced drivers before gaining a Public Commercial Vehicle (PCV) Licence and may start work as a bus driver at any age. It is possible that being an older, experienced driver before learning to drive a bus may be beneficial, but currently there is no evidence to indicate that this is the case. There are several factors that may increase bus crash risk, however. Firstly, they have responsibility for passengers. Secondly, they drive a large heavy vehicle that is constantly pulling in and out of traffic, mostly in built-up areas. Thirdly, bus drivers have a higher annual mileage than private motorists. Finally, their collisions are work related and therefore organisational factors such as bus schedules are likely to exert a strong influence on their driving behaviour. They cannot easily adjust to task demands in the same way as private motorists can if it means running late.

To examine crash risk, many studies use official accident data (e.g. Abdel-Aty *et al.*, 1998; Evans and Courtney, 1985; McGwin and Brown, 1999; Ryan *et al.*, 1998). These databases have the advantage of being large and usually collected over a long time-period. Although official data are not often collected for research purposes and may lack relevant information. For example, culpability may not be recorded (e.g. Wählberg, 2002). Other studies are limited by small sample sizes (e.g. Hancock *et al.*, 1990). Within company databases, there may be additional problems. Crash data are often collected for insurance purposes, with culpability being recorded to support the commercial operation of the company. Such databases are concerned with policies, claims and claimants rather than accident and driver characteristics. Arriva is a major UK bus company and its incident database collects information not only for insurance claims purposes but also for risk management purposes, hence driver characteristics are available. Their database can help to determine the factors that may be influential in the increased crash risk of drivers driving for work. A further advantage is that all incidents are reported and attributed to a particular driver, no matter how minor. This is due to a strictly adhered to company policy that all vehicles are checked at the start and end of each shift.

There are many ways to assess the crash risk associated with different types of road user. Since conclusions on safety issues cannot be reliably drawn without exposure information (Evans, 1991), crash rates are usually normalised against some measure of exposure. Several researchers have suggested using induced exposure techniques to produce a relative risk ratio index. The calculation of crash risk used for the present study is a ratio of the proportion of all at fault drivers represented in each group divided by the proportion of non-responsible in each group (Cooper, 1990; Lyles *et al.*, 1991; Stamatiadis and Deacon, 1997). This method is based on the assumption that in two-vehicle crashes there is a driver who is responsible for the collision and that the second driver is selected randomly from the driving population (Haight, 1973).

Many organisations are concerned about the frequency with which their employees are involved in crashes, but there is little published data to guide company policy on what can be done to address their increased exposure to risk. As part of a Training Needs Analysis, this study aims to investigate the role of age and bus driving experience on crash risk.



# Method

## Crash data

There are 121 Arriva depots in the UK and analysis includes crashes that occurred throughout these depots from December 2000 to June 2003. Only crashes that met the following criteria were included: drivers were between 18 and 64 years, had 0–35 years service history with Arriva, and details about the crash and culpability were complete. This left a total of 15,100 incidents that were suitable for inclusion in the analysis. The crash database also includes passenger falls inside the bus, but they have not been included in the following analysis.

## Participants

There were 12,244 bus drivers included in the analysis. Drivers were aged between 18–64 years (mean = 42.8 years, SD = 10.8). Information about a driver's sex was not available, but almost all Arriva bus drivers are male. Years in service ranged from one month to 35 years (mean = 6.1, SD = 7.6). Length of service (LOS) was the operational definition of bus driving experience. LOS was categorised into three groups, with equal proportions of drivers in each category: LOS1 (0 to 1 years); LOS2 (1 year and 1 month to 5 years); and LOS3 (over 5 years).

## Crash risk ratio and culpability

The analysis presented is based on the frequency of collisions, so that any one driver may appear in the data more than once if they have been involved in multiple collisions between the time periods of interest. For culpability, at fault, part fault and not at fault categories are assigned to every crash based on a claims investigation that may include police statements, witness reports, photographic evidence and driver self-reported details of the circumstances surrounding the crash.

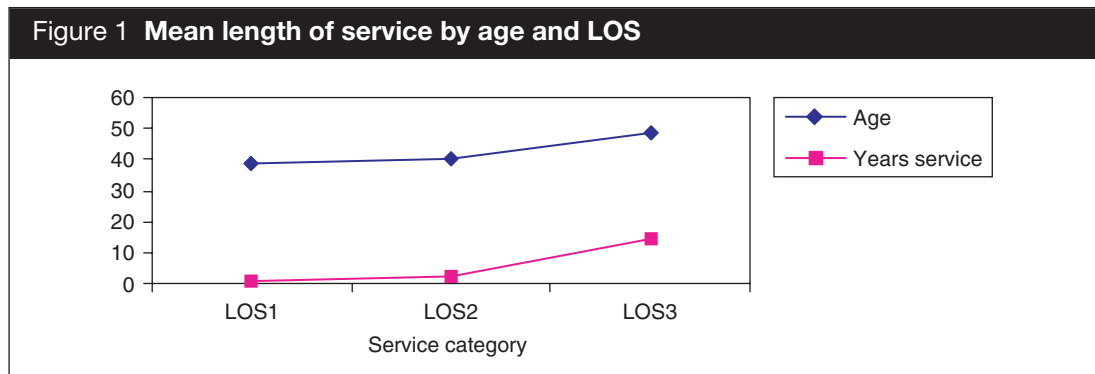
Two measures of crash risk are calculated from crash frequency data. Firstly, those 'Solely Responsible' for a crash, defined as the risk of being the sole cause of a crash. This was calculated by dividing the frequency of at-fault crashes with the frequency of not at-fault crashes. Secondly, those 'Partly Responsible' for a crash, defined as the risk of contributing to the cause of the crash and is calculated by adding the frequencies of at-fault and part-fault crashes and then dividing by the frequency of not at-fault crashes. A ratio of 1 means that if drivers are involved in a crash the likelihood of them being responsible for causing the crash and the likelihood of them not being found at-fault is the same. A ratio of less than 1 means that the driver is not likely to be the cause of the crash and a ratio of more than 1 means that the driver is likely to be the cause of the crash (Haight, 1973). Crashes were grouped according to culpability so that separate analyses were performed for at-fault ( $n = 6,230$ ), not at-fault ( $n = 7,448$ ) and part-fault crashes ( $n = 1,422$ ).

# Results

## LOS categories

One-way ANOVA (ANalysis Of VARIance between groups) showed a significant difference in mean age for each LOS category ( $F(2,15097) = 1453.62, p < 0.0001$ ). Post hoc tests show that all three LOS categories are significantly different from each other ( $p < 0.0001$ ). LOS1 had the youngest bus drivers and LOS3 had the oldest bus drivers. The mean years in service for each LOS category was also significantly different ( $F(2,15097) = 12885.56, p < 0.0001$ ) again post hoc tests showed significant differences between LOS1, LOS2 and LOS3 ( $p < 0.0001$ ). Table 1 and Figure 1 show the descriptive statistics for age and LOS.

Table 1 Age and years of service by LOS						
	LOS1		LOS2		LOS3	
	Age	Years service	Age	Years service	Age	Years service
Mean	38.5	0.43	40.5	2.6	48.7	14.2
Std deviation	10.5	.27	10.3	1.1	9.2	7.7
Minimum	18	.01	19	1.01	24	5.01
Maximum	64	1.0	64	5.0	64	35



## Location and manoeuvre at time of crash

Table 2 and Figure 2 shows the proportion of crashes taking place at different locations by LOS.

For all LOS categories, most crashes occur at bus stops, junctions, traffic lights and in bus lanes.

Service length	Bus stop	Junction	Traffic lights	Bus lane	Roundabout	Pothole	Road works	Pedestrian crossing
LOS1	27.8	33.0	12.0	9.9	7.2	6	2.6	1.5
LOS2	26.5	31.4	13.5	10.6	7.2	5.6	3.1	2.2
LOS3	26.9	28	13.1	9.6	8.4	6.4	2.7	2

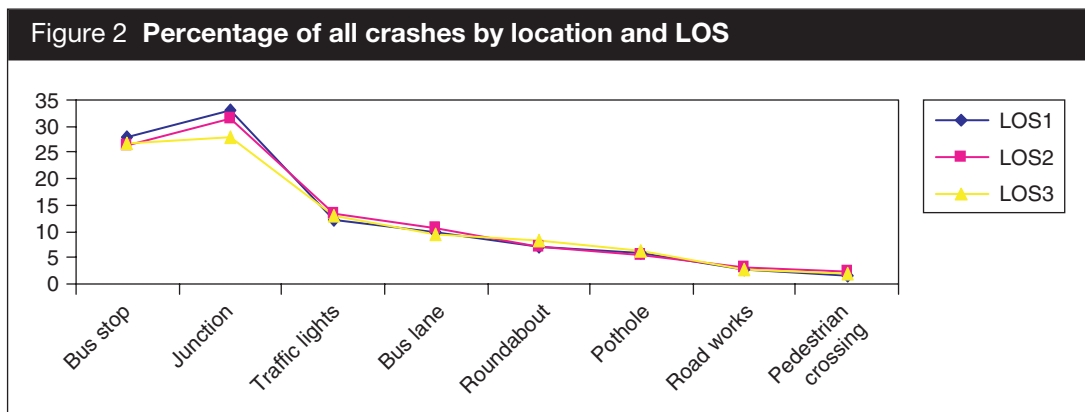
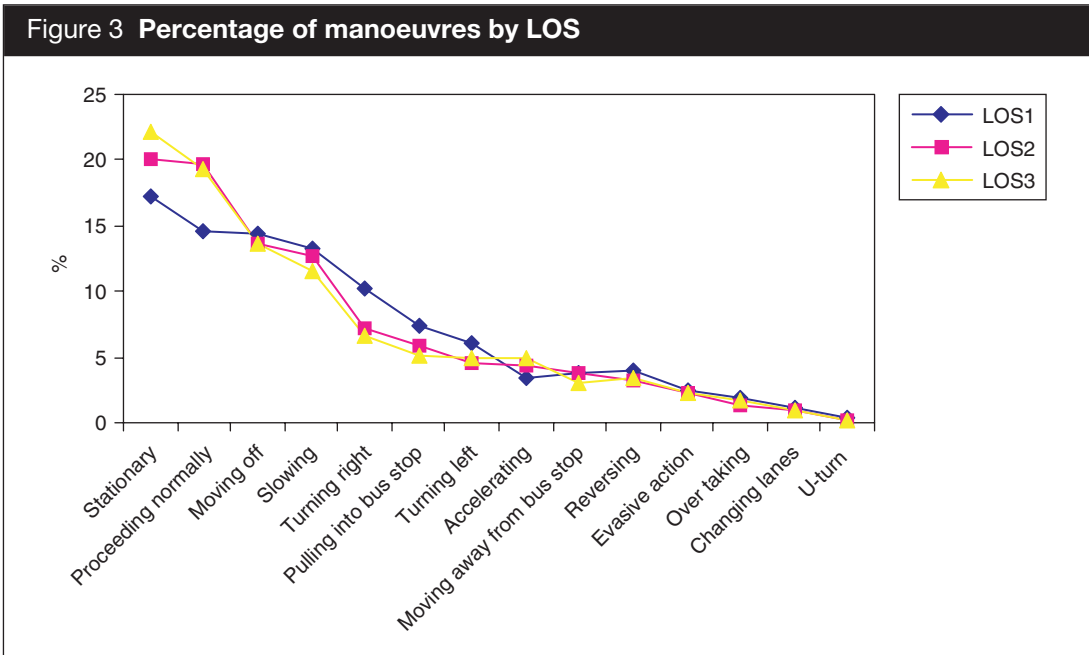


Table 3 shows the kinds of manoeuvres performed at the time of the crash in the order of their proportion relative to all other kinds of manoeuvres performed.

Manoeuvre	LOS1	LOS2	LOS3
Stationary	17.2	20.1	22.1
Proceeding normally	14.6	19.7	19.3
Moving off	14.4	13.7	13.7
Slowing	13.2	12.6	11.6
Turning right	10.3	7.2	6.6
Pulling into bus stop	7.3	5.9	5.1
Turning left	6	4.6	5.0
Accelerating	3.5	4.4	5.0
Moving away from bus stop	3.8	3.7	3.1
Reversing	3.9	3.2	3.4
Evasive action	2.4	2.2	2.2
Overtaking	1.8	1.4	1.7
Changing lanes	1.2	0.9	0.9
U-turn	0.4	0.2	0.2

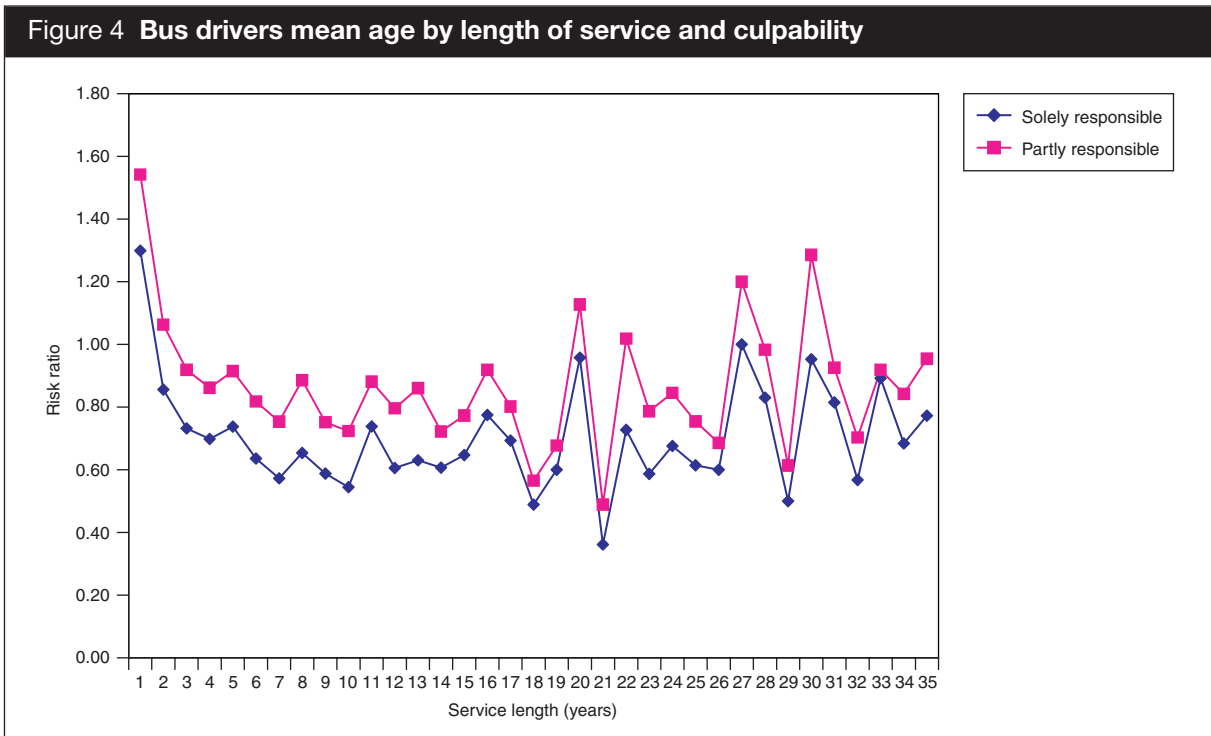
Bus drivers in all service categories reported that they were most often stationary, proceeding normally, moving off from a stationary position or slowing down at the time of the incident. To a lesser extent turning right and pulling into bus stops posed a problem as did turning left for novice bus drivers. Accelerating and pulling away from bus stops, reversing, taking evasive action, overtaking, changing lanes and making U-turns were reported less often at the time of the incident. The pattern is similar across LOS categories, with the possible exception of being stationary at the



time of the crash and proceeding normally for which less experienced bus drivers appear to be under-represented compared with more experienced drivers.

## LOS and culpability

Figure 4 provides information relating to the risk ratios for every year of service according to whether the driver was classified as solely or partly to blame for a crash. The results show that risk ratios decline after the first two years of driving but crash risk ratios exceed 1.0 three times after 20 years of service for part-blame crashes, whereas for sole-blame crashes it exceeds 1.0 for the first year only. Given



these findings, a more focused analysis of the first three years of service was conducted.

## First three years of service

Table 4 shows the frequency of at-fault, not at-fault and part-fault crashes and the total number of crashes for the first three years of service.

Table 4 Crash frequency by service length				
Service length	All crashes (frequency)	At-fault crashes (frequency)	Not at-fault crashes (frequency)	Part-fault crashes (frequency)
Year 1	4,166	2,129	1,639	398
Year 2	2,106	874	1,021	211
Year 3	1,541	588	803	150

Table 5 shows the ratios for a driver being solely responsible and partly responsible for the cause of the crash for the first three years of service. The asterisk indicates whether the driver is more likely to be involved in the cause of the crash.

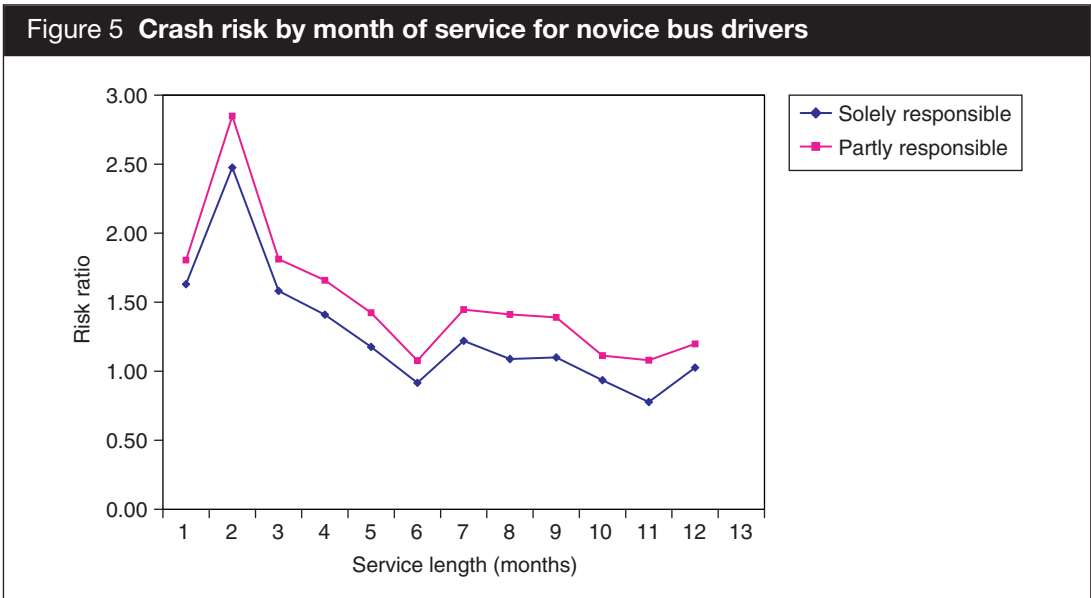
Table 5 Risk ratios for first three years of service by culpability		
Service length	Solely responsible	Partly responsible
Year 1	1.30*	1.54*
Year 2	0.86	1.06*
Year 3	0.73	0.92

Given that the first year of service carries the greatest risk of being both solely and partly responsible for a crash, a more detailed analysis of the first year of service was conducted.

## Month by month crash risk

The same data cleaning procedures were also conducted on drivers in their first year of service only, which left a total of 4,166 crashes that were suitable for inclusion in the analysis. Length of service was then categorised into 12 groups in increments of one month each. The data were then divided according to culpability for at-fault ( $n = 2,129$ ), not at-fault ( $n = 1,639$ ) and part-fault crashes ( $n = 398$ ), and crash risk ratios were calculated as previously described.

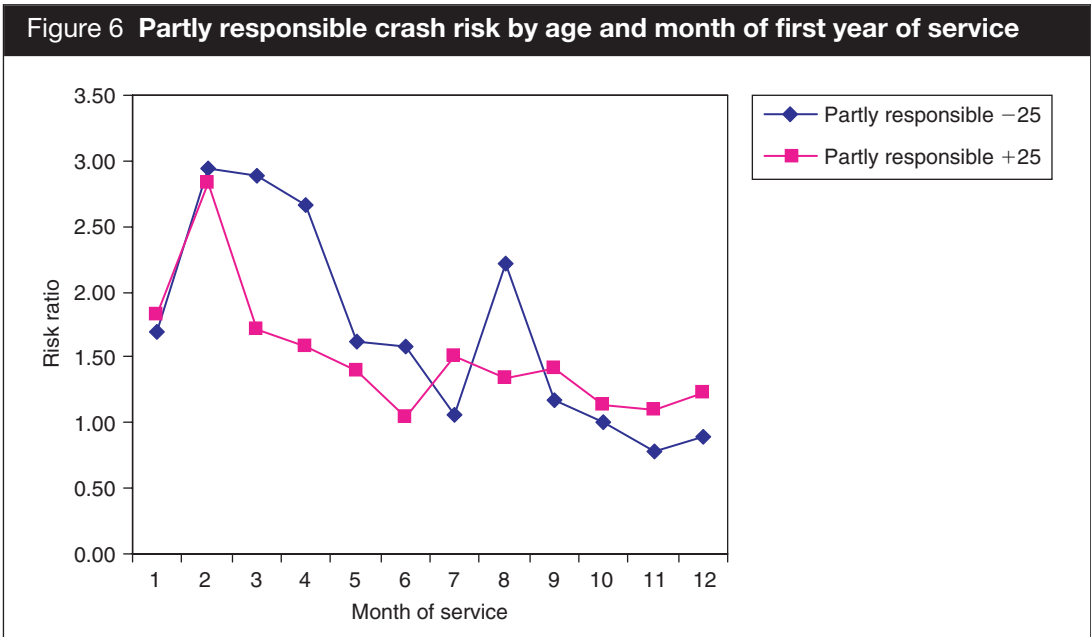
Figure 5 shows a sharp decline in crash risk for both sole- and part-blame crashes during the first year of service.

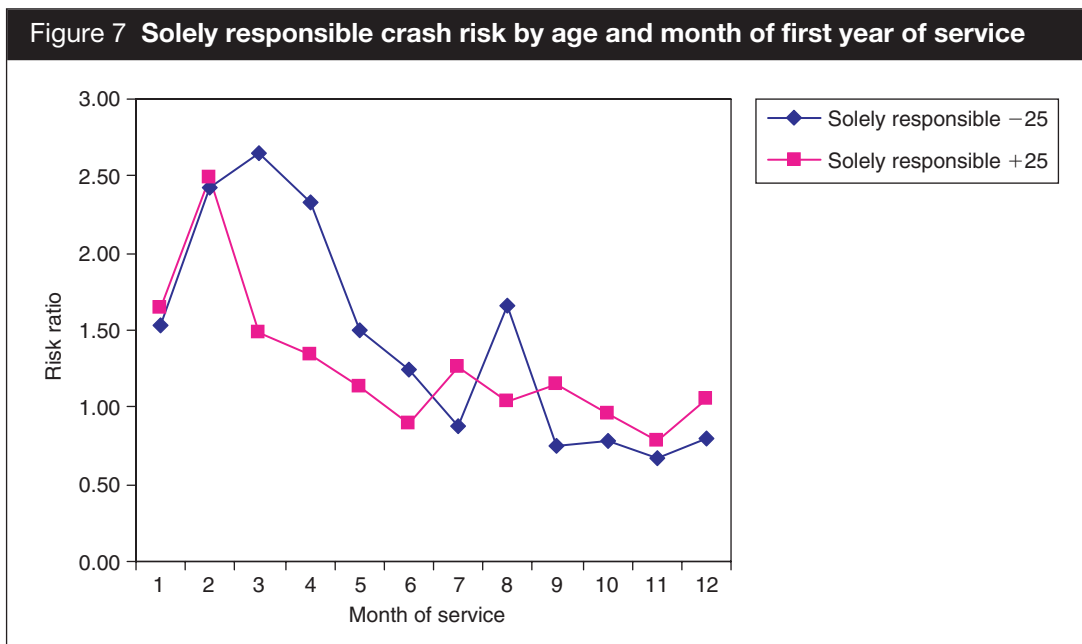


To investigate crash risk according to age and first year of service, an analysis of older and younger novice drivers was then conducted. The results are shown in Figure 6 for part-blame crashes and in Figure 7 for sole-blame crashes.

To determine the relative contribution of age and bus driving experience, the crash risk for novices who were similar in experience but different in age is shown in Figures 6 and 7.

Figures 6 and 7 shows that younger novice bus drivers have generally higher risk ratios for the first few months of driving a bus compared with older novice bus drivers for both part- and sole-blame crashes. Older novices show a steeper decline in crash risk compared with younger novices. An effect of experience is also in evidence with an overall decline in crash risk over the first year of driving.





## Prediction equations: age, length of service and culpability

A multiple regression analysis was used to evaluate the relative contributions of age and LOS on crash frequency. Crash frequency was divided into three types, at-fault, not at-fault and part-fault crashes, and a regression analysis was conducted to evaluate the relative contributions of age and LOS on crash frequency. In particular, age and LOS were used to predict three criterion measures of crash frequency: at-fault, not at-fault and part-fault crashes.

## Risk of at-fault crashes

The linear combination of age and experience was significantly related to at-fault crash frequency ( $F(2,15097) = 46.46, p < 0.001$ ). The sample multiple correlation coefficient was 0.078, indicating that approximately 6% of the variance in at-fault crash frequency could be accounted for by age and LOS. Table 6 represents indices to show the relative strength of the individual predictors. All correlations were statistically significant. Age was positively correlated with at-fault crashes, experience was negatively correlated with at-fault crashes.

**Table 6 Correlation coefficients for at-fault crash frequency, age and LOS**

Predictor	Correlation between predictor and crash frequency	Correlation between predictor and crash frequency controlling for other predictor
Age	0.03*	0.037*
LOS	-0.069*	-0.078*

\* =  $p < 0.0001$

The prediction equation for the standardised variables is given below to understand better the relative importance of the predictors on crash frequency:

$$Z \text{ Risk (at-fault crash)} = 0.041 Z \text{ age} - 0.087 Z \text{ LOS}$$

This indicates that LOS is relatively more important than age in predicting at-fault crash frequency.

## Risk of part-fault crashes

The linear combination of age and LOS was not significantly related to part-fault crash frequency ( $F(2,15097) = 2.51, p < 0.05$ ). The sample multiple correlation coefficient was 0.018, indicating that only 0.03% of the variance in part-fault crash frequency could be accounted for by age and LOS.

Table 7 represents indices to show the relative strength of the individual predictors. The correlation between experience and crash frequency was statistically significant, however age was not significantly correlated with part-fault crash frequency.

Table 7 Correlation coefficients for part-fault crash frequency, age and LOS		
Predictor	Correlation between predictor and crash frequency	Correlation between predictor and crash frequency controlling for other predictor
Age	-0.011	0.003
LOS	-0.018*	-0.015*

\* =  $p < 0.10$

The prediction equation for the standardised variables is given below to understand better the relative importance of the predictors on crash frequency:

$$Z \text{ Risk (part-fault crash)} = -0.003 Z \text{ age} - 0.016 Z \text{ LOS}$$

This indicates that LOS is relatively more important than age in predicting part-fault crash frequency.

## Risk of not at-fault crashes

The linear combination of age and LOS was significantly related to not at-fault crash frequency ( $F(2,15097) = 55.82, p < 0.001$ ). The sample multiple correlation coefficient was 0.086, indicating that approximately 7% of the variance in not at-fault crash frequency could be accounted for by age and LOS.

Table 8 represents indices to show the relative strength of the individual predictors. All correlations were statistically significant.

The prediction equation for the standardised variables is given below:

$$Z \text{ Risk (not at-fault crash)} = 0.095 Z \text{ LOS} - 0.038 Z \text{ age}$$



**Table 8 Correlation coefficients for part-fault crash frequency, age and LOS**

Predictor	Correlation between predictor and crash frequency	Correlation between predictor and crash frequency controlling for other predictor
Age	0.003*	-0.035*
LOS	0.078*	0.086*

\* =  $p < 0.0001$

This indicates that experience is relatively more important than age in predicting risk of involvement in not at-fault crashes.

High bus crash frequency cannot be attributed to driver immaturity. It appears that lack of experience of driving a bus is more influential than youth in its contribution to crash risk for at-fault and not at-fault crashes.

## Discussion

Generally, bus drivers are not to blame for most crashes, rather it is the behaviour of other road users that seem to be culpable. However, bus drivers in their first year are more likely to be responsible for crashes. Bus driving has a positive influence on both older and younger novices, so that by the end of the first 12 months of driving, their risk of being involved and not involved in a blameworthy and part-fault crash is about the same. Consistent with previous research (Sagberg, 1998; Mayhew *et al.*, 2003) this study shows that crash risk is attributable to age-related factors, with younger novices having a higher crash frequency than older novices with the same amount of bus driving experience. However, contrary to previous research, older novices show a more dramatic reduction in crash risk for at-fault and part-fault crashes compared with younger novices. Older novices appear to learn more quickly from their on-road experiences and develop the skills to avoid bus crashes. Crash risk increases in the second month of driving, this may be due to over-confidence after skills training. There is a suggestion here that perhaps professional driver training should include training in how human factors might impact on their crash risk.

There is now a body of evidence that some skills training may not be beneficial for road safety. Even specific skills training, such as skid control and braking techniques, have failed to find measurable improvements in accident rates (Lynam and Twisk, 1995; Gregersen, 1991). For example, in skid pad training, Katila *et al.* (1996) found that young drivers failed to comprehend that the purpose of training was to avoid a skid rather than be able to control it. This is particularly important given that an overestimation of driving skill may lead to *increased* accident risk (Gregersen, 1994).

For both at-fault and part-fault crashes, LOS and crash frequency is negatively correlated showing that bus drivers have fewer crashes as their length of service increases. Novices are involved in more crashes and are likely to be responsible for the crashes they are involved in. On the other hand, not at-fault crashes are

negatively correlated with LOS showing that drivers with longer service length are involved in more crashes that are the fault of another road user. Age and crash frequency are positively correlated in at-fault and part-fault crashes, with older drivers being more likely to be to blame for a crash. The negative correlation between age and not at-fault crashes suggests that younger drivers have more crashes that are caused by another road user. The results indicate that, although both age and LOS are important, LOS is the greatest predictor of crash risk in at-fault, part-fault and not at-fault crashes.

One possible interpretation of the findings for LOS and manoeuvres as the time of the crash is that experienced drivers appear to be over-represented in passive crashes that they are not to blame for. They more often are involved in crashes when they are stationary or proceeding normally. When the driver is deemed to be at-fault, the definition of culpability here might assume that the driver has exhibited behaviour that is inappropriate for the prevailing traffic demands and/or the capabilities of the vehicle being driven. Given that there are schedules to maintain, bus driving is governed by factors outside the traffic system that may increase crash risk if a bus driver is running late and feels the need to take risks. Therefore, culpability is a questionable assumption, even if assigned correctly. This is especially true when there are multi-vehicle crashes. Analysis of culpability should always be regarded with some caution.

Whether they are responsible or not, it is clear that training needs to target the risks associated with driving a bus particularly at bus stops and junctions, especially for novices. The findings suggest that inexperienced drivers have a higher percentage of crashes at junctions. Generally, bus crashes occur primarily at junctions that are problematic locations for all road users (Clarke *et al.*, 1998). Other crashes are due to problems inherent in the bus driving environment, such as bus stops and bus lanes. Inexperience in the form of lack of knowledge about hazards and the appropriate vehicle handling skills to allow the driver to manoeuvre safely may result in the driver taking unnecessary risks in unknown situations (Bailey *et al.*, 2003; McKnight and McKnight, 2003; Underwood *et al.*, 2002; McKenna and Horswill, 1999). At present, the average new bus driver receives about two weeks' instruction in a driving school based on vehicle handling skills training, in common with many other professional driver training courses. Currently, professional driver training neglects to consider work-related factors that might impact on driver behaviour. For example, driver stress is associated with riskier driving behaviour amongst professional drivers (Dorn, 2005; Dorn and Brown, 2003) and crash-involved bus drivers score significantly lower on dimensions of driver stress and higher on ineffective coping strategies (Dorn and Garwood, 2005).

Driving simulators can differentiate between professional and non-professional drivers (Dorn and Barker, 2005) and may be a useful tool for higher order skills training. The Arriva Bus Simulator has been developed to provide repeated opportunities to assimilate familiar experiences and accommodate to unfamiliar ones (Muncie and Dorn, 2003; 2004). Future research will consider the transfer of training effectiveness of a training programme that includes both simulating the demands of driving a bus under time pressure and classroom-based sessions designed to manage the human factors associated with driving for work.

There are methodological limitations that need to be considered. It is reasonable to assume that many of the employees with greater crash involvement will tend to

either leave the company or be asked to leave. Perhaps the reduction in crash frequency over time is due to the natural selection of drivers who are still with the company because of their higher safety standards. To follow the same group of drivers over time in a longitudinal analysis would take this into account (Maycock *et al.*, 1996).

## Conclusion

Experienced drivers who are newcomers to driving a bus seem to demonstrate similar changes in crash risk as has been observed amongst inexperienced non-professional drivers. This suggests that both groups of drivers learn to drive after gaining a licence, calling into question the usefulness of current approaches to driver training. For bus drivers in particular, there is a suggestion that the training they receive may not adequately prepare them for the job of driving a bus. Given the elevated crash risk of novice bus drivers, the findings suggest that training could be improved to improve road safety. Van Zelst (1954) found over 50 years ago that training reduces the initial accident frequency peak by a substantial amount, especially for younger novices. Most bus crashes take place at junctions and bus stops in the first year of driving. Novice bus drivers have an increased risk of being involved in bus crashes and the length of service rather than age contributes most to crash risk. In contrast to previous literature for private motorists, professional older novices show a steeper decline in crash risk in the first few months of driving compared with younger novices. Work-related crash risk then is governed by different factors to that of private motorists, not only in terms of driver characteristics and risk exposure, but also due to organisational pressures. Specific training to deal with these demands is required to improve work-related road safety.

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# 13

## Fuel efficiency training in a full-mission truck simulator

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### Introduction

In 1996 a report of the Federal Highway Administration (FHWA) detailed a scoping study on commercial motor-vehicle driving simulator technology. It cited an earlier 1991 special issue of *Heavy Duty Trucking* that claimed ‘Cost-effective training simulators are becoming technologically possible – there have been astounding leaps in computer graphics and realism – at the same time the driver shortage and the Commercial Driver License (CDL) are forcing the trucking industry to seek more effective methods for driver training, selection and screening’. Some people outside the industry might view it as surprising that, given the size of the trucking industry in the US and Europe, there are relatively few commercial truck simulators in existence in 2005, and little consensus on the content of any curriculum delivery.

Indeed, the intervening period since the FHWA study has seen continued technological development in simulators, particularly in visual database rendering, but very patchy uptake and development of simulation facilities for commercial truck-driver training. From a worldwide perspective a clear lead has been taken by France and the Netherlands, but even in those countries there is neither the capacity to introduce simulation components to all drivers undergoing current training nor to satisfy any potential increase in demand. There appear to be three fundamental reasons for the relatively slow adoption of simulation as a key component of professional truck-driver training:

- a lack of documented evidence showing a clear benefit of simulation training over traditional on-road and test-track methods;
- a concern over the economics of providing high technology facilities and the attendant high costs of entry to the area; and
- a concern from the drivers and transport managers that such training will be additional to, rather than replace parts of, the current requirements.

The picture, in Europe at least, may soon change. The European Commission Directive on Training for Professional Drivers (EU Commission, 2001, and adopted by European Parliament in April 2003) stipulates that all persons wishing to drive large goods vehicles (LGVs) in excess of 7.5 tonnes in a professional capacity will have to undergo training for, and obtain, a vocational Certificate of Professional Competence (CPC) further to the LGV licence.

The total length of *full basic training* is 420 hours (12 weeks of 35 hours each). For *minimum basic training* this will be 280 hours. Each trainee driver must drive for at least 20 hours individually in a vehicle of the category concerned. This new Directive is of paramount importance to the training and simulation industries because, for the first time, explicit reference is made to simulators for both training and testing.

Each driver may drive for a maximum of eight hours of the 20 hours of individual training:

... on special terrain or on top-of-the-range simulators so as to assess training in rational driving based on safety regulations, in particular with regard to vehicle handling in different road conditions and the way they change with different atmospheric conditions and the time of day or night (European Parliament, 2003, p. 24).

This wording does not go so far as to say that training *should* include simulation, nor that the time devoted to such training *should* be eight hours, nor does it *recommend* simulation; but for the first time, it allows the possibility.

The new Directive goes even further. It opens the way for simulation to play a part in the practical element of the driving test. It states that the basic elements of the practical test must have a duration of at least 90 minutes. This practical test may be supplemented by an assessment taking place on special terrain or on a top-of-the-range simulator:

The duration of this optional test is not fixed. Should the driver undergo such a test, its duration may be deducted from the 90 minutes ... but the time deducted may not exceed 30 minutes. (op.cit. p. 25)

So, simulation is seen as a viable medium for testing and early skills development for novice drivers. However, the Training Directive is also concerned with the skill set of existing experienced drivers. A driver who has obtained his or her licence must undergo 35 hours of continuous training every five years:

Such periodic training may be provided, in part, on top-of-the-range simulators, (op.cit. p. 27).

The current wording poses some problems, for, as yet, there is no satisfactory consensus view on the definition of *top-of-the-range*. It begs the question: who will be the arbiter and monitor of such a distinction?

As the industry expands there is a general expectation that simulation will become more common, and could eventually be a core component of the curricula. However, it could be a mistake to assume that simply because simulators are widespread,



successful and necessary in aviation or military ground vehicle applications that they will be similarly well accepted and suitable for truck-driver training.

The review by Williges *et al.* (1973) pondered the then 50-year history of flight simulation, and concluded that ‘... many issues concerning ground based flight simulators and trainers remain unanswered’. Many concerns remain in aviation, and most remain to be addressed in a systematic fashion in the truck industry.

Potential operators of training simulators need to know the following:

- what can they really do?
- how much will they cost?
- what new skills will trainers need?
- how will they be accredited?
- how should simulators be used within a wider curriculum?

There is little known in relation to truck driving, and little that is directly transferable from aviation, that can inform discussion of what should be delivered in a simulation training package, nor how the costs and benefits might compare to real road training.

Williges *et al.* (1973) proposed the notion of *essential realism*, relating not to what might be regarded as essential for improved face validity but, instead, essential to the particular training requirements under consideration. They discuss three important elements that should drive decisions on simulation provision within the training process:

- the efficiency and acceptability of the learning in the simulator;
- the transfer of the learning to the real world; and
- the retention of what was learned.

Welles and Holdsworth (2000) reviewed features necessary to successful training in a range of commercial simulators and concluded that ‘... data to date, although sketchy, anecdotal or very preliminary, provides strong suggestion that driving simulators ... can reduce accidents, improve driver proficiency and safety awareness, and reduce fleet operations and maintenance costs’. They refer to hazard perception training, with a particular police force, leading to reductions in intersection accidents of around 74%, and overall accident reduction of around 24%, in a six-month period following training. These figures are indeed appealing.

More recently, Dolan *et al.* (2003) presented evidence from a fuel management simulation study that tracked 40 drivers through a two-hour simulation-based training programme, and later for a six-month follow up. Drivers were given specific training in the operational and tactical aspects of appropriate gear selection in a medium fidelity simulator. The results indicated an average 2.8% fuel improvement, with over 7% being indicated for those drivers with a poor pre-training record.

Such evidence provides some confidence that synthetic training might have both a safety and an efficiency benefit for drivers, though these studies are relatively small scale and may not be generalised to the wider truck-driving population in the UK. This paper describes the second phase of the TRUCKSIM programme, and seeks to start to address the issue of benefit analysis on a wide scale.

## The trucksim programme

TRUCKSIM seeks to extend an approach outlined by the US FHWA (1999) and also reflected in European projects (such as RESPECT, TRAINER and GADGET), which have attempted to move away from validating particular simulators in terms of component performance (motion, image, sound) towards a cost-benefit analysis of particular curriculum components with direct comparison to traditional on-road training.

The Department for Transport, via the Road Haulage Modernisation Fund (RHMF) has commissioned the Transport Research Laboratory (TRL) to investigate the feasibility of a truck driving simulator tailored to the needs of the UK road haulage industry. TRL contracted EADS Dornier to provide a full-mission high-fidelity simulator, with appropriate bespoke UK road databases and courseware (Parkes, 2003; Parkes and Rau, 2004).

The full system became operational in October 2003 at the TRL headquarters. During the period November 2003 to March 2004 over 600 drivers took part in training and validation trials. The main focus was to provide analysis of the efficiency and acceptability of training exercises provided within the synthetic environment.

The second phase sought to further develop the approach and to focus on fuel-efficiency training.

## Method

### Participants

400 volunteer qualified truck drivers were recruited from a wide range of transportation companies and participated in the trials. Analysis is restricted to those drivers who reported levels of simulator sickness (as measured via the Kennedy Simulation Sickness Questionnaire (SSQ)) below the 75th percentile.

### Equipment

TRUCKSIM comprises a dedicated facility to provide training for drivers of commercial vehicles. The Full Mission Simulator (FMS) consists of a Mercedes Actros cabin mounted within a pod and surrounded by a curved screen (Figure 1).

Figure 1 Interior and exterior of the truck simulator



An array of seven projectors in the pod provides the driver with a 270° field of view plus the facility to use the rear-view mirrors as normal. A TFT monitor mounted on the nearside of the cabin supplies the equivalent view of a kerb mirror. The simulator display has a refresh rate of 60 Hertz, a resolution of 1280 × 1024 pixels and approximately 2.9 arc minutes per pixel. The pod is mounted on hydraulic actuators to give full motion with 6 degrees of freedom: pitch, roll, heave, yaw, surge and sway. An eight-speed manual gearbox (four on four with range change) is provided in the cab. The motion characteristics are described in more detail in Table 1.

Table 1 Summary of the full motion potential of the truck simulator

	Pitch	Roll	Heave	Yaw	Surge	Sway
Displacement (°)	10°	12°	8°	±0.5 m	±0.65 m	±0.6 m
Acceleration	>100°s <sup>2</sup>	100°s <sup>2</sup>	100°s <sup>2</sup>	0.5 g	0.75 g	0.75 g

A simulated road network is used, containing generic motorway, rural, urban, and suburban areas with correct UK-specification junction layouts and signage, and a special distribution centre for parking manoeuvres (Figure 2). The software controlling the simulated environment allows the instructor to adjust various features of the driving experience from the simulator control room. These include the weather, the ambient lighting, the road friction, the truck load, the truck configuration (articulated trailer/tanker, rigid, tractor), load type and load centre of gravity. Up to 40 other vehicles with intelligent behaviour can be displayed in the scene at any one time.

Figure 2 Examples of the road scene in the urban route section



# Procedure

On arrival at the facility, participants were given an introduction to the objectives of the programme before completing pre-drive questionnaires. They were then given a 10-minute familiarisation drive of the simulator along an unchallenging urban route. Once familiar with the vehicle and controls, participants completed the first recorded drive. Then participants were given a video presentation explaining fuel-efficient driving principles and how these might be applied in a real driving situation. It instructed participants to keep the engine RPM in the green band of the RPM gauge by selecting an appropriate gear and accelerator position for the conditions, to use gravity rather than the accelerator to build speed on downhill sections, to block change gears when appropriate, and to avoid harsh braking or acceleration. The video considered the benefits of traffic awareness and forward planning to keep the vehicle moving efficiently as far as possible. The drivers then had the opportunity to demonstrate these principles in a repeat of the fuel efficiency exercise. The measures of interest were: time to complete the task, the number of gear changes shown and the apparent fuel usage.

## The driven vehicle

In the simulator exercise, drivers were asked to operate a Mercedes Actros tractor unit pulling a fully laden (44-tonne) semi-trailer. This vehicle type was used to achieve maximal differentiation in fuel usage between drivers who demonstrate good and bad driving techniques for fuel efficiency.

## The route

The route was the same for both drives and consisted of three sections: rural (1.6 miles), high-speed motorway and dual carriageway (4.4 miles), and urban (0.7 miles). This took around 19 minutes on average to complete.

# Results

Not all of the results of this study can be presented here. There follows a small subset that focuses on some of the key metrics of interest. Two comparisons are made. First a comparison across age groups of driving style during the initial (pre-training) drive. Then, a series of analyses focused on the difference between each driver's first and second drives.

## Initial driving style

Table 2 shows the mean time taken to complete the high-speed section of the route according to the age group of the driver.

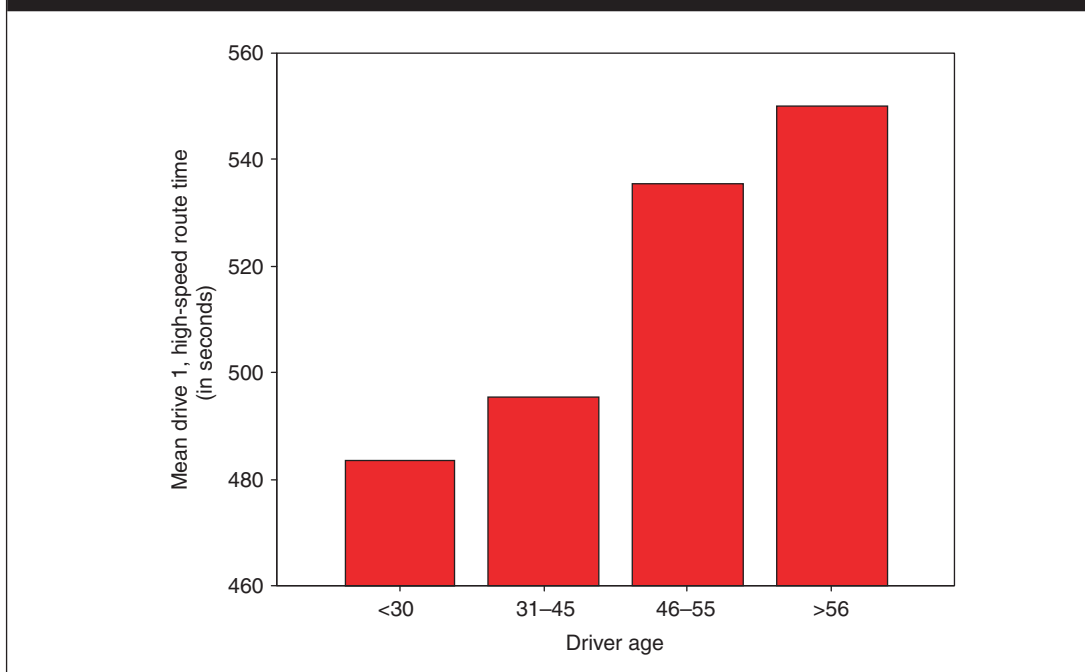
A one-way ANOVA (ANalysis Of VAriance between groups) revealed a significant main effect ( $F(3) = 11.254, p < 0.001$ ). Post-hoc comparisons using the Bonferroni

**Table 2 Time taken to complete drive 1, by driver age**

Driver age	Drive 1, high-speed route time (seconds)				Total N
	Mean	Minimum	Maximum	Standard deviation	
<30	483.42	403.00	660.00	59.37	22
31–45	495.49	334.00	629.00	43.39	155
46–55	535.49	243.00	1,138.00	94.36	98
>56	550.00	422.00	688.00	65.15	41

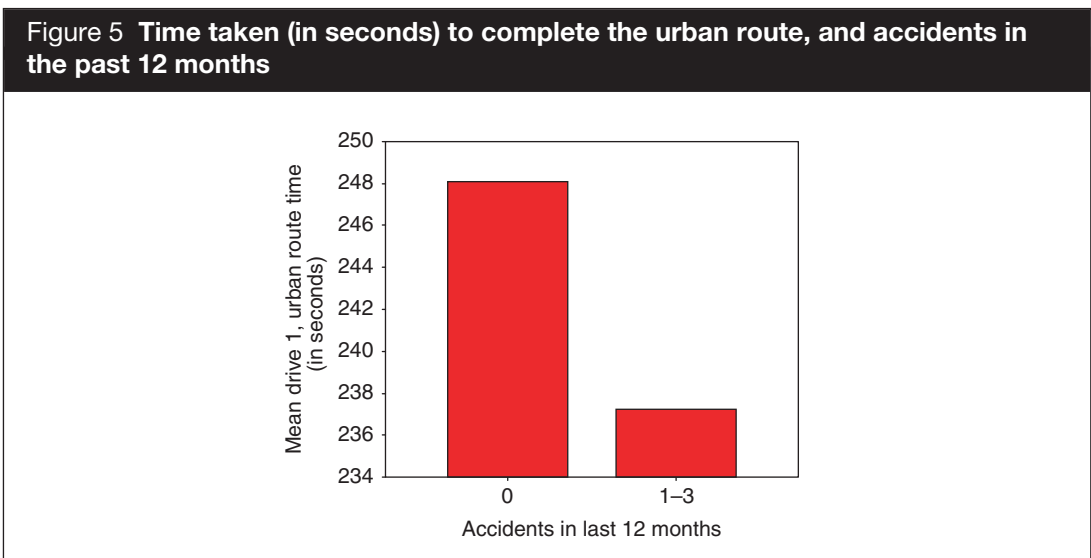
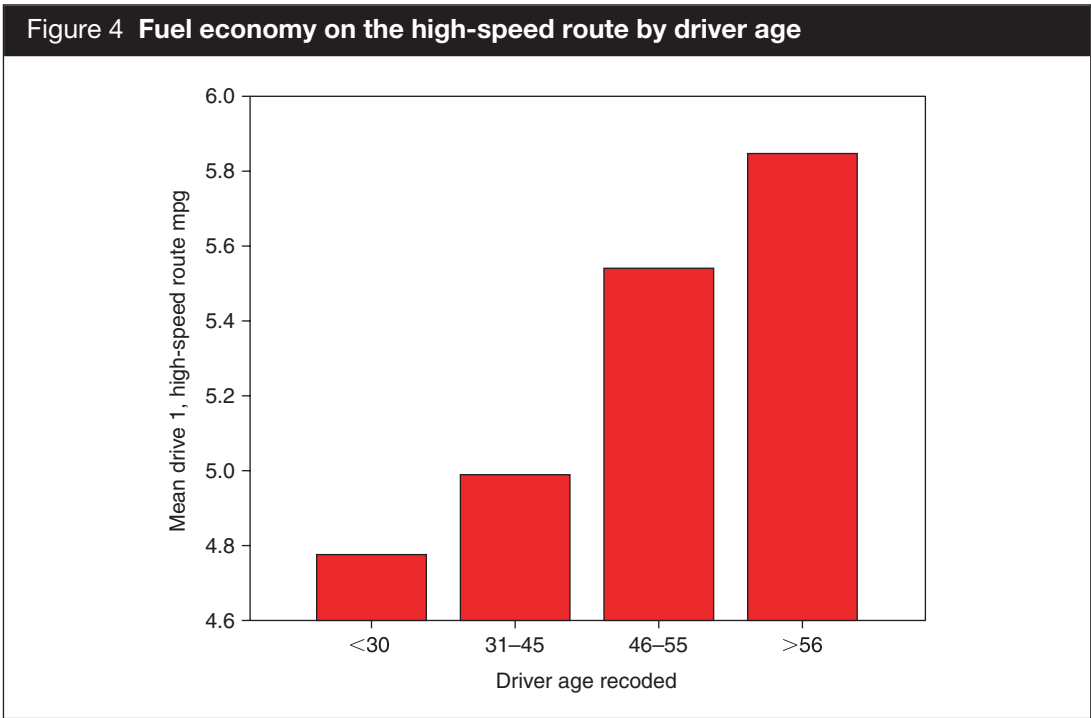
correction revealed that drivers in the 46–55 years category took significantly longer to complete the high-speed route than drivers in the <30 years category (mean difference = 52.0676,  $p = 0.014$ ) and drivers in the 31–45 years age category (mean difference = 39.9994,  $p < 0.001$ ). Drivers in the >56 years age category took significantly longer to complete the high-speed section than drivers in the <30 age category (mean difference = 54.5108,  $p < 0.001$ ) and drivers in the 31–45 age category (mean difference = 54.5108,  $p < 0.001$ ).

**Figure 3 Time taken (in seconds) to complete the high-speed section by driver age**



This pattern was reflected in the measure of fuel economy. Figure 4 shows the miles per gallon figure for each age group on the same section of the route. A comparison was also made of driving style as a function of previous accident rate.

A one-way ANOVA revealed that there was a significant effect of the number of accidents in the past 12 months on the time taken to complete the urban route ( $F(1) = 3.935$ ,  $p = 0.048$ ). Figure 5 indicates that drivers who had been involved in no accidents took significantly longer to complete the urban route than those who had been involved in 1–3 accidents.



## Effect of fuel efficiency training (difference between drive 1 and 2)

Table 3 shows the mean overall time taken to complete drive 1 and drive 2. The mean reduction in time between drive 1 and 2 was 71 seconds.

Table 3 Total time (seconds) taken to complete drive 1 and 2					
	N	Minimum	Maximum	Mean	Std deviation
Drive 1 total time	282	640.00	1,729.00	1,081.6348	122.27225
Drive 2 total time	251	745.00	1,298.00	1,010.6295	97.74212
Valid n (listwise)	241				

The distribution of the time data for drives 1 and 2 was normal, and a paired t-test showed that drivers took significantly less time to complete drive 2 ( $t = 13.283$ ,  $df = 240$ ,  $p < 0.001$ ).

**Figure 6 Mean total time (in seconds) taken to complete drive 1 and drive 2**

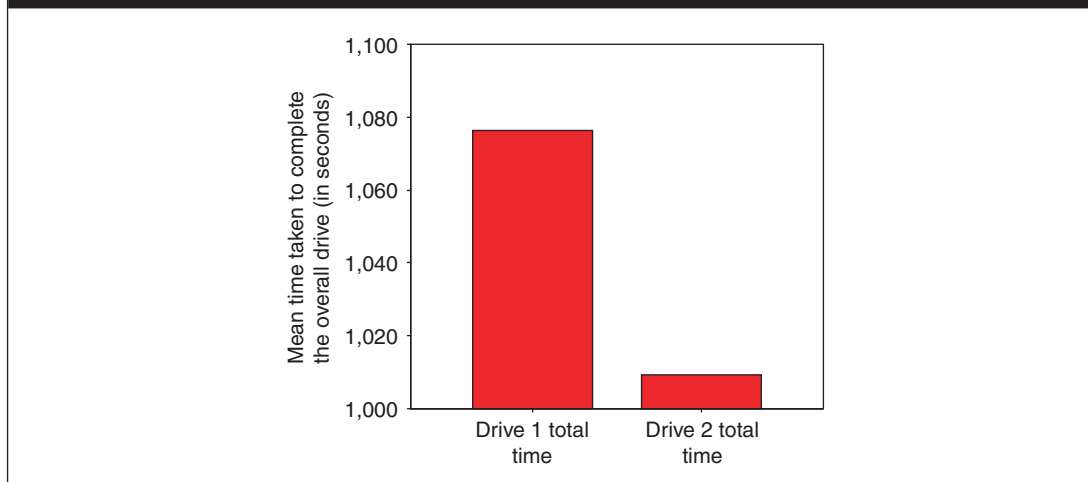


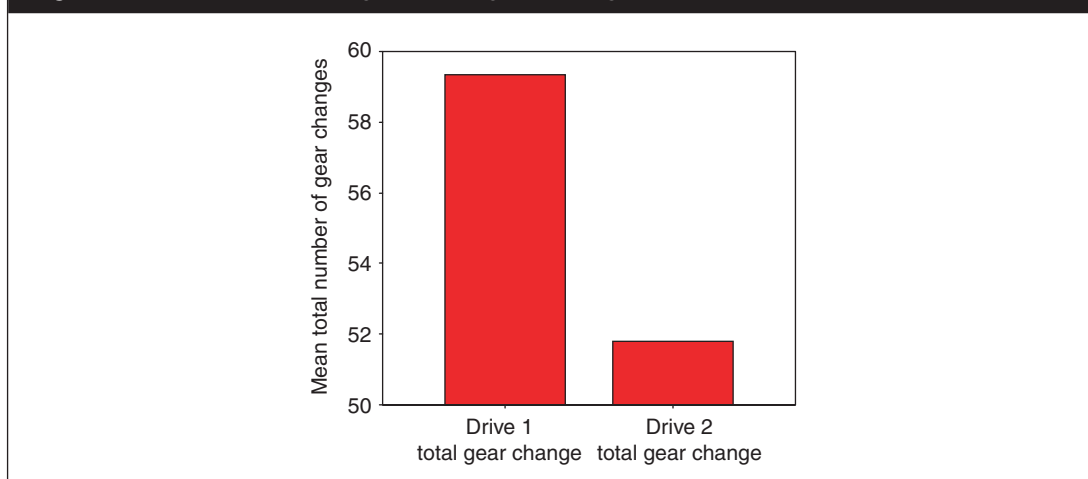
Table 4 shows the mean number of gear changes made overall during drives 1 and 2. The mean overall reduction in the number of gear changes was 7.6.

**Table 4 Number of gear changes during drives 1 and 2**

	n	Minimum	Maximum	Mean	Std deviation
Drive 1 total gear changes	282	31.00	157.00	59.5248	15.66513
Drive 2 total gear changes	251	25.00	151.00	51.9323	13.23538
Valid n (listwise)	241				

A paired sample t-test was used to compare the total number of gear changes made during drives 1 and 2. Drivers made fewer gear changes during drive 2 ( $t = 10.372$ ,  $df = 240$ ,  $p < 0.001$ ).

**Figure 7 Mean number of gear changes during drives 1 and 2**



The pattern so far shows that increased speed can be accompanied by a reduction in gear changes, and hence a saving on wear-and-tear on mechanical components. The result, however, with greatest salience to the freight industry is likely to be that of changes to fuel consumption.

Table 5 Fuel consumption (mpg) on rural sections of drives 1 and 2					
	n	Minimum	Maximum	Mean	Std deviation
Drive 1, rural route mpg	315	0.84	6.73	2.8142	0.42782
Drive 2, rural route mpg	259	0.88	6.80	2.8944	0.37632
Valid n (listwise)	256				

Fuel consumption on drive 1 was compared to fuel consumption on drive 2 using a paired sample t-test. There was a significant difference ( $t = - 6.970$ ,  $df = 255$ ,  $p < 0.001$ ). Figure 8 shows that fuel consumption was significantly lower (higher mpg) during drive 2 than during drive 1.

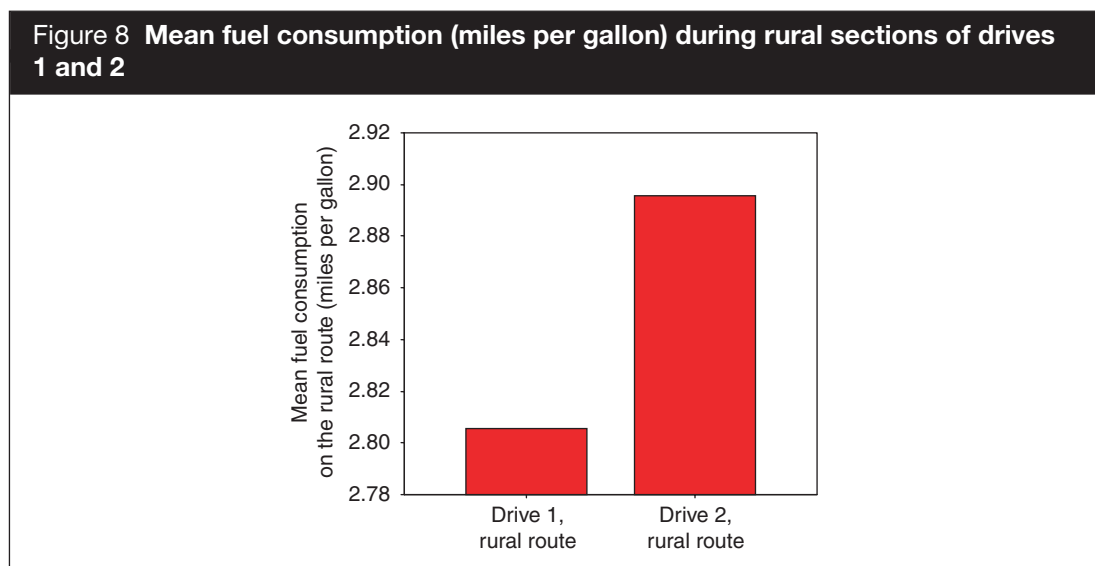


Table 6 shows fuel consumption across the entire route for drives 1 and 2. The means show that fuel consumption was lower during the rural section of drive 2.

Table 6 Fuel consumption across the whole route for drives 1 and 2					
	n	Minimum	Maximum	Mean	Std deviation
Drive 1 mean mpg	282	3.05	16.53	4.2286	1.00236
Drive 2 mean mpg	251	3.03	22.31	4.3487	1.26231
Valid n (listwise)	241				

Fuel consumption for the entire route on drive 1 and drive 2 was compared using a paired sample t-test. The difference between the drives did not reach significance.



## Summary of results

There was:

- an 11% decrease in gear changes ( $t(250) = 10.61$ ;  $p < 0.001$ );
- a 6% decrease in time taken to complete the route ( $t(249) = 13.82$ ;  $p < 0.001$ );  
and
- a 3.5% improvement in fuel efficiency ( $t(247) = -7.25$ ;  $p < 0.001$ ) on the rural section. The overall figure of 2.8% improvement for the complete route did not reach significance.

The results show that although the drive was completed quicker, less fuel was used and there were fewer gear changes, therefore producing less wear on the (simulated) vehicle.

## Conclusions and future work

These results are encouraging given such limited training time in the simulator, but it must be emphasised that there is no transfer of training measure here. The improvement in performance given the changes in driving behaviour have only been measured within the simulator environment, and the carry over in performance to real world driving has not been made in this phase of the research programme. The next phase will place an emphasis on extending the capability of the simulator to provide much more detailed feedback to the driver of their performance in relation to group norms on a much wider series of driving elements relevant to safe and fuel efficient driving.

Around 40 drivers are to take further simulator training at roughly one-month intervals for three further visits. This approach in itself will only confirm the benefits or otherwise of the simulation training on further simulator activity, and does not necessarily generalise to real world behaviour. Therefore, it is intended to augment such findings in two ways: by accessing real world fuel-consumption data for the trainees over the experimental period and, if possible, to compare this cohort to two matched cohorts who have either undertaken normal safe and fuel efficient driving (SAFED) training, or no formal training over the same time period.

This longitudinal cohort approach should allow us to address some of the issues succinctly raised by Williges *et al.* thirty years ago, and provide an objective basis for some of the future decisions on curriculum content and the cost effectiveness of synthetic training.

## Acknowledgements

The TRUCKSIM programme reported here was supported by the Road Haulage Modernisation Fund (RHMF) and the Department for Transport (DfT) under contract PPAD 9/142/5.

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# 14

## Effects of a high sugar content 'energy' drink on driver sleepiness

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### Summary

Although the ingestion of high levels of glucose might have a short acting alerting effect, there is some evidence that it may then promote sleepiness in people already sleepy. Motorway service areas have on prominent display a variety of high glucose drinks that appear to be of benefit to the tired motorist. A standard 380 ml bottle of a well-known energy drink (ED) contains 65 g of sugars, although it also contains some caffeine (46 mg) for flavour. Using our driving simulator we compared the effects of the ED with 380 ml of similar tasting drinks, one being sugar free, and the other having an intermediate sugar content (30 g). Drinks were given randomly, double blind on separate occasions in a repeated design, to eight young adult sleepy male drivers, just prior to a two-hour afternoon drive on a full-size car simulator under motorway conditions. We monitored their: steering for lane drifting (i.e. signs of 'microsleeps'), subjective sleepiness, and electroencephalogram (EEG) for signs of sleepiness. There were non-significant trends for the ED to reduce all three measures of sleepiness when compared with the other conditions. This effect was more evident in the second hour. However, this result of the ED was small in comparison with our previous findings where we utilised: i) a typical (80 mg) amount of caffeine, found in a cup of coffee, and ii) a 'functional energy drink' having less sugar (26 g) and more caffeine (80 mg) than the ED. It appears that the sugars in the ED may well promote sleepiness, which is counteracted by the 46 mg of caffeine it contains. The net result of a marginal improvement of the ED on sleepiness is inferior to drinks containing less sugar and more caffeine.

# Background

On the market are various non-caffeinated 'energy' drinks containing very high sugar levels, with the most prominent well-known energy drink (ED) claiming on its label to be for 'brain and body energy'. The motoring public are increasingly viewing this particular drink as a method for combating sleepiness, especially as it is on prominent display in many motorway service areas. A 380 ml bottle of this ED contains 65 g of sugars (the monosaccharides, glucose and fructose) – equivalent to 12 spoonfuls of ordinary sugar (the disaccharide, sucrose). Glucose has a high glycaemic index, which means that absorption from the stomach is fast, to produce a rapid increase in blood glucose, declining over an hour or more, depending on a variety of factors, especially insulin output and the degree of prior fasting. Fructose has a lower glycaemic index, having first to be converted in the stomach, to glucose, before absorption. This initial rise in blood glucose can produce increased alertness in otherwise sleepy people, as determined by EEG and subjective measurements. For example, Landstrom *et al.* (2000) gave approximately 60 g of glucose in 350 ml solution (vs water), and reported an alerting effect of glucose lasting 10–15 minutes soon after consumption. Thereafter, for the remaining hour of measurement, and compared with baselines and the water alone condition, there was no beneficial effect of the glucose. Interestingly, careful scrutiny of these latter data suggest a subsequent worsening of sleepiness with the glucose. Whilst there may be a two-phase glucose response here (increased alertness reversing to increased sleepiness), it should be noted that this study was conducted mid-morning when there tends to be a natural, circadian rise in alertness.

Meals, including a high intake of carbohydrates, can produce varying degrees of 'postprandial hyperaemia', whereby blood is diverted to the gut in order to aid absorption. This results in less blood going to other organs, including the brain. People can become lethargic and sleepy after meals, especially early afternoon during the circadian 'dip', even when blood glucose levels have risen. Although this dip is largely circadian, it can be exacerbated by the hyperaemia. The finding that glucose loading increases the ventricular volume of the brain (Puri *et al.*, 1999) is indicative of a reduced brain blood flow, which can last 1–2 hours.

Another mechanism by which a high glucose intake could enhance sleepiness comes from the rather controversial proposal by Wurtman and Furnstrom (1974), who suggested that the glucose-triggered insulin response will elevate the uptake of tryptophan by the brain. The resultant synthesis of this amino acid into the neurotransmitter, 5HT, could heighten sleepiness as 5HT is thought to be a sleep promoter.

Clearly, any putative sleep-enhancing effect of a high intake of sugars will depend on the level of latent sleepiness. This topic has received little attention, especially when circadian 'dips' are considered, particularly postprandially in the early afternoon. The only relevant investigation we can find was by Bruck *et al.* (1994), however, the sleepy individuals were unmedicated patients with the sleep disorder narcolepsy. A control group comprised alert, non-sleepy healthy individuals. The investigators gave (doubleblind) at lunchtime 50 g of glucose vs artificial sweetener in 150 ml liquid to both groups. This was combined with a low-calorie light lunch. Twenty minutes later (i.e. beyond any putative alerting effect), sleepiness was monitored for 60 minutes using the EEG and a vigilance task comparable with the Psychomotor Vigilance Test

(PVT). Whereas the glucose had little effect on the alert controls, it significantly worsened sleepiness in the patients.

The authors of this paper (Horne and Balk, 2004) have noticed, from incidental findings using our car simulator studies of sleepy drivers, that non-caffeinated drinks containing high levels of sugars seem to worsen subjective feelings of sleepiness, which was an effect most evident about 45 minutes after having consumed the drink.

As might be expected, sleep-related crashes show a rise in the early afternoon. We wished to explore whether a high ('bolus') intake of monosaccharides (glucose plus fructose) at lunchtime, consumed with a light meal, would affect the afternoon propensity to fall asleep, especially when driving. Owing to its high monosaccharide content and the assumptions that a certain ED alleviates sleepiness, we focused on this beverage.

When we began this study, the labelling on the ED gave no indication that it contained caffeine. However, recently, the label has changed, and it now states that the drink contains caffeine, which we have ascertained to be 12.1 mg of caffeine per 100 ml. A standard bottle contains 380 ml ED, which is sufficient to have some alerting effect in sleepy people. Caffeine takes about 30–40 minutes to have an alerting effect, which can last for an hour or more, depending on the level of sleepiness, time of day etc. If sugar enhances sleepiness, then these amounts of caffeine might partly or wholly reverse any such sugar effect, with the caveat that these actions of caffeine over time would be different to those of sugar. Tentatively, we might expect that in a sleepy person, a high intake of monosaccharides might have an immediate alerting effect, prior to caffeine becoming effective after say, 30 min which, in turn, might coincide with the beginning of any soporific effect of these sugars.

It should be noted that because of the study design it was not feasible to assess any immediate, short-acting alerting effect of sugars. It would mean that any such putative benefit would only be evident if the driving was to be resumed immediately after consumption, which is usually not the case.

## Method

### Participants

Sleep-related collisions are most prevalent among young men aged under 30 years, and for this reason we selected drivers within this range (mean age 23 years s.e. 1.4 years). The two studies comprised separate participant groups. The study recruited 10 men, however two dropped out, leaving eight. All were: healthy (medication free), non-smokers, had a Body Mass Index (BMI) between 22 and 25, good sleepers (no sleeping complaints, sleeping regular hours, scored <10 on the Epworth Sleepiness Scale (Johns, 1991)), took daytime naps <1/month, were low to moderate (0–4 cups daily) caffeine consumers, were regular but not excessive alcohol drinkers (average 20.2 units/week [s.e. 1.5]), experienced drivers (having held a full UK driving licence >2 years; driving on average >3 h/week). The procedures were fully explained, they signed consent forms and were paid to participate. On an initial day, separate from the main studies, they underwent practice sessions on the driving simulator. The study was approved by the University Ethical Committee.

## Procedure

To ensure at least some afternoon sleepiness, and on the night prior to each experimental day, participants' sleep was restricted to five hours, between 02:00 and 07:00, and was monitored by wrist-worn actimeters. For 36 hours before each experimental session they also had to complete a sleep and food diary to ensure sleep and food intake were consistent for each trial. On trial days, participants were asked to have their usual breakfast, and then to refrain from eating from 09:30 onwards. Caffeine consumption was prohibited from 22:00 the night before the trial, and alcohol consumption for 24 hours previously. Participants came to the laboratory at 12:30 and had their actimeters downloaded and checked for sleep compliance. They were given a bowl of 'minestrone' soup (one can), and then had EEG electrodes fixed. At 13:50 drinks were administered (double blind) and at 14:00 participants went to the simulator.

Commencing at 14:00, and on three separate occasions, participants underwent a two-hour simulated drive under three double blind randomised conditions:

- **NIL** Sugar – 380 ml of an orange flavoured drink containing 'Nil-Sugar' (artificial sweetener) and no caffeine;
- **MEDIUM** Sugar – 380 ml of an orange flavoured drink containing 30 g of sugar; and
- **HIGH** Sugar – 380 ml of ED containing 65 g of sugar plus 46 mg of caffeine.

We appreciate that as 'High' also contains caffeine, that a further condition of 380 ml of an orange flavoured drink containing 65 g sugar without caffeine should have been used. However such a drink does not exist, and would be unpalatably sweet as the bitterness of caffeine helps mask the sweetness. Besides, we wished to focus on drinks actually on the market and easily available to drivers.

## Simulator

This is an immobile car with a full-size, interactive, computer-generated road projection of a dull monotonous dual carriageway (see Figure 1). The image is projected onto a 2.0 m × 1.5 m screen, located 2.3 m from the car windscreen (Figure 2). The road has a hard shoulder and simulated auditory 'rumble strips', with long straight sections followed by gradual bends. Participants sit in the driving seat and drive in the left-hand lane at all times (unless overtaking), and at their normal cruising speed. Lane drifting is the most common manifestation of sleepy driving, and during the drive a car wheel touching (or crossing) the left rumble strip or central white line is identified as a driving 'incident'. Split-screen video footage of the roadway and driver's face (filmed with an unobtrusive infrared camera) enables the cause of the incident to be determined. Those due to sleepiness (e.g. eye closure or vacant staring ahead) are logged as 'sleep-related incidents' (SRIs). As a further check for SRIs, the EEG and electrooculogram (EOG; see below) are examined respectively for alpha/theta intrusions and possible 'eye rolling'.

Figure 1 The simulator



Figure 2 View through windscreen



## Subjective sleepiness

The Karolinska Sleepiness Scale (KSS) consists of a 10-point scale to assess subjective sleepiness (Åkerstedt and Gillberg, 1990): 1 = extremely alert, 2 = very alert, 3 = alert, 4 = rather alert, 5 = neither alert nor sleepy, 6 = some signs of sleepiness, 7 = sleepy, no effort to stay awake, 8 = sleepy, some effort to stay awake, 9 = very sleepy, great effort to keep awake, fighting sleep.

Throughout the drive, and every 200 seconds, participants were verbally prompted to report their subjective sleepiness using the KSS, which was clearly visible on the car's dashboard. Other than this, the experimenter did not engage in any conversation with the driver and remained out of sight.

## EEG and EOG

Electrodes were attached for two channels of EEG (main channel C<sub>3</sub>-A<sub>1</sub>, backup channel C<sub>4</sub>-A<sub>2</sub>). To identify ‘eye rolling’, there were EOG channels (electrodes 1 cm lateral to and below the left outer canthus and 1 cm lateral to and above the right outer canthus; both referred to the centre of the forehead). Inter-electrode distance was carefully maintained between conditions by using the 10–20 system for electrode placement. The EEG and EOG were collected using ‘Embla’ (Flaga Medica Devices, Iceland) and spectrally analysed using ‘Somnologica’ (Flaga) in 4 seconds epochs. Low and high band-pass filtering of the EEG at >30 Hz and <0.3 Hz removed slow eye movements and muscle artefact. An increase of EEG power in the alpha (8–11 Hz) and theta (4–7 Hz) ranges indicate an increase in sleepiness (e.g. Rechtschaffen and Kales, 1968). EEG power in 4–11 Hz (alpha and theta combined) was averaged in one-minute epochs. As there are individual differences in EEG power, and to allow comparisons between conditions, we standardise each individual’s power in these ranges, for all conditions (Horne *et al.*, 2003).

## Statistical analyses

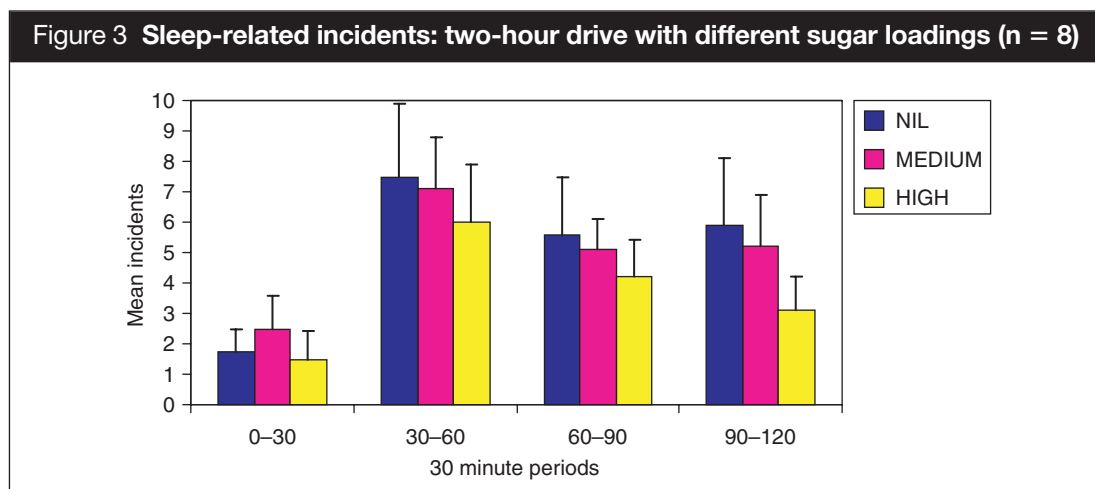
SRI, EEG and subjective sleepiness were averaged into 30-minute epochs per participant and condition. Two-way (condition × time) repeated measures ANOVAs were applied (using the Huynh-feldt [e] adjustment). All degrees of freedom (df) shown below are adjusted for e when appropriate.

## Results

Two participants failed to complete all three conditions and their data are excluded from the following findings (n = 8).

### SRI

Considering the findings with the PVT, the findings with SRIs were unexpected, as can be seen from Figure 3 that the High sugar condition seems to produce the fewest

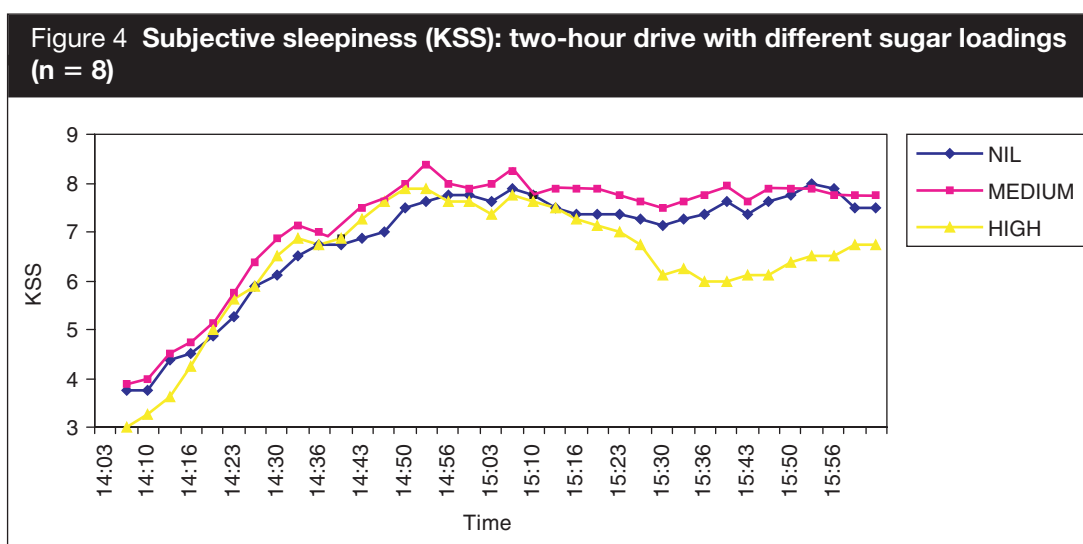




incidents throughout the two-hour drive, however this trend was not significant ( $p < 0.15$ ). SRIs for the Medium sugar condition were mostly in between Nil and High. As might be expected, there was a significant finding with time ( $F = 2.81$ ;  $df$  2.8, 19.7,  $p < 0.045$  [ $e = 0.94$ ]). There was no interaction between condition and time.

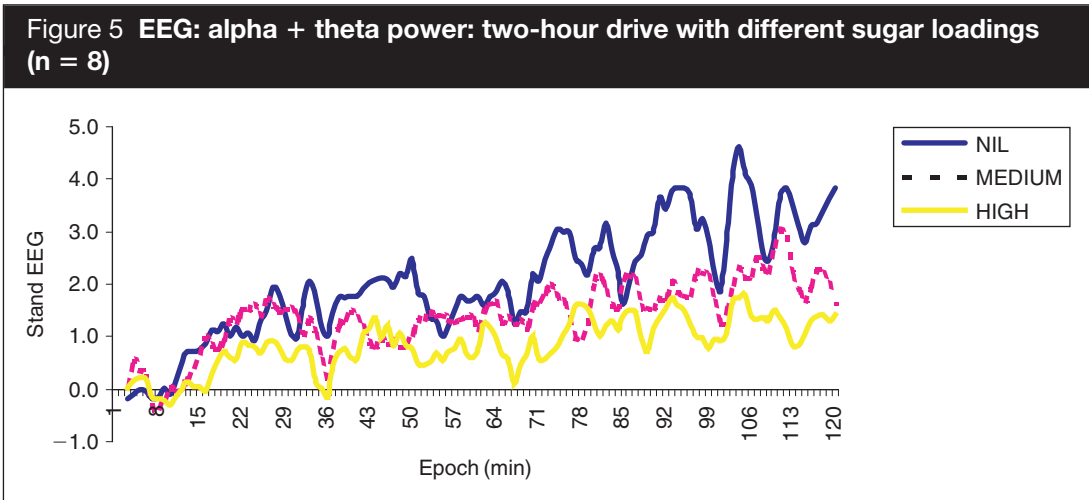
## KSS

Findings with subjective sleepiness are seen in Figure 4, where for the first hour there is no difference between conditions. Although there was no overall significant finding between the sugar conditions with respect to the ANOVA, there is a clear trend for alertness to be improved during the second hour, compared with the other conditions. A post-hoc repeated measures ANOVA between conditions for the second hour only is significant ( $F = 5.78$ ;  $df$  1.23, 8.89,  $p < 0.034$  [ $e = 0.63$ ]), with High being less than the other conditions. Again, there was an overall significant effect of time over the two hours ( $F = 31.8$ ;  $df$  3.21,  $p < 0.001$  [ $e = 1.0$ ]), but no significant interaction.



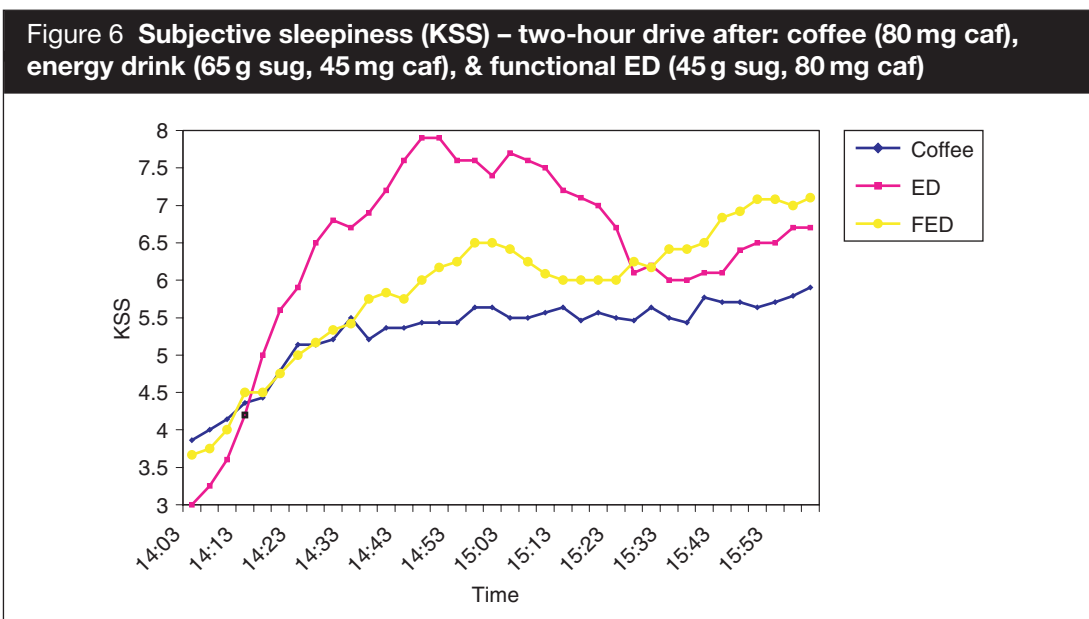
## EEG

Figure 5 shows the mean EEG in one-minute intervals; the higher the power, the greater the sleepiness. Whilst there is a trend for the three conditions to show differences in power in the second hour, in the direction High > Medium > Nil, this does not reach significance, even when the second hour is considered separately. There is a significant effect of time over the two hours ( $F = 10.9$ ;  $df$  1.4, 10.2,  $p < 0.005$  [ $e = 0.48$ ]).



## Discussion

There are trends with all three measures that High sugar does reduce sleepiness somewhat, especially in the second hour. However the extent of this effect is not statistically significant over two hours. The driving protocol we used (sleep restriction; two-hour afternoon driving on the simulator; healthy young adults) has been used for many of our other studies. For reference, and to put the present findings in context, the KSS findings with the High sugar are compared in Figure 6 with those: i) from a study (Reyner and Horne, 2002) using a ‘functional energy drink’ (FED – 250 ml containing 26 g of sugars, 80 mg of caffeine as well as taurine and glucuronolactone), and ii) unpublished findings (Reyner and Horne), utilising 80 mg of caffeine added to decaffeinated coffee. With the caveat that all these data are from different studies, it is fairly clear, nevertheless, that compared with sugar, the caffeine content of drinks is the key factor in alleviating sleepiness, not sugar itself.



# Overall conclusions

It is clear that any benefit the ED provides for the sleepy individual, beyond a putative, immediate but ephemeral alerting effect (up to about 15 minutes), is marginal at best. The Medium sugar drink contained 30 g of sugars (nil caffeine), and produced no discernable differences for sleepiness during driving, compared with the Nil sugar drink. However, depending on the level of sleepiness, any beneficial effect of caffeine would have to be above a minimum amount, especially if it was to reverse any soporific effect of sugars. The net effect seems to have been a trend for reduced sleepiness, especially in the second hour of driving. In sum, the intake of sugars, in whatever form and dose, is a relatively ineffective way of alleviating sleepiness, and that caffeine must be the substance of choice in this respect (cf. Horne and Reyner, 1996; Reyner and Horne 2000).

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# 15

## Towards cognitive vision: a tool for assessing road user behaviour

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### Introduction

The aim of this paper is to present a framework for a more thorough description and analysis of road user behaviour in order to better understand what we define as the traffic safety process. The method is an extension of the Traffic Conflicts Technique (TCT) concept, i.e. the precondition of collision course remains. The idea is, however, to include normal interactive behaviour in the analysis, thus not only exceptional behaviours such as those leading to accidents and/or serious conflicts. To be able to collect such detailed information about behaviour, a more efficient system than the manual observer or video-operator is required. Another aim of the paper is therefore to present cognitive vision as a tool for assessing road user behaviour. It is a tool that can improve data collection of different indicators on safety, mobility, accessibility, etc.

### Background

#### **Accident data analysis**

The traditional way of approaching traffic safety has mainly been concerned with the occurrence of traffic accidents and their consequences. The disadvantages of accident data analyses have been discussed extensively in several papers, e.g. Englund *et al.* (1998), and Grayson and Hakkert (1987). The problems connected to the use of accident data for traffic safety evaluation have made it quite obvious that there is a need to widen the scope. Accidents are, for example, rare events. For the local everyday traffic safety work, it is not sufficient to use accident data only. To produce reliable estimates of traffic safety, additional information is very often needed. There are also difficulties with the recording of accidents. Not all accidents

are reported and the level of reporting is unevenly distributed with regard to the type of road users involved, location, severity of injuries etc. Vulnerable road users are, for instance, heavily under-represented in the police accident statistics compared to what hospital registrations and other studies show (Berntman, 1994). But most importantly, the behavioural or situational aspects of the events are not covered by police accident data. It is, for example, very hard to understand the connection between behaviour and safety by only reading the accident record, or even by making an in-depth analysis of accidents. In the latter case, a major complication is that it is very expensive to obtain data that will be representative enough to allow conclusions to be drawn regarding safety, e.g. at a certain type of intersection or on any other more detailed level.

Sometimes, for various reasons, accident data do not exist at all. For instance, this is the case in countries with no established routines for collecting accident data in a structured way. Or, when a totally new measure is to be introduced, there are no historical accident data to indicate the possible safety effects of the measure. Before introducing such new measures on a larger scale, it is, of course, desirable to know their safety effect. This demonstrates the need for quick and valid results from perhaps many different small-scale trials. Accident analysis is presumably not the most relevant tool to use in such circumstances.

## **TCT – a method to collect and analyse near-accidents**

The need for surrogate or complementary methods for accident analysis is consequently high. The development of the Swedish Traffic Conflicts Technique (TCT) is an attempt to form such a complement.

The first (known) conflict technique was presented in 1968 by Perkins and Harris at the General Motors Laboratory in the USA (Perkins and Harris, 1968). The task was to study intersections and to see whether GM cars performed differently in comparison to other makes of car with regard to safety. This first definition of a conflict was mainly based on brake light indications. Since then a number of different conflict techniques have been developed in different countries. The first International Traffic Conflicts Workshop was held in Oslo in 1977. Here a group of researchers, assembled from many parts of the world, decided upon a general definition of a conflict:

A conflict is an observational situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged.

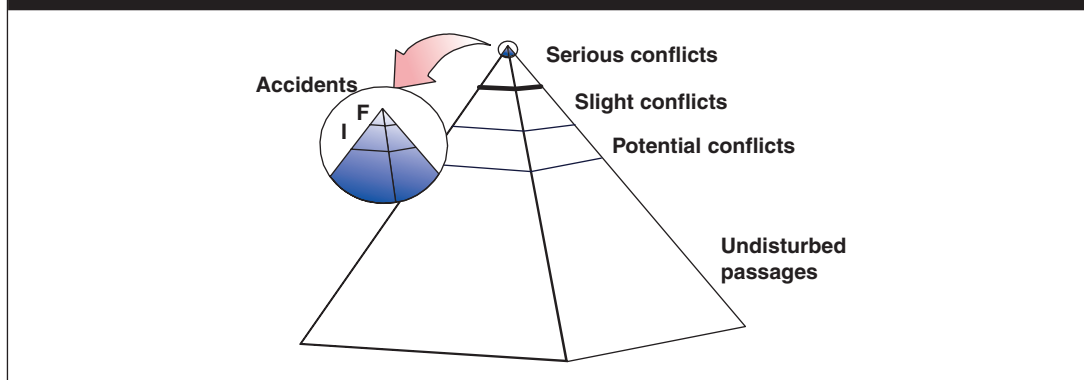
The basic hypothesis is that there is a close relationship between conflicts and accidents. The interaction between road users can be described as a continuum of safety related events (see Figure 1). These events can be looked upon as different levels in a pyramid; the accidents are found at the very top and the ‘normal’ passages at the bottom. The different levels in the pyramid can, in other words, be seen as a severity scale. In the Swedish TCT, this severity scale is accomplished by applying the TA/Speed dimension, i.e. the Conflicting Speed and the Time to Accident value (TA value), which presupposes a collision course. The severity scale in the Swedish TCT implies that the probability of a police reported injury accident is constant within the level and increases towards the top. The pyramid based on the

TA/Speed concept can be seen as one of the severity hierarchies (other severity hierarchies are based on other presumptions):

- The *Conflicting Speed* is the speed of the road user taking evasive action, for whom the TA value is estimated, at the moment just before the start of the evasive action.
- The *Time to Accident* (TA value) is the time that remains to an accident from the moment that one of the road users starts an evasive action *if* they had continued with unchanged speeds and directions.

Besides having a severity scale based on the TA/Speed presumption, the Swedish TCT is also characterised by the elaboration of conflicts with different severity. When developing the Swedish TCT, it was found essential to distinguish the serious conflicts from the rest of the conflicts, as the serious conflicts were found to more strongly possess the quality of being an indicator of a breakdown in the interaction – a breakdown that could correspond to the breakdown in the interaction preceding an accident. A serious conflict is also, like the accident, a situation that nobody puts him/herself into deliberately.

Figure 1 The pyramid – interaction between road users as a continuum of events (Hydén, 1987)



Reliability and validity are two issues strongly connected to the usability of TCT. The external reliability of observers answers the question if the observers are able to distinguish serious conflicts from other events in the same way among themselves and in accordance with the conflict criteria. In an international calibration study, there was an opportunity to check the subjective estimates with objective measures (analyses by Hydén (1987) from results of Grayson (1984)). The Swedish conflict observers' estimate of TA values were just about as often an overestimate as an underestimate. On average, however, the observers' estimates were somewhat biased, with a 0.05 second difference from the objective evaluation. There was a tendency to underestimate high objectively measured TAs and to overestimate low objectively measured TAs. When comparing the figures on speed, there was also found to be a small bias. The estimates of the speeds were on average 3 km/h lower than the objectively measured speeds. The analysis also showed that the observers failed to score about 26% of the conflicts that should have been scored.

Validity in this context means to what extent conflicts describe the phenomenon in traffic that they are intended to measure. Some state that the validity of TCT depends on how well it can predict accidents. This is sometimes called product validity, i.e. to what extent serious conflicts can be used in order to predict the number of accidents.

Hauer and Gårder (1986) have looked into the issue of validity and they state ‘some will regard the TCT as valid if it proves successful in predicting accidents; others will judge validity by the statistical significance or the magnitude of the correlation between conflicts and accidents’. There is, in other words, some confusion. They try to overcome this problem by defining safety for some part of the transportation system (e.g. an intersection) as expected number of accidents per unit of time. They continue that ‘the proper question to be asked is: how good is the TCT in estimating the expected number of accidents? In this sense the TCT should be compared to other methods, e.g. accident data or exposure, and comparisons should be made between the variances of the estimates. Hauer and Gårder conclude, in their attempt to make a final definition of ‘validity’, that ‘A technique (method, device) for the estimation of safety is “valid” if it produces unbiased estimates, the variance of which is deemed to be satisfactory.’ The Swedish TCT has been validated following this theory and the analyses show that at lower accident frequencies it is preferable to use conflicts instead of accidents in estimating the expected number of accidents (Svensson, 1992).

Process validity means the extent to which conflicts may be used for describing the process that leads to accidents. The process is here understood as the events preceding the accidents. In the process validation work of the Swedish Conflicts Technique, Hydén (1987) has compared the processes preceding injury accidents to those preceding conflicts. Analyses showed big similarities between accidents and conflicts when the comparison was based on TA values and conflicting speed. Accidents and conflicts were continuously distributed with a tendency for the accidents towards lower TA values and higher speeds. Analyses also showed that the distributions of different types of evasive action were very equal for accidents and conflicts.

## Extension of the TCT concept

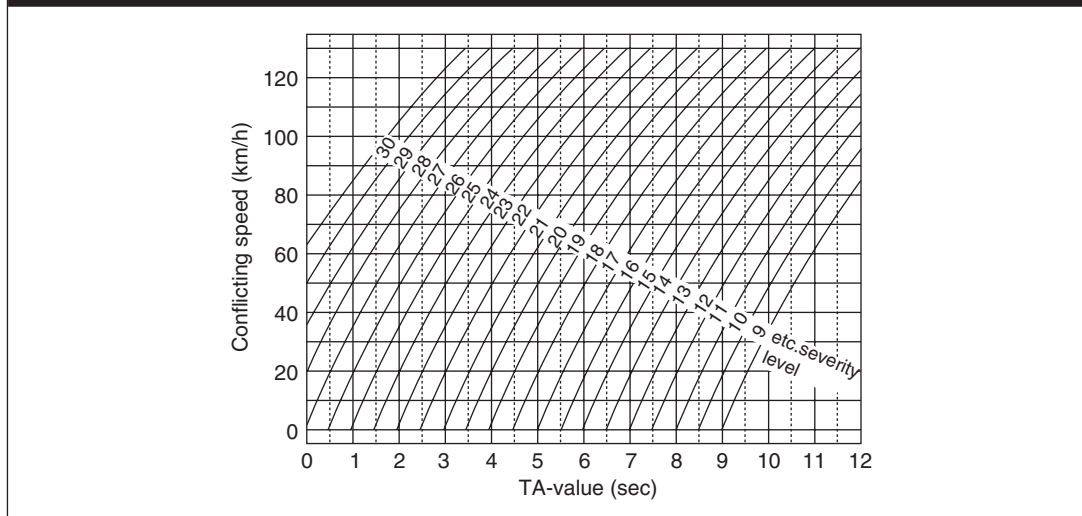
Many of the shortcomings in accident data analyses are provided for with the use of TCT, but not all. Serious conflicts are also rare events from a statistical point of view. The primary focus in TCT, as in accident data analyses, is set on rather exceptional events; exceptional in the sense that they deal with failures and almost accidents. These are indeed exceptional if we consider the vast majority of events in traffic, the normal everyday road user behaviour that have safe outcomes. There must be a lot to learn from these “more normal” road user behaviours. A conclusion is therefore that it might be very feasible to extend the TCT concept towards less severe events in the severity hierarchy and thus increase the possibility of working with safety estimates on a more detailed level.

Validation work with the Swedish TCT has indicated a correlation between serious conflicts, where the severity has been assessed by using the TA/Speed value and police reported injury accidents. When less severe events are to be included in the traffic safety process, it seems to be important to assign the evasive action criteria to these events as well, in order to maintain the continuum.

The traffic safety process is a continuum of events, all with a linkage to injury accidents. The events in the traffic safety process are called interactions and are characterised by a collision course. The severity of the process is described by the

TA/Speed value. In the severity hierarchy, as mentioned earlier, an event with a certain severity cannot be classified as an injury accident or a conflict etc. Severity does not refer to the known outcome after the evasive action but to the severity of the event for an infinitesimal unit of time before the evasive action. The outcome then depends on the success of the evasive action. What we can say is that an unknown event with a certain location in the severity hierarchy has a certain probability of being an injury accident as its outcome. The different severity levels in the hierarchy describe different probabilities for the occurrence of an injury accident. In analogy with the definition of severity, we can say that traffic safety is the probability of not being seriously injured in traffic.

Figure 2 TA/Speed graph defining the different severity levels. There is a continuation towards lower severity levels (Svensson, 1998)



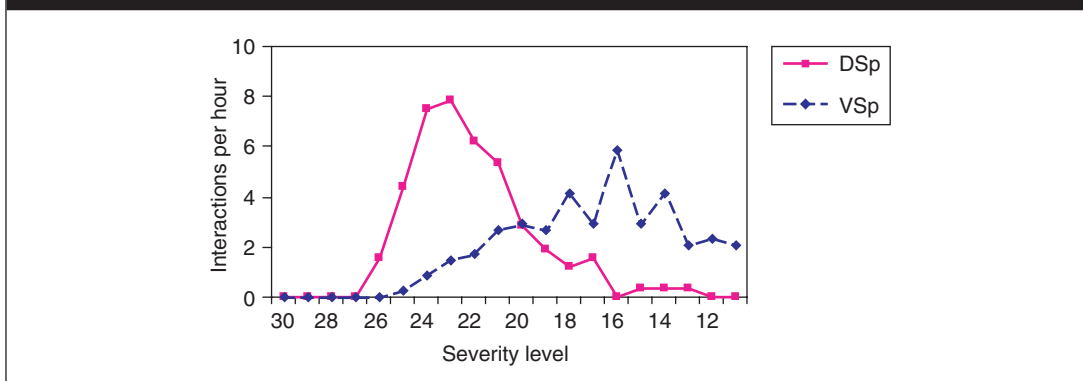
The approach includes studying interactions, positioning them in the TA/Speed graph (Figure 2), with the estimated TA/Speed value obtained at the moment of evasive action, and illustrating the shapes. A study was designed according to the following set up:

- *type of road users* – interactions between a motor vehicle driver and a pedestrian;
- *type of manoeuvre* – vehicles driving straight ahead interacting with pedestrians;
- *type of intersection* – a signalised intersection and a non-signalised intersection;
- *type of situation* – situations involving a collision course, i.e. this implies the existence of an evasive action.

The results show that there seems to be a difference between the distributions with regard to whether the intersection is signalised or not. At the non-signalised intersection the convexity of the distribution is located towards higher (but not the highest) severities as compared to the signalised intersection. The convexity of the distribution at the non-signalised intersection is more narrow, restricted to extend over only a few severity levels as compared to the more widely spread convexity covering several severities at the signalised intersection (see the example in Figure 3).



**Figure 3 An example of different shapes with regard to severity. VSp, vehicles driving straight ahead at a signalised intersection. DSp, the same manoeuvre at a non-signalised intersection (Svensson, 1998)**



The results suggest a border in the severity hierarchy above in which a high occurrence rate of interactions is a sign of being unsafe and beneath which a high occurrence rate of interactions is a sign of safety. This could be of help when differentiating between locations with mainly safe road user behaviour and locations characterised by unsafe road user behaviour.

It is, however, to be noted that a location with a high interaction frequency at low severity levels seems to produce the conditions for occasional events with high injury accident potential. The convexity of these interactions with less severity was, in this study, widely spread out over several severity levels. The opposite pattern, a narrow convexity at reasonably high severities, seems to be the insurance for preventing the most severe types of events from occurring. This is probably due to the learning process, i.e. the increased awareness of the road users brought about by involvement in interactions with reasonably high severity. It is, therefore, from a safety perspective not only interesting to analyse the part of the hierarchy with the most severe events, but also to take the convexity of the distribution into consideration. Hence, the shape of the hierarchy as such includes valuable safety information.

## Cognitive vision

To be able to collect and analyse detailed data about road user behaviour we need a more efficient system than the manual observer or operator. The overall objective of an ongoing project at the Department of Technology and Society in Lund, Sweden, is therefore to combine and extend the current knowledge in traffic engineering and computer vision for the automatic analysis and gathering of data from a traffic environment. The long-term goal in this respect is to design a system where a digital video camera is mounted in a traffic environment. The camera, together with software, should be able to automatically extract important information from a scene, draw conclusions from it, and trigger actions in response. In this project, the goal is threefold: (i) to detect and track all road users' categories (including pedestrians and bicycles) in complex situations under difficult conditions, (ii) to identify road user behaviour, and (iii) to interpret and analyse these behaviours in terms of safety and efficiency. Thus, such a system could provide a basis for a decision support tool for more efficient and sustainable traffic management.

More specifically the objectives of the project are broken into the following measurable goals:

- The development of a computer vision system adapted to traffic conditions and needs. One of the objectives is to develop a computer vision system that can detect and follow road users in different types of environments. Thus, it would be able to detect small objects such as pedestrians and cyclists. It would also be capable of following these road users not only when they are moving straight ahead but also when they make sudden changes in directions and speeds. The system would manage complex situations with complex movements, such as in the urban environment, and would thus improve the operative and strategic traffic management.
- Develop algorithms for analysing relevant road users' behaviour and interaction. From the trajectories, which describe the road user's location at each unit of time, we would be able to interpret the road user's movement. The basic pieces of information are location, speed and direction. This can then be analysed in relation to other types of information, such as the presence of another road user, distance to another road user, predicted time to accident (TA value), etc. We would be able to make operational definitions of relevant road user behaviour and interaction; an approach that increases the potential for standardising definitions which, in turn, is a requirement for comparing results from different studies in an objective way.
- Interpretation of a set of road user behaviours (indicators) in terms of overall system performance (safety, efficiency, comfort etc). Here, we focus on the validity and reliability of the chosen indicators in their role as predictors of more important qualities.

## Conclusion

This paper presents cognitive vision as a tool that can make the collection and analysis of detailed road user behaviour possible. With such a system it will be possible to collect data on various interesting indicators of safety, mobility, accessibility, etc. It will also, in the longer run, provide good possibilities for validating such indicators, i.e. to analyse to what degree the collected indicators actually describe the phenomena in traffic that they intend to describe. The development of a system based on cognitive vision has just started; it is still in a very premature phase.

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## Distortions of drivers' speed and time estimates in dangerous situations

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It has often been suggested that the rate of passage of time becomes slower during a car crash – the moments seem to stretch out towards the inevitable collision. Any such distortion of subjective time would have important implications for people's behaviour in dangerous driving situations and their subsequent memory of the events they experience. This paper briefly reviews research on retrospective and prospective time estimation tasks, and introduces a new task in which films of events are systematically altered in speed. Participants then have to judge what alteration to the film speed has been made. In a first experiment drivers were reliably found to judge films of dangerous driving situations as having been sped up, while films of safer driving events were judged as playing too slowly. There was some evidence that older, more experienced drivers might overestimate the speed of dangerous events more than younger novice drivers. In a second experiment, participants viewed films of themselves or other people performing easy or harder tasks in the laboratory. Easy tasks and films of the participants themselves were most likely to be judged as having been sped up. The overestimation of the speed of dangerous events seems to be a real phenomenon and does not seem to be simply interpretable in terms of the difficulty of the task or a lack of control. The results are consistent with the observation that drivers remember dangerous situations as if time had slowed down, but they do not resolve the question of whether any such distortion actually happens at the time a dangerous event is experienced, or happens because of a later distortion of memory.

## Introduction

When we consider the possibility that there may be a subjective distortion of time in dangerous situations, it is important to distinguish between prospective time estimates (those made while the time interval is being experienced) and retrospective time estimates (those made later, when looking back at a time interval in memory).

This difference between prospective and retrospective tasks, or experienced duration vs remembered duration (Block, 2003), turns out to be critical to understand before making any predictions about what might happen to subjective time during a dangerous driving situation. Retrospective time estimates have often been found to increase as a function of the amount of information stored (e.g. Ornstein, 1969), such that a tape with frequent sounds recorded on it is judged as having been playing for longer than a similar tape with less frequent sounds. Although there is a general tendency for more complex stimuli to produce longer time estimates than shorter ones, subsequent theories have suggested that the absolute amount of information stored as stimulus is not what determines its retrospective duration but particularly important types of information are those providing segmentation of the interval (e.g. Poynter, 1983) or changes in context (e.g. Block, 1978, 1982). A critical issue in retrospective judgements is that the participant is not aware that they will be making time estimates at the time they experience the interval or event whose duration will later be judged. Unlike retrospective tasks, in prospective tasks the participant actively attends to the passage of time. This makes it possible to present multiple stimuli in complex within-subjects designs, greatly increasing the power of designs using prospective tasks over those using retrospective tasks.

Many different prospective tasks have been used by researchers. In some paradigms participants give simple numerical judgements of the passage of time, while in interval reproduction tasks participants might have to press a button when they felt a specific interval had passed. Although there is plenty of evidence that different prospective tasks produce quantitatively different results (e.g. Zakay, 1993), there is broad agreement on some of the factors that influence prospective judgements. Eventful intervals tend to result in the feeling that time is passing rapidly, and consequently people make short verbal estimates or reproduced time intervals (e.g. Hicks *et al.*, 1976; Zakay and Block, 1997). However, it is not simply the nature of the interval that is important in this case, but the way in which attention is devoted to the passage of time. Many current theories assume that people have broadly accurate, timing information available from some form of internal clock (e.g. Matell and Meck, 2000). Although the clock is generally thought to be accurate, it may be influenced to a small degree by factors such as body temperature (e.g. Hancock, 1993; Wearden and Penton-Voak, 1995). Nonetheless the ability to use information from any central pacemaker requires the allocation of attention to these timing signals. As attention to such signals increases, so does the experienced duration, and when attention is removed from these signals timing becomes less accurate (e.g. Macar *et al.*, 1994; Brown, 1998). Zakay *et al.* (1997) have proposed that the relationship between mental workload and prospective duration estimations is so close that in some circumstances prospective judgements can be used as a sensitive, practical and unobtrusive measure of mental workload.

In dangerous situations, we would predict that events will generally be high in workload and in the amount of information stored (see Chapman and Groeger, 2004; Chapman and Underwood, 2000). This would lead us to predict that retrospectively the duration of such events should be overestimated, however, we might expect prospective time judgements to show that time passes faster in such situations (because of a speeding up of an internal clock, or a distraction from internal timing signals). Of course an additional issue with dangerous situations is the stress and emotion experienced, and this may have effects additional or contrary to those of workload. Loftus *et al.* (1987) had participants watch a short film of a bank robbery and later answer a series of questions about the film, including a retrospective

duration estimate. Participants made dramatic overestimates of the film's, duration (thus a 30 second film received a mean duration estimate of 147 seconds in Experiment 1). In Experiment 3, two versions of the film were used, a high stress and low stress version. Large overestimations were observed in both cases, but were significantly higher for the stressful version than the low stress version. For retrospective tasks then the predictions based on stress and workload seem to be in accordance, the subjective duration of dangerous situations should be overestimated in retrospect.

The influence of stress on prospective time judgements is rather less clear. Angrilli *et al.* (1997) had participants view a series of slides taken from the International Affective Picture System (IAPS; Centre for the Study of Emotion and Attention, 1995). The slides systematically differed in valence (positive or negative) and arousal (high and low), based on previous ratings of the slides (Lang *et al.*, 1993). One group of participants used an analog scale to rate the perceived duration of each slide, while a second group of participants used an interval reproduction method in which they had to hold down a button for as long as they felt the slide had been present. Both groups of participants made substantial underestimates of the true durations of the slides (a mean underestimate of around 25% of the original stimulus presentation time), with the underestimates being larger in the reproduction task than in the analog scale task. There was an interaction between arousal and valence, with the largest underestimates being made to high arousal positive slides and to low arousal negative slides. Less dramatic, but still significant, underestimates were observed for high arousal negative slides and low arousal positive slides, though these underestimates were no larger than those observed for neutral slides. They also found that for high arousal slides (positive or negative), underestimates were greater when the original display time was longer. Angrilli *et al.* (1997) concluded that their low arousal results were consistent with the predictions of attentional theories of prospective time estimations. Thus the greater attentional demands of the negative stimuli (as evidenced by electrodermal activity) caused subsequent underestimates of duration. However, they conclude that understanding the high arousal results would require a different explanation, and they propose that for high arousal stimuli a physiological distinction between avoidance and approach reactions needs to be considered. The idea that high arousal negative stimuli might produce prospective overestimates is exciting in that it would be consistent with the idea of time subjectively slowing down in a car crash. However it is important to note that the results from this condition are still underestimates of duration, and are no different to estimates made to low arousal pleasant stimuli or neutral conditions. Predictions about prospective estimates of dangerous driving situations are thus hard to make with confidence. Another issue with this type of task is that the stimuli are static slides. It is difficult to be sure that the results obtained when viewing a static slide will actually apply in real world situations.

The literature reviewed so far leaves little doubt that retrospective tasks are likely to produce large overestimates of duration consistent with the idea that remembered dangerous events will appear to have passed slowly. However, this can be seen as a subsequent distortion of memory and not evidence for time actually passing slowly when the event was experience. Unfortunately the evidence from prospective studies is much less clear, studies looking at workload seem to imply that time should speed up in a dangerous situation, while from Angrilli *et al.* (1997) we would predict a general underestimation of time in dangerous situations but that the precise degree of arousal might be critical in determining any effect, however applying results from

static slides to dynamic scenes might be difficult. We thus decided to use a novel type of prospective task to explore the perception of time in filmed dangerous events. We suggest that if time perception really is distorted at the moment a stressful event is experienced, participants should be systematically biased in their ability to judge the actual speed at which a film of such an event is playing. If time really slows down in stressful events, then a film watched at the correct speed, but without any subjective feeling of danger, should be judged as playing too fast. The following study was designed to explore this possibility by having drivers watch a series of driving events, some dangerous, some safer, whose speed had been systematically distorted and asking them to judge what distortion had been made.

# Experiment 1

## Method

### PARTICIPANTS

Twenty drivers took part in the experiment. Ten were young novice drivers with a mean age of 19.2 years, a mean driving experience of 1.4 years, and an average annual mileage of 910 miles. The other group was 10 older more experienced drivers with a mean age of 53.1 years, a mean driving experience of 29.9 years, and a mean annual mileage of 6,400 miles.

### STIMULI/APPARATUS

Twenty short sections of driving similar to that described by Chapman and Underwood (1998) were selected. Each section showed eight seconds of film recorded from a moving vehicle in traffic taken from the driver's point of view. These consisted of 10 pairs of stimuli, such that each item in a pair showed a section of driving on similar roads and traffic conditions, but in one of the pair a dangerous event occurred, while in the other item in the pair events were generally safe, normal driving events. The safety of events was assessed by having a wide selection of previous participants view the full films and press a response button when they felt that a dangerous event was occurring. The films were then digitised and edited using Apple Final Cut Pro. Each clip was then sped up or slowed down using Final Cut Pro. Where the film was slowed down, footage was then removed from the end of the clip such that the total clip duration remained at eight seconds. When the film was speeded up additional footage was added to the end of the clip to retain a total length of eight seconds. Five versions of each clip were thus created, one at 80% of its true speed (slowed down), one at 90% (slightly slowed down), one at 100% (the original clip), one at 110% (slightly speeded up), and one at 120% (speeded up). The 20 films were then edited into a series of stimulus tapes in which the order and presentation speed of individual films was counterbalanced such that each type of film was always displayed at a mean speed of 100%. Each tape contained 20 clips – half dangerous, half safe – and within each film type there were clips shown at each of the five possible speeds. Final tapes were output onto MiniDV tapes and played using a Sony DSR-11 digital tape deck connected to a television monitor with a 40 × 30 cm screen at a distance of 70 cm.

## PROCEDURE

Participants were informed that they would be viewing a series of brief films of driving situations, some of which had been digitally sped up, some of which had been digitally slowed down, and some of which were playing at the correct speed. They first viewed a brief film of pedestrians walking through a shopping centre and were shown what this film looked like slowed down to 70%, 80% and 90% of its true speed, played at the correct speed (100%) and sped up to 110%, 120%, and 130% of its true speed. They then viewed the series of 20 clips of driving situations and after viewing each clip circled a number on a seven-point scale to indicate their estimate of the speed the current clip was being played at. The response alternatives were 70%, 80%, 90%, 100%, 110%, 120% and 130%. The scale was labelled as much too slow (70%), correct (100%) and much too fast (130%).

## Results and discussion

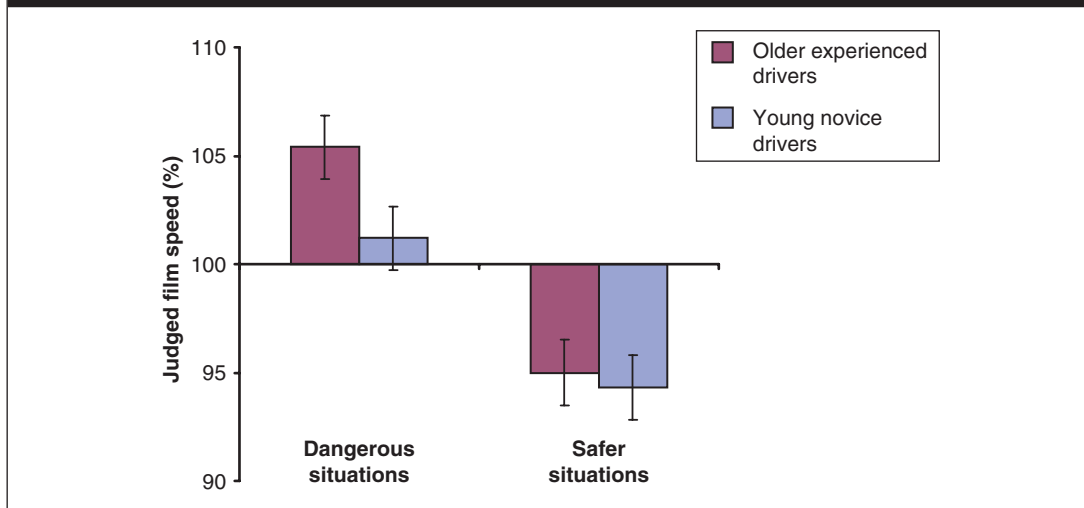
Data were analysed in an analysis of variance, with one between subjects factors with two levels (whether the drivers were older, more experienced drivers or younger, novice drivers), and two within subjects factors, one with five levels (the true film speed being judged – 80%, 90%, 100%, 110%, or 120%) and one with two levels (whether the driving situation was dangerous or relatively safe). There were significant main effects of both within subjects factors; driving situation,  $F(1,18) = 38.67$ ,  $p = 0.001$ , and true film speed,  $F(4,72) = 35.20$ ,  $p = 0.001$ . The former effect simply demonstrates that participants were sensitive to the manipulations in film speed that were made, while the latter effect comes about because dangerous driving situations were generally rated as having been sped up (mean rating 103.3%), while safer situations were generally rated as having been slowed down (mean rating 94.65%). There was also a significant interaction between the two factors,  $F(4,72) = 3.52$ ,  $p = 0.011$ . Analysis of simple main effects demonstrates that the difference in speed ratings between dangerous and safe situations is significant,  $p = 0.05$  at all levels of true film speed except when the film was sped up to 120%.

Although the older, more experienced drivers did tend to give generally higher speed ratings than the younger, novice drivers (100.2% vs 97.75%), the main effect of driver experience was not significant,  $F(1,18) = 2.53$ ,  $p = 0.129$ , and nor was the interaction between driver experience and situation type,  $F(1,18) = 1.44$ ,  $p = 0.246$ . Although this main effect and interaction does not reach significance, the relatively small sample size and relatively large effect sizes as assessed by Cohen's  $f$  ( $f = 0.37$  for the main effect of experience,  $f = 0.28$  for the interaction) suggest that it might be worth exploring these effects with a larger sample. Analysis of simple main effects on this interaction does suggest that there is a marginally significant effect of driver experience in dangerous situations,  $F(1,36) = 3.92$ ,  $f = 0.47$ ,  $p = 0.055$ . This is illustrated in Figure 1.

The clearest aspect of these results is that participants do reliably judge that films of dangerous situations give the impression of being speeded up, while films of safer situations give the impression of having been slowed down. Although this is consistent with our prediction, before attempting to interpret these results further it



**Figure 1 Speed estimates for dangerous and safer road environments. Values greater than 100% represent a judgement that the films have been sped up**



is worth considering two factors that may be important in accounting for the effect, firstly that the dangerous situations showed much more difficult driving situations than the safer ones, and secondly that participants are watching events that they have no control over. Although it is difficult to systematically manipulate these factors within a driving context, a related experiment has explored these factors within a non-driving context and these results will be reported now.

## Experiment 2

### Method

#### PARTICIPANTS

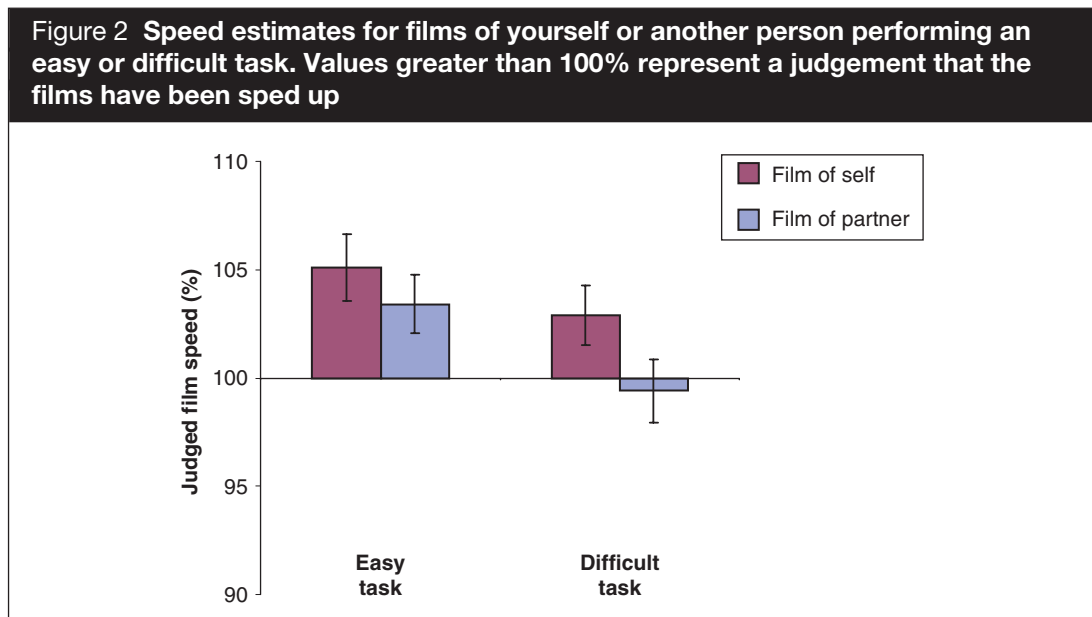
The participants were 48 undergraduates, 24 male and 24 female, mean age 21 years (range 19 to 23).

#### PROCEDURE

Participants were tested in pairs and each performed two shape matching tasks, one easy task involving simple two-dimensional shapes, and one more complex task involving three-dimensional shapes. In each case the active participant had to collect items from one side of the room and place them on a board on the wall while the passive participant watched. The task was video-recorded and two 20-second clips from each task-participant combination were taken away and digitally manipulated as for Experiment 1. In this case half the clips were sped up to 115% and half were slowed down to 85%. Participants then each individually watched the same demonstration video as before and attempted to judge the speed of the manipulated videos – half of which showed them performing the task themselves, and half of which showed their partner performing the task.

## Results and discussion

Speed estimates were analysed using a repeated measures analysis of variance with three within subjects factors: task difficulty (easy/hard), film speed (85%/115%) and actor (self/other). The film speed factor, as would be expected, was highly significant,  $F(1,47) = 230.8$ ,  $p < 0.001$ , showing that participants were sensitive to the manipulation of film speeds (mean estimate for 115% films was 113.1%, mean estimate for 85% films was 92.3%), though this did not interact significantly with either of the other factors. There was also a main effect of task difficulty,  $F(1,47) = 4.66$ ,  $p < 0.05$ , with the more difficult task generally judged to have been sped up less than the easier task (mean 101.1% vs 104.3%) and a marginal main effect of actor,  $F(1,47) = 3.40$ ,  $p = 0.071$ , with films showing the participant themselves being judged as playing faster (mean 104.0%) than films showing their partner (mean 101.4%). However, there was no evidence of an interaction between these two factors [ $F(1,47) = 0.45$ ,  $p = 0.505$ ]. These results are illustrated in Figure 2.



It is worth noting that the easy task was generally completed much faster (mean 103.7 seconds) than the more difficult task (mean 209.9 seconds), thus it is possible that the easy task does indeed include faster motion than the more difficult task, but this is worth contrasting with the situation in Experiment 1, where speeds were likely to be higher in the safe driving situations. What Experiment 2 demonstrates is that it is not inevitable that difficult tasks are judged as having been sped up, and it also suggests that having been in control at the time of an event is unlikely to be critical in determining time estimates. While there is a slight tendency for tasks the participant was performing themselves to be rated as running faster than tasks they had watched a partner performing, the effect is the same in both easy and difficult tasks and does not represent a simple tendency for situations where you are not in control to be later judged as being sped up.

# General discussion

Experiment 1 demonstrates that, as predicted, there is a substantial main effect of danger, with the more dangerous films being judged as playing too fast, while the safer ones are generally judged to be playing too slowly. Experiment 2 suggests that this is a genuine effect and not an inevitable consequence of difficult tasks appearing to be sped up and easy ones appearing to be slowed down. One criticism of the methodology used in Experiment 1 is that participants have no control over the situations they are viewing – perhaps time only appears to be slowed in a car crash because such events are characterised by the driver losing control, and being unable to prevent a collision. Experiment 2 directly explores the issue of control by getting speed judgements for events that participants were performing themselves and for those that they view another person performing. The lack of any substantial difference between these two conditions suggests that any effect of control is unlikely to be sufficient to account for the basic differences in speed estimates given for dangerous and safer driving situations. How then can we account for the substantial difference in estimates that was observed in Experiment 1?

The obvious prospective prediction would be that if time is subjectively lengthened in dangerous situations, events will appear to slow down and dangerous films will be judged as playing too slowly. This of course is exactly the opposite pattern of results to those that we observed in Experiment 1. A prospective interpretation of our results would thus be the rather counterintuitive suggestion that time actually speeds up in dangerous situations. An alternative framework for understanding the judged speed of dangerous situations would rely on a retrospective interpretation of the data. Although the task is prospective in the sense that a time judgement is made while the film is being watched, it can be seen as involving a retrospective comparison with a remembered dangerous event. If real dangerous events are remembered as if time slowed down, this will create an expectation that videos of such events should run slowly, consequently the more dangerous the scenes in a video appear to be, the more viewers will expect events to slow down. Because the actual speed of the video does not slow down, viewers will judge films of dangerous events as having been sped up. Note that this explanation supports the prediction that the duration of dangerous events will be overestimated in retrospective paradigms, but requires that any prospective effect while actually watching the film is relatively small in comparison. It thus supports the idea that dangerous driving situations might be remembered as if time slowed down, but provides no support for the idea that time is actually distorted in such situations.

The possibility that time is distorted in dangerous situations has important potential practical implications. Actual distortions of time while an event is being experienced could affect judgements of the speed or time to contact and could result in poor car control or decision making. Retrospective distortions could affect our ability to learn from dangerous situations, and could be particularly important in distorting witnesses' reports of road accidents (see Loftus *et al.*, 1987, for potential examples of time distortion in witness memory). Our current interpretation of our results suggests that retrospective distortions are likely to be a more reliable phenomenon than prospective distortions. Nonetheless the issue of resolving retrospective and prospective interpretations of our data is not yet resolved. One way of exploring the retrospective interpretation of the data might be to manipulate viewers' previous

experience with dangerous events. If the retrospective interpretation is correct, then participants would have to have previously experienced similar dangerous events before any time distortion would occur – if we have not learned to expect time to slow down in dangerous driving situations, our speed judgements of these tapes should not be systematically biased in this way. The prediction would thus be that more experienced drivers would produce greater overestimates of speed in dangerous driving situations than novices with less experience of such situations. This is precisely the trend that is visible in Figure 1, although we need to be careful not to over interpret an interaction that does not reach significance. It is also important to note that our participant groups differed dramatically in age as well as in driving experience. Many researchers have found time estimation differences as a function of age (e.g. Block *et al.*, 1998; see also, Draaisma, 2004), so it would be important to dissociate these variables as much as possible in future research. An alternative approach might be to provide actual reference events for some participants. If participants watch a specific film at the correct speed first and then later have to judge the speed of a distorted version of the same event, we can be more confident in giving any distortion to a retrospective interpretation. Further research is ongoing to explore these predictions.

## Conclusions

The two experiments described above support the idea that there are likely to be large differences in the temporal experience of dangerous and safer driving situations. Films of dangerous driving situations are reliably judged as playing too fast relative to films of safer situations. Such results do not appear to be related to the simple difficulty of the situation, or to the lack of control in the experimental task. The results are consistent with the idea that dangerous events are remembered as if time slowed down, however, we cannot conclude that this represents an actual slowing of subjective time at the moment of the event rather than a retrospective bias in how such events are remembered.

## Acknowledgements

This research was partly supported by a pump-priming grant from the School of Psychology, Nottingham University. The authors would like to thank Dr Nicola Phelps for her assistance in testing and providing access to the group of older, more experienced drivers.

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# 17

## The take up of Pass Plus within the Cohort II samples

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### Introduction

Young drivers are an old problem. For example, over thirty years ago Goldstein (1972) was able to state ‘that youthful drivers are over-represented in accidents and this has been well known for several decades’, and a major review a few years later concluded that ‘young drivers are overrepresented at all time periods and at all levels of severity of accidents’ (OECD, 1975). Young drivers have been a major focus of research and policy in traffic safety in the developed countries of the world for many years.

There has also long been a debate about whether the ‘young driver problem’ arises because young drivers are immature or because they are inexperienced. A basic problem is that age and experience are usually highly correlated, in that the majority of inexperienced drivers are also young drivers. The age versus experience issue is not just of academic interest, for there are clear implications for safety countermeasures. At a practical level, maturity cannot be accelerated, while the lessons of experience can – in principle – be taught. Attempts to disentangle the separate effects of age and experience have often encountered problems in the past, largely because of the methodological issues involved.

The first investigation into the new driver problem on a large scale in Great Britain was started in 1988 in the Cohort I study (Forsyth, 1992a,b; Forsyth *et al.*, 1995; Maycock and Forsyth, 1997). The results of the modelling exercise in this study showed that for young drivers the effect of experience alone over the first three years of driving was some four times that of age. There was a 40% reduction in accident liability between the first and second years of driving for 17–18-year-olds attributable to experience. The reduction in accident liability in the first years of driving was most marked in the youngest age groups, but was evident at all ages, raising the question of just what happens in the first two or three years of driving to turn a high-risk novice into a lower-risk driver.

The results of the Cohort I study provided valuable input to policy on driver training and testing. However, with the passage of time there have been changes to the training and testing regime, notably the introduction of a separate theory test, as well as changes to the practical test itself and in the legislation relating to new drivers. A Cohort II project has therefore been carried out in order to provide up-to-date information about learner and novice drivers that can inform Department for Transport (DfT) policy.

This report contains the findings of an analysis carried out as part of the Cohort II study. In this study, samples of 8,000 candidates taking their practical driving test in a particular week have been selected every three months since November 2001. These candidates were sent a questionnaire that asked them about their learning experiences, attitudes and reported behaviours during the learning period. This questionnaire (the Learning To Drive Questionnaire) has been completed by over 33,000 test candidates in the cohorts analysed in this report. Respondents who pass their practical driving test are sent a Driver Experience Questionnaire (DEQ) at 6, 12, 24 and 36 months after passing the test. The DEQ covers attitudes, further training, self-reported behaviour, accidents, offences and exposure to driving. We therefore have data on a large sample of new drivers as they develop their skills and experience over the early driving period.

Analyses of the driving task (e.g. Grayson, 1991) suggest that in the first few years a new driver is learning not just new skills, but is formulating new rules, developing a new repertoire of strategies, and learning new patterns of interaction. However, much of this process takes place in an unstructured and informal way, with no guarantee that what is learned is the most appropriate for the safety of the traffic system. Given the importance of experience in reducing accident liability, it would clearly be desirable if the lessons of experience could be imparted by some formal intervention, rather than being acquired in an uncontrolled learning situation.

The introduction of the hazard perception element into the theory test was designed to try to accelerate the gaining of experience and to encourage new drivers to be trained more thoroughly in the competencies linked to good hazard perception, which safer and more experienced drivers had gained over time. The Pass Plus training programme is another.

This report looks at the characteristics of some of the novices who have taken Pass Plus training (one of various types of structured training) during the first six months after passing the practical test.

It should be noted that the Cohort II samples are similar, but not identical, to the sample of candidates who take their practical driving test. In general, females had a slightly higher response rate than males, but age patterns for the respondents and the full sample were fairly similar. Those who passed their practical test were slightly more likely to return the questionnaires.

## Pass Plus training

Pass Plus is a training scheme for new drivers designed by the Driving Standards Agency (DSA), with the help of the motor and driving instructor industries. Training



is delivered by approved driving instructors (ADIs), who are registered. It was introduced in November 1995 since when there has been a steady increase of new drivers taking the training. The monthly take up of the scheme by new drivers has recently exceeded 20% for the first time. One of the incentives for new drivers is that the scheme is supported by many in the insurance industry (representing over 63% of the private car insurance market), most of whom offer a one year's no claims bonus as a discount to new drivers who have successfully completed Pass Plus. This is likely to make it particularly attractive to those who buy and insure their own vehicle soon after passing their practical driving test.

A small number of local authorities (currently eight in Scotland, two in England and two in Wales) offer discounts for Pass Plus training, based on a perception that accident rates will be reduced.

Pass Plus requires a minimum of six hours' training, though this may not necessarily be separate sessions. It consists of six modules which are generally taken within 12 months of a new driver passing their practical test. The modules cover:

- town driving;
- all-weather driving;
- driving out of town;
- night driving;
- driving on dual carriageways; and
- driving on motorways.

The aim of the Pass Plus programme is to enable new drivers to gain experience and confidence, especially in conditions they may not have met during the pre-test training. There is no formal test at the end of the programme but the ADI will assess whether the new driver has achieved the required level of competency on each module.

Driving instructors generally charge the same hourly rate for Pass Plus training as for learner driver training.

The results reported below refer to those who took Pass Plus training within six months of passing their practical driving test.

## Results

### Types of further training

Not all new drivers take further training. Where they do, most of this takes place during the first six months after passing the practical driving test and the results discussed in this paper focus on this first six-month period. The results are based on the first 12 cohorts.

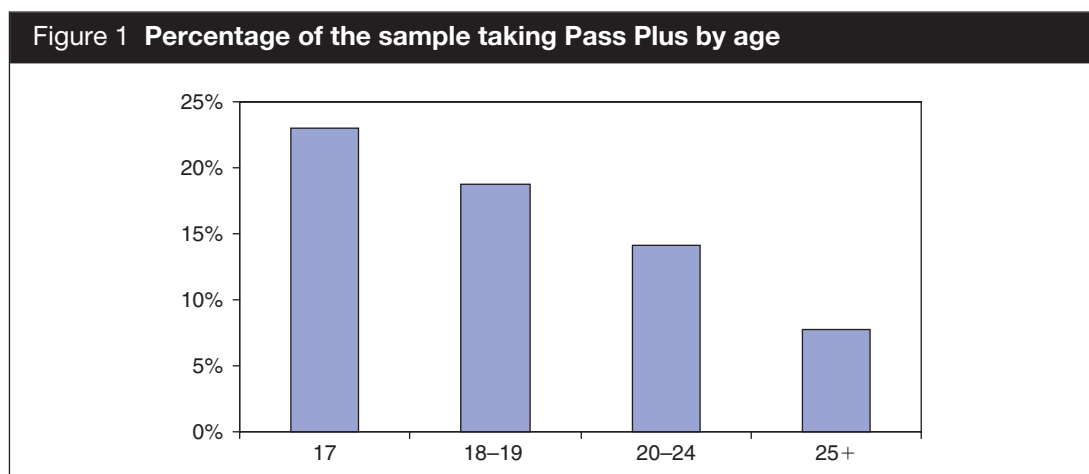
Table 1 shows that although the overall numbers are small, males are more likely to take some form of post-test training. Most of this training is Pass Plus.

Table 1 Percentage of sample taking further training (within six months of passing the practical test)		
	Female (%)	Male (%)
None	82.8	75.0
Pass Plus	14.0	21.9
Motorway lessons	4.2	4.4
Company car training	0.1	0.7
Other advanced training	0.3	0.7
Other	0.3	0.3
Total respondents (100%)	4,592	2,565

## Who takes Pass Plus?

### AGE

Figure 1 shows that it is the youngest drivers who are most likely to take Pass Plus. Almost a quarter (23%) of the 17-year-olds in the sample took Pass Plus, while this dropped to less than 8% of the older drivers.



### GENDER

53.3% of those in the Cohort II sample who took Pass Plus are females. However, as Table 1 showed, males are more likely to choose to take this training. The apparent difference is because there are more females than males in the Cohort II sample (see Table 2).

Table 2 Gender split for Cohort II		
	Female	Male
No training	3,950	2,003
Pass Plus	642	562
<b>Percentage taking Pass Plus</b>	<b>14.0%</b>	<b>21.9%</b>
Group total	4,592	2,565

## What are they like?

### CONFIDENCE

The cohort questionnaires asked about confidence levels at each stage. Of interest in this context is that those who took Pass Plus and those who took no further training did not differ significantly in their claimed levels of confidence either immediately after passing their driving test or six months later. In both cases over 50% of new drivers claimed to be 'very confident' in their driving ability. So it does not appear that those who chose to take Pass Plus did so because of a lack of confidence at that point. Although their confidence levels had dropped six months after their tests, there was no difference between the Pass Plus group and those who had taken no further training. Data are also available within the project on the specific areas where novices identify a need to improve and this will be the subject of analysis at a later date.

### TEST PERFORMANCE

As part of the cohort data collection we have data on the faults committed within the driving test. It is possible to pass the practical test with up to 15 driving faults. The Pass Plus group and the no training group had very similar numbers of faults on their tests. It does not seem, therefore, that a relatively poor driving test pass (i.e. one with a high number of faults) is an important factor in the decision to take Pass Plus training.

### PERCEPTION OF SKILL

Those who took Pass Plus were more likely to rate themselves as more skilful than others (Figure 2).



There are likely to be two mechanisms at work here. Since they have undertaken further training they may well be more skilled. However, the cost of this training is significant and they also need to justify to themselves that it has been of value.

### DRIVER STYLE AND ATTITUDE

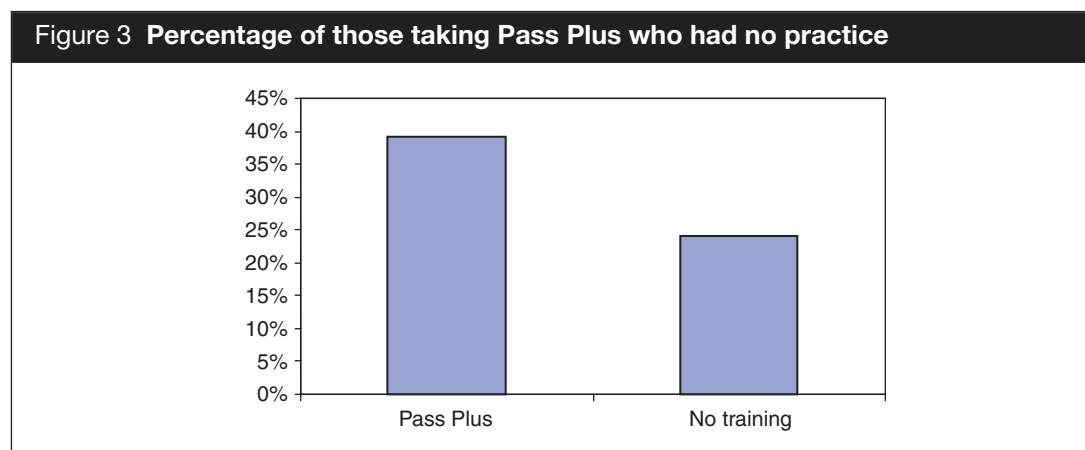
Data are available on attitudes and driver styles, and it is possible that those choosing to take Pass Plus differ in attitudes and style from those not doing so. It is also

possible that Pass Plus training may affect these. This analysis will be reported in later reports on the project.

## Training/practice

Among new drivers who had practice with friends and relations before they passed their practical test there was a difference between those who then chose to take Pass Plus training and those who took no additional training. Those who chose to take Pass Plus training had, on average, less hours of practice, though there was no difference in the amount of professional instruction the two groups had.

New drivers who had not done any practice at all with friends or relations before passing their test were more likely to take Pass Plus training (see Figure 3).



## Amount driven

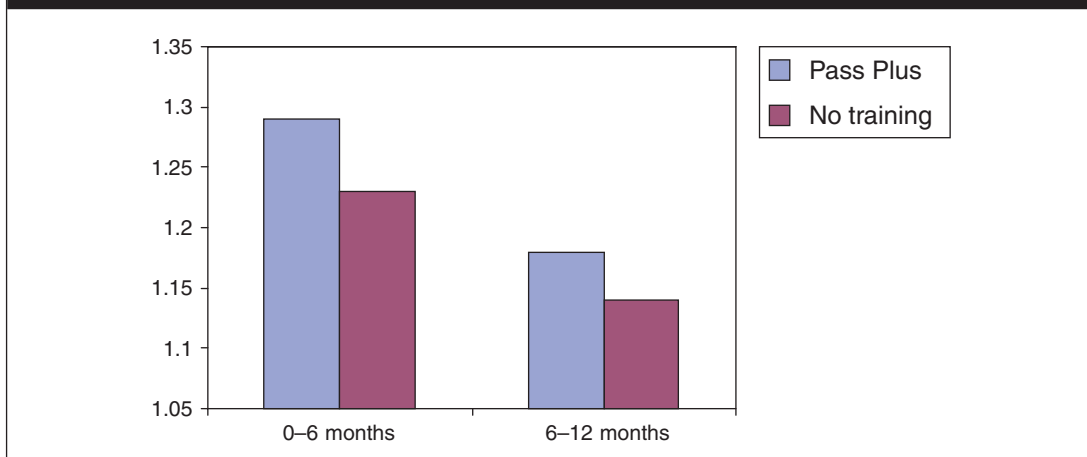
Those who took Pass Plus drove, on average, a similar mileage in their first six months of driving to those who took no further training. However the youngest group (those aged 17 at the time they took their test) had, on average, driven slightly less than the overall average (whether or not they took further training).

## Driver performance

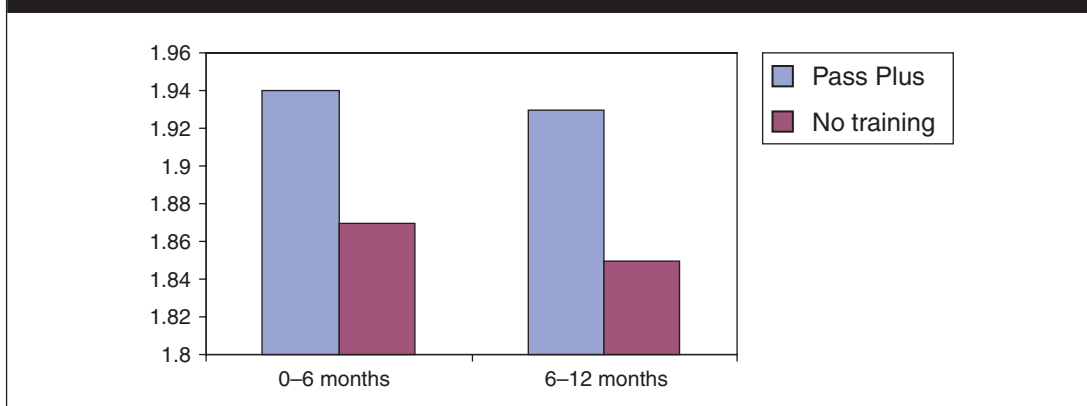
Although the mileage driven did not differ between the Pass Plus group and the no training group, the accident and near miss data suggest that those who took Pass Plus have a slightly worse performance in terms of both accidents and near misses (see Figures 4 and 5).

It is, however, notoriously difficult to assess the effects of driver training programmes when they operate by self-selection. It is possible, for instance, that the new drivers who chose to take Pass Plus were more safety conscious and more likely to report accidents. The results could also point to self-selection on an economic, rather than a safety basis. It is also possible that the accident levels in the first six months were skewed because for some of the new drivers the decision to take Pass Plus training

**Figure 4 Accidents in the first month of driving**



**Figure 5 Near misses in the first month of driving**

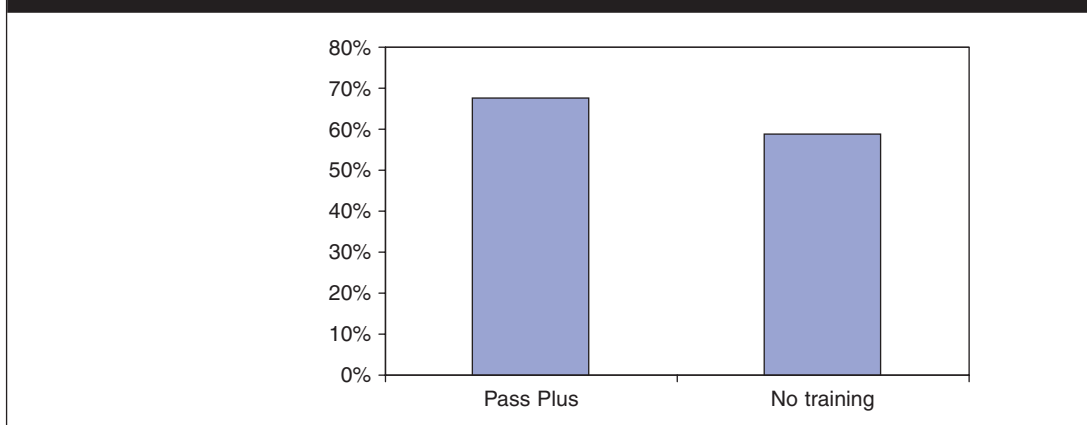


was a result of having had an accident. However, if this were the case, and the course had addressed the risk factors, we would not expect the accident levels in the 6-12 month period to show the same degree of difference between the two groups. Figures 4 and 5 show that the difference in accidents persists into this later period.

## Car ownership

New drivers who drive a vehicle they own were more likely to take Pass Plus than those who drive a family vehicle. The incentive here is likely to be financial.

**Figure 6 Percentage of Pass Plus candidates who drive their own vehicle**



The support of the insurance industry for the Pass Plus training means that young drivers who have taken Pass Plus can obtain discounts on their premiums when insuring their own vehicle (In some cases this can be deferred for up to two years.) Since insurance premiums for young drivers are high, this can result in a significant cost saving, even when the cost of the Pass Plus training is included in the calculation.

## Discussion

Pass Plus is the main opportunity for novice drivers to increase their skills in a structured way after they pass their practical test. It provides a structured process for new drivers to increase their skills in a wider range of situations than is generally possible within the learner driver period. The Cohort sample data are not able to make any direct assessment of the effects of Pass Plus on driver behaviour, accidents etc. Those who decide to take Pass Plus are a self-selected group and we are not, therefore, at this stage of the analysis, in a position to discuss causal relationships.

Overall, the Cohort II data do not exhibit many differences between those who choose to take Pass Plus and those who do not. However, some specific results from the data are of interest:

- those who own their own vehicle are more likely to take Pass Plus;
- those who had no practice prior to passing their test are more likely to take Pass Plus; and
- the youngest drivers are more likely to take Pass Plus.

One of the main advertised inducements for taking Pass Plus training is the discounts offered by some insurance companies. The higher number of car owners, who will be seeking to insure these vehicles in their own names, suggests that this is, indeed, a motivator.

The fact that those with no practice during their pre-test period are more likely to take Pass Plus training might suggest that this group feel unready for solo driving. However, the results did not show that they claimed to be any less confident in their abilities at the time they completed the Learning to Drive Questionnaire. Grayson and Elliot (2004) showed that confidence levels, in general, fall between this stage and the time the six-month questionnaire is completed. One possibility is that those new drivers without practice lost confidence more rapidly and decided to undertake further training to increase their confidence (though there may be other explanations).

## Acknowledgements

The work described in this report was carried out in the Safety Group of TRL Limited. The author is very grateful to Graham Grayson for advice and assistance in the analysis.

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# 18

## An evaluation of the enhanced Pass Plus scheme operated by Kirklees Metropolitan Council

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### Executive summary

- The Kirklees Metropolitan Council's (KMC) Pass Plus scheme appears to be showing some positive results with a lower than expected self-reported accident rate.
- A significant improvement in driver's attitude has been identified in the novice drivers completing Pass Plus through the KMC scheme three months post-course.
- There is some evidence to indicate that the KMC scheme may also be having a positive effect on STAT19 reported slight injury accidents for drivers in the 16- to 19-year-old age group.
- The KMC scheme appears to encourage the participating instructor to alter their instruction techniques, increasing the content of instruction on human factors associated with accident involvement at both the pre- and post-test.
- The scheme is being delivered directly to 4.87% of newly qualified drivers for the area.
- The instructor training delivered by KMC as part of the scheme may be influencing the training of over 1,200 drivers per year in the local area.
- There is some evidence to suggest that many of the human factors covered on the KMC instructor training day are not covered in other instructor training courses run by other instructor training organisations.



- It appears the instructor training has improved the participating instructor’s view of the scheme. This, in turn, may lead to the instructor promoting the scheme more actively and so leading to higher levels of participation by novice drivers.
- It is difficult to assess whether the New Driver Discussion Group would reduce take-up of the scheme nationally if it became part of the Driving Standard Agency (DSA) Pass Plus syllabus. As, locally, the 50% subsidy offered by KMC appears to have increased take-up of the scheme by approximately 26%.

## Background

Many studies (for a literature review see Engström *et al.*, 2003) have linked novice drivers with high rates of accident involvement. The Government’s document *Tomorrow’s Roads: Safer for Everyone* (DETR, 2000) outlined that 17- to 19-year-olds account for 7% of the UK driving population but are involved in 13% of injury accidents (p. 23).

**Table 1 Goals for driver education (Hatakka *et al.*, 2002, cited by Engström, 2003)**

Hierarchical level of behaviour	Knowledge and skill the driver has to master	Risk-increasing factors the driver must be aware of and be able to avoid	Self-evaluation
Goals for life and skills for living	<b>Knowledge about/ control over:</b> how general life goals and values, behavioural style, group norms etc. affect driving style	<b>Knowledge about/ control over risks connected with:</b> life goals and values, behavioural style, social pressure, substance abuse, etc.	<b>Awareness of personal tendencies re:</b> impulse control, motives, lifestyle, values, etc.
Goals and context of driving (specific trip)	<b>Knowledge and skills re:</b> trip-related considerations (effects of goals, environment choice, effects of social pressure, evaluation of necessity, etc.)	<b>Knowledge and skills re:</b> risk connected with trip goals, driving state, social pressure, purpose of driving	<b>Awareness of personal:</b> planning skills, typical driving goals, driving motives, etc.
Mastery of traffic situations (specific situations)	<b>General knowledge and skills re:</b> rules, speed adjustment, safety margins, signalling, etc.	<b>Knowledge and skills re:</b> wrong speed, narrow safety margins, neglect of rules, difficult driving condition, vulnerable road users, etc.	<b>Awareness of personal:</b> skills, driving style, hazard perception, etc. from a view-point of strength and weaknesses
Vehicle manoeuvring (specific situations)	<b>Basic knowledge and skills re:</b> manoeuvring, vehicle properties, friction	<b>Knowledge and skills re:</b> risks connected with manoeuvring, vehicle properties, friction, etc.	<b>Awareness of personal:</b> strengths and weaknesses re basic driving skills, manoeuvring in hazardous situations, etc.

Closer analysis (Grayson, 2004) indicates that 19.6% of novice drivers self-report an accident within the first six months of passing the test. This accident rate reduces to 14% in the following six months. The causation factors for this initial high rate of accident involvement have been linked to: age-related factors (such as thrill seeking) and low levels of driving experience. These factors are included in the Goals for Driver Education (GDE, Table 1) (Hatakka *et al.*, 2002, cited by Engström, 2003).

Parker and Stradling (2001) have identified that drivers develop in three phases: technical mastery, reading the road and the expressive phase. This final phase refers to how the driver gives expression to their personality, attitudes and motivations through their driving. Edwards (2004) argues that this expressive phase is unlikely to be seen by an instructor before the driving test is passed, as the learner driver will be motivated, by the desire to be put forward for the test, to drive inline with the social model being advocated by their driving instructor. Therefore, traditional driver training in the UK has generally been confined to the mastery of traffic situations and vehicle manoeuvring, the two lower parts of the GDE matrix.

## KMC enhanced Pass Plus scheme

Based upon the discussion outline above, KMC has developed a post-course driver interventions scheme for novice drivers. This scheme aims to reduce the accident rate for novice drivers in their first six months of driving through the achievement of the following objectives:

- increasing the drivers' awareness of human factors that affect driving performance and their particular impact on novice drivers;
- improving the ability of the novice driver to analyse near misses and to self-evaluate driving performance; and
- an improvement in attitude towards the driving task.

It is hypothesised that through the achievement of these objectives some of the limits of experience and age-related issues can be negated. This in turn may reduce crash involvement over the first six months of a driver's career. The KMC scheme is based upon the DSA Pass Plus scheme. The DSA scheme has six modules: motorways, night driving, dual carriageways, all-weather driving, driving out of town, town driving. The main incentive for a novice driver to take the DSA scheme is that completion may lead to reduced insurance premiums.

No extra qualification needs to be attained or training attended by a driving instructor in order to deliver the DSA Pass Plus syllabus; above the minimum level to be a DSA approved driving instructor.

The KMC scheme uses the six DSA modules but has three further enhancements:

- a 50% reduction in the cost of the scheme;
- all instructors delivering the KMC scheme have to attend a one-day training day; and

- all the participating novice drivers need to attend a two-hour ‘New Driver Discussion Group’.

## Scheme subsidy

KMC offer a 50% subsidy to all drivers completing the KMC scheme. All the instructors registering for the scheme agreed to charge a maximum amount for the basic DSA six-module course. This provides one hour of tuition per module. The subsidy aims to increase take-up of the scheme in the Kirklees area and to make the scheme more attractive to groups who may not be normally interested in taking further driver training. It also aims to act as an incentive to the novice driver to attend the New Driver Discussion Group.

## Instructor training day

The training provided by KMC aims to improve the instructor’s ability and skills to provide post-test driver training. The day particularly focuses on:

- the human factors associated with accident involvement and their effect on novice drivers, e.g. alcohol, stress, fatigue, peer pressure, etc. – this element of the training is in part based on Fuller’s (2000) task capability interface model for driver training;
- the effective use of a question and answers technique to prompt discussion about beliefs and attitudes;
- common accident types and causation factors for affecting novice drivers (For an overview see Clarke *et al.*, 2001);
- familiarisation of the subjects to be covered in the New Driver Discussion Group;
- phases of driver development (Parker and Stradling, 2001) and the GDE matrix (Hatakka *et al.*, 2002, cited by Engström, 2003); and
- the role of attitude on behaviour (Ajzen, 1988).

## New Driver Discussion Group

This element of the scheme brings together groups of novice drivers who have passed their driving test in the last 10 months. The groups are asked to discuss a variety of topics which may be of issue to novice drivers. These issues are identified by the novice drivers through an initial group work exercise. This exercise asks the groups to plan the following journey and to identify all the risks associated with the trip:

You and three of your friends have been invited to go to a party in Liverpool (approximately 2½ hours from the Kirklees area) on a November evening. You are the driver and you all intend to return after the party. You will need to drive

on a variety of roads. You have agreed to meet more friends first, in a pub, before following them on to the party.

The session facilitator encourages the group not to simply look at the skills aspects of driving, such as low levels of experience on the motorway, but the higher levels identified within the GDE matrix such as: thrill seeking, peer pressure, fatigue, alcohol, drugs, etc.

Each risk is then discussed by the group to identify both the extent of the danger and possible coping strategies.

A second element of the course aims to increase a novice driver’s ability to self-assess their driving style, particularly if a near miss has occurred. This element of the scheme uses a group-work approach which looks at a near-miss situation relating to a motorway. The group assesses this scenario for key ways in which the drivers involved could have reduced their risk. The group facilitator then uses the points raised by the group to encourage the novice drivers to evaluate their own driving strategies if they are involved in a near-miss situation.

## Evaluation methodology

### Instructor evaluation methodology and results

The participating instructors were sent a questionnaire approximately one month after the completion of the KMC Instructor Training Day. The aim of this element of the evaluation was to identify the participating instructor’s view of the KMC enhancements of the scheme.

### Sample

Of the 30 instructors enrolled on the scheme at the time, 28 returned a questionnaire; giving a return rate of 93.33%.

Table 2 indicated the length of time the instructors had been qualified. The four-year intervals used in the table relate to the length of time that an approved driving instructor’s licence lasts before renewal.

Table 2 Length of time qualified			
	Years qualified	Valid per cent	Cumulative per cent
Valid	Less than a year	3.6	3.6
	1 to 4 years	32.1	35.7
	5 to 8 years	25.0	60.7
	More than 8 years	39.3	100.0
	Total	100.0	

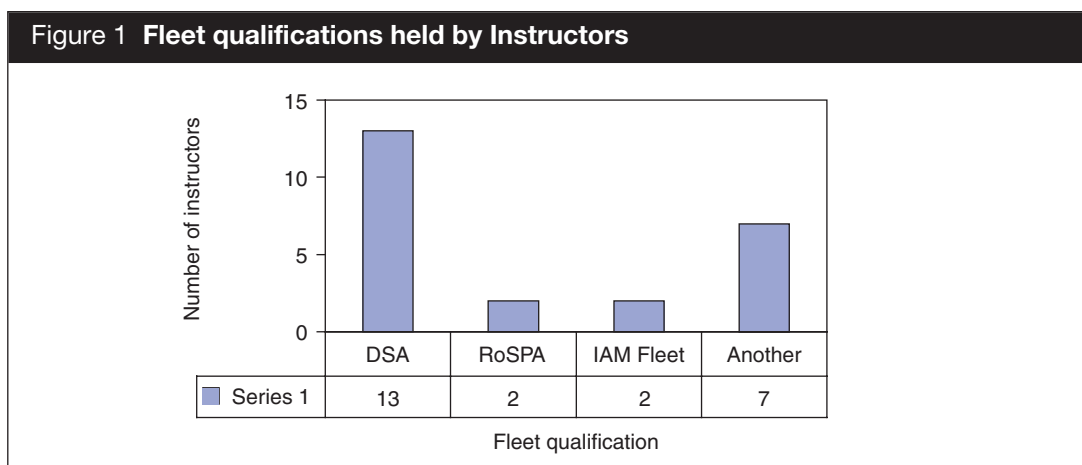
Table 3 shows the length of time the instructors had been delivering Pass Plus. The majority (53.6%) had been registered for the scheme for five or more years.

Table 3 Length of time delivering Pass Plus			
		Valid per cent	Cumulative per cent
Valid	Less than a year	3.6	3.6
	1 to 4 years	42.9	46.4
	More than 5 years	53.6	100.0
	Total	100.0	

The participating instructors were asked about other post-test instructor training they had received. This element of the evaluation had two objectives:

- to help to ascertain the percentage of instructors who had received training in the delivery of post-test driver instruction; and
- to contribute to the current debate on Continued Professional Development (CPD) for instructors.

Of the sample, 13 (46%) held, in addition to their DSA approved driving instructor qualification, at least one other driver training qualification, with several having more than one. Figure 1 shows the details by type of qualification.



## KMC Instructor Training Day

Over 82% of the instructors rated the course content as very appropriate, with the remaining 18% rating it as appropriate.

The instructors were also asked specific questions about the first three elements of the training. All instructors rated these elements of the training as appropriate or very appropriate. Table 4 shows the percentage of instructors rating the content of the training as very appropriate.

Table 4 Instructors' rating of the training day content	
Course element	Valid percentage of instructors rating it as very appropriate (%)
Analysis of accident data	82.1
Driver development and theory of behaviour	78.1
Effective use of questions and answers	82.1

The questionnaire asked the instructors to rate how strongly they agreed or disagreed with a set of statements on the training provided. A five-point scale was used, ranging from strongly disagree to strongly agree.

The first of these statements looked at whether the training received by the instructors had altered their view of Pass Plus. This was felt to be an important issue for three reasons:

1. Anecdotal evidence has indicated that Pass Plus has been widely criticised by many instructors for offering little new and that this has made it difficult to promote to pupils.
2. The low take-up levels of the scheme nationally, currently about 16.5%, had been one incentive for Kirklees to develop their scheme.
3. The main way in which the scheme is marketed was thought to be through instructors. Therefore without their support, for both the KMC scheme and for the national Pass Plus, it is difficult to see how the low take-up rates for the scheme can be substantially improved upon.

Therefore the instructors were asked to rate the following statement:

*I am much more likely to encourage Pass Plus since attending the Kirklees training day.*

The result was that 62.9% of instructors indicated that they either agreed with this statement or strongly agreed with this statement (Table 5). This finding would indicate that a large percentage of instructors could do more to actively promote the scheme and training may be a way in which to encourage more instructors to do so.

Table 5 I am much more likely to encourage Pass Plus since attending the Kirklees Training Day			
		Valid per cent	Cumulative per cent
Valid	Disagree	3.7	3.7
	Neither agree or disagree	33.3	37.0
	Agree	40.7	77.8
	Strongly agree	22.2	100.0
	Total	100.0	

Several findings seem to suggest that the training received has encouraged the instructors to view Pass Plus in a more favourable manner. When asked if they

believed if their pupils would *not* benefit from the training the instructor had received, 92% disagreed or strongly disagreed with the statement (Table 6).

<b>Table 6 My Pass Plus pupils will not benefit from my attending the Kirklees Instructor Training Day</b>			
		<b>Valid per cent</b>	<b>Cumulative per cent</b>
Valid	Strongly disagree	48.1	48.1
	Disagree	44.4	92.6
	Agree	3.7	96.3
	Strongly agree	3.7	100.0
	Total	100.0	

Table 7 identifies that 81% of the instructors felt that they would deliver Pass Plus differently since attending the training.

<b>Table 7 I will deliver the Pass Plus syllabus differently since attending the Kirklees Training Day</b>			
		<b>Valid per cent</b>	<b>Cumulative per cent</b>
Valid	Disagree	7.4	7.4
	Neither agree or disagree	11.1	18.5
	Agree	59.3	77.8
	Strongly agree	22.2	100.0
	Total	100.0	

Over 92.5% (Table 8) of the instructors indicated that they disagreed or strongly disagreed with the statement:

*The training will have no effect on the way in which I deliver Pass Plus.*

<b>Table 8 The training will have no effect on the way in which I deliver Pass Plus</b>			
		<b>Valid per cent</b>	<b>Cumulative per cent</b>
Valid	Strongly disagree	48.1	48.1
	Disagree	44.4	92.6
	Neither agree or disagree	7.4	100.0
	Total	100.0	

A second encouraging finding also seemed to appear. The instructors believed many of the issues and skills discussed on the Instructor Training Day were transferable to the pre-test level. Of the participating instructors, 81.5% (Table 9) felt that they would alter some aspects of their training to learners as a result of the training received. This cascade effect to the learner-trainer syllabus was one of the secondary aims of the KMC project.

Table 9 I feel the training I received will alter the way in which I deliver some elements of my learner training			
		Valid per cent	Cumulative per cent
Valid	Disagree	7.4	7.4
	Neither agree or disagree	11.1	18.5
	Agree	66.7	85.2
	Strongly agree	14.8	100.0
	Total	100.0	

The general feeling about the training seems to have been very good, with just over 96% indicating that they would like to attend similar training in the future (Table 10).

Table 10 I would like to attend more training of this type			
		Valid per cent	Cumulative per cent
Valid	Neither agree or disagree	3.7	3.7
	Agree	55.6	59.3
	Strongly agree	40.7	100.0
	Total	100.0	

The instructors when asked about their feelings on this type of training being made compulsory did not echo this finding, with only 55.5% agreeing or strongly agreeing (Table 11) with the statement:

*All driving instructors should be made to attend this type of instructor training.*

This finding may reflect instructors’ worries about the cost implications of attending compulsory training; even though they had identified substantial benefits of the training received. Kirklees delivered their training free of charge but the instructors will almost certainly have lost substantial income due to them having to take a day to attend.

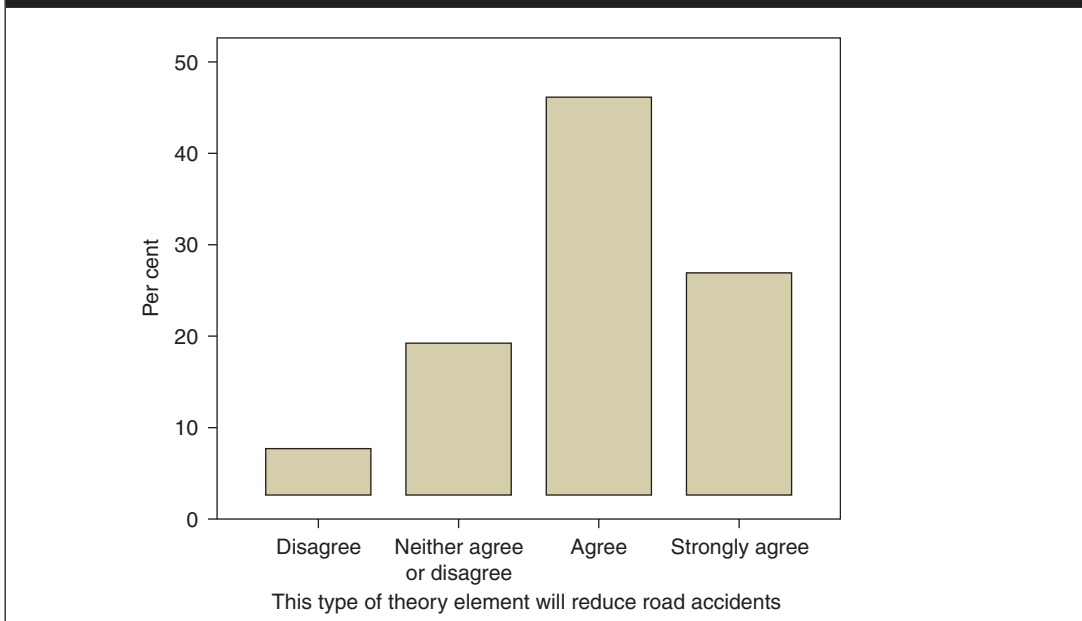
Table 11 All driving Instructors should be made to attend this type of instructor training			
		Valid per cent	Cumulative per cent
Valid	Disagree	7.4	7.4
	Neither agree or disagree	37.0	44.4
	Agree	40.7	85.2
	Strongly agree	14.8	100.0
	Total	100.0	

## Instructors’ views of the New Driver Discussion Group

The instructors also expressed the opinion that the theory element would have a beneficial affect on road crashes, with 73.1% indicating that they felt the theory would reduce road crashes (Figure 2).



**Figure 2 Instructors' response to the statement: this type of theory element will reduce road accidents**



However, some concern was expressed that the New Driver Discussion Group may reduce the take-up of the scheme (Table 12). This was felt to be a possible issue as novice drivers may be unwilling to attend classroom-based training. Although 50% of the instructors felt that this would not be a major issue, 35.7% were unclear about the affect and 11.5% did see it as an area of concern. This concern was one of the reasons why KMC introduced the subsidy in order to help decrease this possibility.

**Table 12 My pupils are put off taking the Kirklees Pass Plus scheme by having to attend the theory session**

	Valid per cent	Cumulative per cent
Valid Strongly disagree	23.1	23.1
Disagree	26.9	50.0
Neither agree or disagree	38.5	88.5
Strongly agree	11.5	100.0
Total	100.0	

## Novice driver evaluation methodology and results

This element of the evaluation used two methods of data collection: STAT19 reports and a survey design. The survey element of the evaluation aims to eventually compare three groups of novice drivers:

- novice drivers who have completed the DSA Pass Plus scheme (DSA group);
- novice drivers who have completed the KMC Enhanced Pass Plus scheme (KMC group); and
- a group of novice drivers who taken No Pass Plus training (NPP group) after passing their driving test.

In order to achieve this, two groups (the DSA group and the NPP group) are being recruited from a number of geographical areas adjacent to the Kirklees area. These groups will receive similar questionnaires to the KMC group at the same time intervals. To date insufficient returns have been gained from these groups to draw any conclusions and this element of the evaluation is still ongoing. *Therefore only the results for the KMC scheme are reported in this paper.*

All novice drivers who complete the KMC scheme are sent a questionnaire two weeks before attending the New Driver Discussion Group. They are asked to return the questionnaire when attending the New Driver Discussion Group and are asked to complete a second questionnaire at the end of the session prior to leaving. Follow-up questionnaires are then sent at three months and six months post-course. Only the results up to the three-month questionnaires are discussed in this paper, as to date insufficient six-month returns have been received to draw any firm conclusions.

The questionnaires contained several sections, covering:

- demographic information;
- a 20-item Driver Attitude Scale (DAQ) (Parker *et al.*, 1996); and
- questions about driving history and involvement in adverse traffic events.

## Sample

These results are based on a sample of 219 novice drivers who had attended the scheme and completed at least one element of evaluation. Over this period approximately 280 novice drivers had completed the scheme, giving an approximate return rate of 78%. As not all the participants have completed all elements of the evaluation, the sample size is given for all results.

## Age and gender

The mean age for the course was 19.25 years. Figure 3 shows the age profiles of the drivers attending the KMC scheme. The sample was fairly evenly distributed by gender, with 47.5% being male and 52.5% being female.

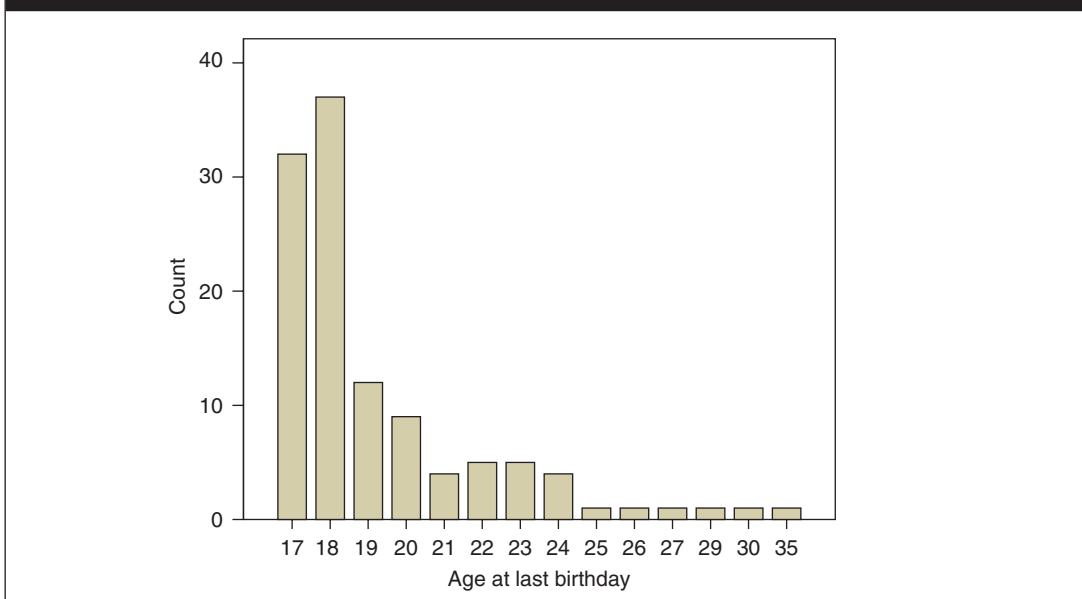
## The effect of the 50% KMC subsidy

Of the sample ( $n = 221$ ), 26.1% indicated that they would have been unlikely or very unlikely to have a Pass Plus scheme without the KMC subsidy.

## Time taken from test to completing the KMC Pass Plus scheme

60% of the drivers completing the scheme did so within two months of passing their test. The mean time taken between passing the test and completing the course was 48 days.

**Figure 3 Age profile of drivers attending the KMC scheme**



## Access to a vehicle

Pre-course 49.3% of the novice drivers owned a car, three months post-course this increased to 61.2%. Of the group who did not own a car, pre-course 64.7% reported having access to a car, three months post-course this had increased to 85.1%.

## The way in which novice drivers found out about the KMC Pass Plus scheme

Table 13 displays the valid percentages for the medium by which the novice drivers found out about the KMC scheme. The majority (84%) found out about the scheme from their instructors; this is despite KMC having successfully attracted substantial media coverage for their scheme.

**Table 13 The way in which the pupil found out about Pass Plus**

		Valid per cent	Cumulative per cent
Valid	Local paper	7.0	7.0
	Radio	2.0	9.0
	Television	1.0	10.0
	Instructor	84.0	94.0
	Insurance company	2.0	96.0
	Other	4.0	100.0
	Total	100.0	

## Self-reported accident involvement

Since passing their test, but before attending the New Driver Discussion Group, 6.1% (n = 115) reported being involved in what they considered to be an accident.

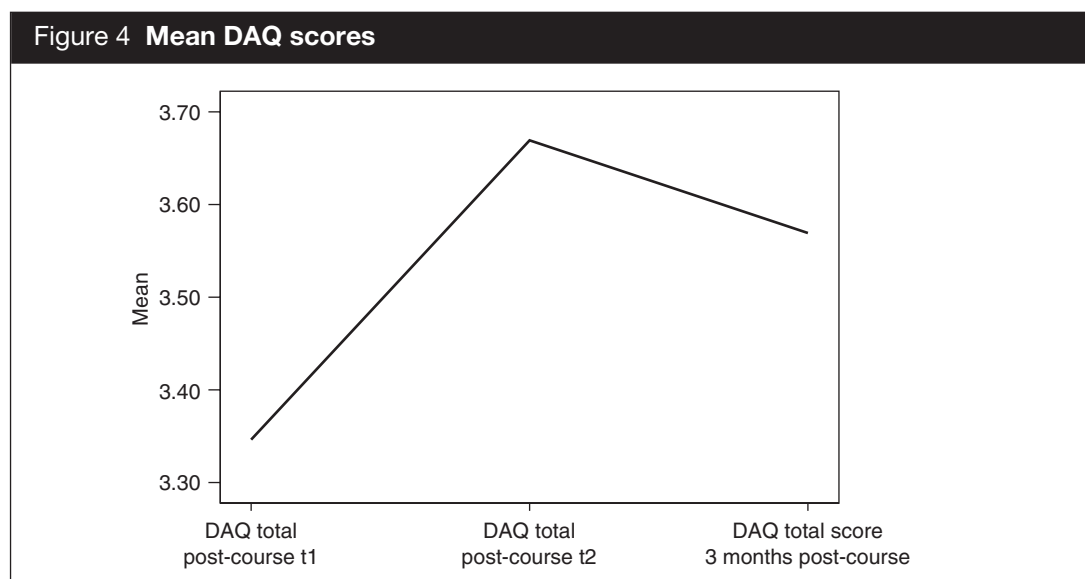
This increased to 13.7% (n = 73) three months post-course. When analysed by gender, males appear to have a slightly higher rate of accident involvement than females over both periods. Pre-course, males accounted for 57.1% of the accidents and, three months post-test, they accounted for 66% of the accidents.

## Driving offences

Since passing their test, but before attending the New Driver Discussion Group, 1.1% self-reported being prosecuted for a driving offence. This increased to 2.4% three months post-course.

## Driver attitude questionnaire

The mean DAQ score improved significantly ( $p < 0.05$ ) from a pre-course mean score of 3.48 (SD = 0.476) to 3.76 (SD = 0.490) immediately post-course. A paired sample t-test gave the following results:  $n = 54$ ,  $SD = 0.398$ ,  $t = -5.109$ ,  $df = 53$ ,  $p = 0.0005$  (2-tailed). At three months post-course the DAQ score had reduced from the immediate post-course high, but a paired sample t-test still showed the three-month post-course DAQ score to be significantly better than pre-course DAQ scores. The results of the test were:  $n = 28$ , pre-course mean score 3.44 (SD = 0.405), 3 months post-course mean score 3.60 (SD = 0.392),  $SD = 0.365$ ,  $t = -2.432$ ,  $df = 27$ ,  $p = 0.022$  (2-tailed). Figure 4 shows the mean score for the sample.



## STAT19 accident reports

In 2004, 4,319 (data supplied by DSA) drivers qualified in the KMC area. Over this period the KMC scheme delivered training to 210 novice drivers, 4.86% of the total newly qualified drivers for the area. The STAT19 accident reports for 2003/04 time period show that car driver slight injury accidents decreased by 12% for the 16- to 19-year-old age group. Table 14 shows a comparison for all age groups and by all accident types. Whilst this improvement in slight injury accidents cannot be attributed

solely to any success of the scheme, they may give some early indication that the scheme is having an impact. This finding is discussed in detail later in this paper.

**Table 14 KMC comparison of 2003 to 2004 accident statistics for car driver injury by age groups**

Year	Age group	16–19	20–29	30–59	60+
2003	Fatal	1	1	0	0
	Serious	4	16	24	4
	Slight	72	283	517	74
	Totals	77	300	541	78
2004	Fatal	1	1	4	0
	Serious	4	15	15	11
	Slight	63	273	502	68
	Totals	68	289	521	79
Percentage improvement from 2003 to 2004		11.68831	3.666667	3.696858	–1.28205

## Discussion

Whilst it is still early in the development of the KMC scheme, it does appear to be achieving some positive results both with the instructors delivering the scheme and with the novice drivers attending the scheme.

Whilst it is difficult to get a clear picture of the accident rate being experienced by the novice drivers until a larger sample of novice drivers have returned their six month questionnaires, the initial results are encouraging. Although 13% of the novice drivers self-report being involved in an accident three months post-course, 6.1% of these accidents were reported pre-course. Furthermore, when taking into account that three months post-course is likely to be up to five months post-test, this allows for the 48 days taken from passing the test to completing the course, this rate of 13% accident involved compares well to the accident rate of 19% cited by Grayson (2004) six months post-test. The Grayson study evaluates a group of newly qualified drivers over their first year as a qualified driver; not just drivers who have completed a Pass Plus Scheme.

However, offending rates were worse for the KMC group, with 1.1% reporting committing an offence pre-course, increasing to 2.4% reporting an offence three months post-course. This compares to the Grayson study, which reported 2.2% committing offences six months post-test.

One consideration here may be the increased take-up of the KMC scheme caused by the 50% subsidy in the cost of the scheme. With 26.1% of the KMC sample indicating they would have been unlikely to take Pass Plus without the KMC subsidy. This may be encouraging drivers who would not normally take part in further driver training, or return questionnaires without an incentive to do so, to participate in the KMC study. This possible difference in samples may explain the

increased offending rate. However, if this is correct, the lower than expected accident rate is very encouraging.

Whilst it is problematic to analyse the effect the scheme is having on STAT19 reported accidents in the local area, it is promising that the 16–19 age group have shown a decrease. This reduction of 12% slight injury accidents for the 16- to 19-year-old drivers in 2004 on 2003 compares to a reduction of only 3% over the same period for the combined other age groups. However it is difficult to reconcile this decrease in the 16- to 19-year-old group with the relatively small numbers, 4.87%, of the total newly qualified drivers in the KMC area who have completed the KMC scheme. This is true for several reasons, including the following:

- *Numbers taking part in the KMC scheme:* approximately only 4.87% of all newly qualified drivers in the area completed the KMC scheme.
- *Dispersal of the driving population in the age range:* the newly qualified drivers would be dispersed throughout the 16- to 19-year-old age range. Therefore the 4.87% who have completed the scheme would represent a much lower proportion of the total driving population in that age range.
- *Other road safety initiatives:* other national and local road safety initiatives may have had an impact on the reduction in the figures for this age group.

However, it is possible that the instructor training being delivered by KMC could have had some positive effect on these figures. The training may have encouraged the instructors to alter the focus of their learner training to cover not only skills but human factors associated with the driving task. If this is the case, it is possible that over 1,200 (27% of the total newly qualified drivers in the area) may have been directly affected by the instructor training delivered as part of the KMC Pass Plus scheme. This figure of 1,200 is based on discussions with local instructors who estimate that 30 drivers pass their test per year, per instructor, multiplied by the 40 instructors delivering the KMC scheme in 2004.

This hypothesis seems to have some credibility, as the 81% of the participating instructors indicated that they believed the instructor training would alter the way in which they deliver some element of their learner training. This finding is mirrored in the delivery of the Pass Plus scheme, with 81% of instructors indicating they would alter their delivery of the scheme as a result of the training received from KMC.

This seems to be substantiated in the outcomes of the DAQ scores, which showed a significant improvement three months post-course. Whilst this is an inconclusive result, as a standard Pass Plus course may achieve a similar result, this is felt to be unlikely. The then Department of the Environment, Transport and the Regions (DETR, 2000) estimated that a learner driver will receive approximately 30 to 35 hours' professional training pre-test. It is hypothesised by the author that an instructor delivering Pass Plus in the same way as this pre-test training is unlikely to achieve a substantial improvement in driver attitude over the standard Pass Plus course; usually delivered over six hours. Although, as Pass Plus is competency based, this period can be extended.

Ajzen's (1988) Theory of Planned Behaviour would indicate that an improved DAQ score may indicate an improved level of behaviour and so a reduced accident risk. However, it is important to note that the role of attitude on behaviour is not simple, as many things may affect behaviour, in particular context (Bohner and Wanke,

2002). Therefore, an improvement in a driver's attitude alone may not have a significant impact on behaviour and accident risk. However this improvement in driver attitude linked to greater experience and knowledge of situations and times when novice drivers are most at risk of accident involvement may have a positive effect on accident liability.

## **New Driver Discussion Group**

The New Driver Discussion Group attended by the novice drivers aims to address these issues by raising the awareness of the novice driver of specific road safety messages associated with novice drivers. This element of the scheme aims to increase the knowledge and understanding of novice drivers of trip-related issues and personality issues that may increase their risk of accident involvement.

The sessions are facilitated by driving instructors who have had extensive experience of delivering classroom-based driver training through KMC's delivery of the National Driver Improvement Scheme and a Speed Awareness Scheme.

The New Driver Discussion Groups use a similar methodology in delivery to the National Driver Improvement Scheme, a scheme which has been found to be successful at improving a driver's attitude and behaviour three months post-course (Burgess, 1998). The delivery of the New Driver Discussion group is based on group work exercises designed to engage a small group of novice drivers, usually 10, in discussion about their driving beliefs.

Initially, when setting up the scheme some concern was expressed by the instructors that the New Driver Discussion Groups would reduce take-up of the scheme. Any difficulty in this area appears to have been off set through the introduction of the 50% subsidy. This may have increased take-up of the scheme by 26%. What effect the New Driver Discussion Group would have had on scheme take-up without the subsidy is difficult to say. However there is evidence to suggest that the instructors' view of the Pass Plus scheme was improved through the KMC Instructor Training Day. If this is the case, this may have also helped to reduce any negative impact of the New Driver Discussion Group on take-up.

## **The instructor's view of Pass Plus**

The instructor training also appears to encourage the instructors to view Pass Plus in a more positive light generally, with 62.1% of the instructors indicating that they were more likely to encourage a greater take-up of the scheme. This is an important finding as 84% of the novice drivers coming on to the KMC scheme did so after finding out about Pass Plus from their instructor. Therefore, if the instructor does not see the full potential of the scheme it is difficult to see how take-up, of either the KMC scheme or the DSA Pass Plus scheme, can be increased on a voluntary basis.

This finding also seems to suggest that the current DSA Pass Plus syllabus may not reach its full potential as a majority of instructors delivering it may only see the scheme as a way of delivering further skills based training, and as an opportunity to gain extra experience on other road types. Whilst these are certainly good aims for the scheme to seek to achieve, they may be of limited benefit in reducing road

accidents as it is generally the human factors associated with the driving task which increase the accident risk. Post-test training may offer a more effective way to deal with these human factors than pre-test training for two reasons.

The first is that the novice driver may be able to more readily associate the effects that human factors will have on the learnt driving strategies. For example, a novice driver may have already experienced some degree of driving fatigue in the period that has elapsed between passing the test and taking Pass Plus. This offers the opportunity for the instructor to use this experience to discuss the issues relating to driver fatigue in a manner in which the novice driver can relate to easily. The second possible reason why post-test training may offer a more effective opportunity to deal with human factors is the reduced role of the instructor as a motivational factor in the car.

As discussed earlier in this paper, the expressive phase may not be seen at the pre-test phase of learning to drive due to the driver wishing to please the instructor and the instructor insisting on a driving style that suits the instructor's personality. However, once the test is passed the novice driver has the opportunity to practise driving in a style that is more compatible with their own personality. Therefore it is more likely that an instructor will have an opportunity to identify and discuss potential dangerous driving styles as they develop as a consequence of the driver's own beliefs and attitude to the driving task post-test.

However both these opportunities will only fully present themselves if the novice driver has the opportunity to practise between passing the test and taking Pass Plus. Two findings in the evaluation seem to confirm that this is taking place. The first is that the majority of the novice drivers had access to a vehicle and the second is the mean time taken from passing the test and completing the KMC scheme: 48 days. These two findings indicate that, generally, novice drivers have the opportunity to practice and develop their own driving styles.

## **Previous training received by instructors**

Generally, the instructors delivering the KMC scheme had been involved with the DSA scheme for sometime; with over 96% being registered to deliver the scheme for over a year.

The vast majority, 96%, had been qualified as an instructor for more than a year, with 64% having been qualified for over five years. Furthermore, just over 46% of instructors on the KMC Pass Plus scheme had attended a recognised post-test instructor training course, yet a majority of instructors were indicating that the training delivered by KMC would alter both their delivery of Pass Plus and their pre-test training. This may indicate that many of the issues covered on the KMC instructor day are not covered in other driver instructor training courses and therefore get little coverage in the DSA scheme. A second explanation could be that the instructor has failed to associate the training they have received from other courses with Pass Plus. In either case, it would indicate that instructors may not be delivering human factors training as part of the current Pass Plus syllabus.



# Conclusions

The KMC scheme has attempted to follow the Goals for Driver Education by encouraging the instructor to focus not only on car skills and road literacy but also on issues related to personality and motivations related to the journey.

Whilst the results reported here cannot be regarded as conclusive, they do appear to lend some support to the concept that greater instructor training, linked to a targeted intervention, may substantially improve the delivery of pre-test and post-test driver training. It is hoped that this improvement in driver training will result in reduced accident liability, but further, more detailed research needs to be completed before any firm conclusions about the KMC scheme can be drawn.

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## Development and evaluation of a simulator-based training programme for emergency vehicle driving

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### Abstract

Emergency vehicle driving is associated with an increased accident risk and it requires a high level of driving proficiency from police officers. The anticipation and early recognition of potentially dangerous traffic situations, as well as the clear communication of the driver's intentions to other road users, are critical skills for safe emergency driving. The emergence of high capacity driving simulators allows a focus on the training of high-level danger cognition processes by presenting trainees with complex traffic scenarios and interactive traffic without putting other road users at risk. This is in contrast to conventional driver training programmes focused on the development of advanced vehicle control skills.

This paper describes the development and evaluation of a simulator-based training programme for emergency vehicle driving that was developed as part of a comprehensive driving programme for the Bavarian Police Force. The training goals and selection of training scenarios, their implementation in the simulator, and the two days' training curriculum will be outlined.

The results of the evaluation of the training in terms of improved driver performance and acceptance of the simulator as a training device will be presented. The findings are based on data from instructors, observers and 44 police trainees. Recommendations for improvements of simulator training programmes will be presented.

# Objectives

The development of a simulator-based training programme for emergency vehicle driving was part of a three-year pilot project commissioned by the Bavarian Police Force in 2003. The overall aim of the project was ‘to develop and test a technology-supported driver training system that is based on psychological theories and findings from traffic research to train young officers on the complex task of police emergency driving efficiently and economically’ ([www.polizei.bayern.de/bpp/](http://www.polizei.bayern.de/bpp/)). A two-day training programme was developed to replace the third and last stage of the police driver curriculum. Whereas stage one of the curriculum deals with technical aspects of driving and vehicle dynamics, stage two focuses on advanced vehicle handling skills. Stage three concerns all aspects of emergency vehicle driving and comprises 27 training units (20 hours).

The evaluation of the new training programme at the end of 2005 will result in a recommendation about the future use of simulation technology in the driver training curriculum of the Bavarian Police Force. Training development and evaluation were carried out by the Interdisciplinary Centre for Traffic Sciences at the University of Wuerzburg, Germany.

# Introduction

The need for additional post-licence driver training of young police officers stems from: 1) high task demands and the increased accident risk associated with emergency vehicle drives (Schmiedel and Unterkofler, 1986); and 2) the general over-representation of young drivers in accident statistics (Hattaka *et al.*, 1999). Until recently, the explanation for increased accident involvement of young drivers was seen in terms of insufficient vehicle handling skills and the solution to the problem in the improvement of those handling skills through more practice. However, such training measures have been found to be of limited success in reducing accident rates (Christie, 2001). More recent approaches to driver training, e.g. those developed within the framework of EU projects TRAINER or GADGET, stress the importance of covering not only lower levels of the driving task taxonomy, such as vehicle control and simple driving manoeuvres, but the comprehensive coverage of all levels of the taxonomy, including the motivational aspects of driving and a particular focus on higher level processes such as self-evaluation and danger cognition (Hoeschen *et al.*, 2001).

Such training goals are difficult to realise in practical on-road driver training without simultaneously endangering other road users. The emergence of high-end driving simulation technology allows the training of complex driving scenarios with interactive traffic, and also promises repeatability, standardisation and controllability of those scenarios. However, since its introduction there is also growing agreement between training developers to use simulation technology not as a sole training device but within a comprehensive training programme that also includes other components, such as classroom teaching, practical on-road driver training and computer-based training (Kappè *et al.*, 2002). Furthermore, the development process of a simulator training programme should start with a thorough didactic analysis and

definition of training goals, instead of making do with the capabilities of a given simulator (Thoeni, 2002).

# Definition of training goals and simulation requirements

## Information sources

As a first step, learning goals for the simulator training were defined and requirements with regard to the simulation software were specified. The latter particularly concerned modelling the behaviour of the autonomous traffic when reacting to emergency vehicles. Learning goals and simulator requirements were derived from psychological literature and the following information sources:

1. Existing police training curricula and driver programmes.
2. Emergency vehicle accident files and analysis of court cases.
3. Interviews with police officers, who had experienced an accident on an emergency ride.
4. Video observations of other road users' behaviour during encounters with emergency vehicles. The video analysis showed that road users frequently did not simply clear the way for the emergency vehicle, but frequently:
  - took some time to orientate themselves and then made way for the emergency vehicle;
  - did not notice/ignored the emergency vehicle and carried on driving;
  - accelerated and continued driving in front of the emergency vehicle; and
  - stopped on the spot and did not give way.

These findings were used by the simulator manufacturer to model the behaviour of the autonomous traffic in the simulator for the emergency driving training.

5. Pilot study on emergency driving (Krueger *et al.*, 2000). The pilot study was conducted to give a detailed account of task requirements during emergency driving as well as to identify skill deficiencies in novice emergency drivers. In the study, a team of experienced police officers and a team of novice police drivers were asked to drive along a predetermined route under emergency conditions in a vehicle equipped with video cameras and instruments to measure operator input. The same route was also driven without lights and sirens (baseline). Each police officer acted as driver and as co-driver (number of drivers altogether  $n = 4$ ). The following measures were recorded on all four

emergency drives and were compared to the four baseline drives without lights and siren:

- subjective measure of workload;
- pulse rate;
- video observation of the vehicle crew's behaviour;
- video observation of other road users' behaviour; and
- operator input and vehicle reactions.

The analysis showed no significant difference between experienced and novice drivers with regard to subjective workload or physiological reactions in the emergency condition. Both teams reported high levels of workload, which were also reflected in a steep increase of heart rates at the beginning of the emergency drive. This demonstrated the highly demanding nature of emergency driving independent from experience and the high level of activation that is typically associated with it.

Significant differences between the teams were found with regard to the tolerance of risk: for a minimal time advantage over the experienced team, the novice drivers chose far riskier driving strategies. Negotiating junctions and overtaking manoeuvres proved to be particularly dangerous as a result of poor anticipation of situation development on the part of the inexperienced team. This also resulted in more extreme driving inputs compared with the experienced team. Furthermore, the experienced team demonstrated better task-sharing and multi-tasking skills.

## Definition of learning goals

Utilising the information sources and findings mentioned in the previous paragraph, the following learning goals were formulated for emergency driving:

1. Early recognition of dangerous situations in traffic and anticipation of situation development.
2. Successful interaction with other road users.
3. Proper use of warning devices to indicate their driving intention to other road users.
4. Acquisition of an error tolerant driving style: continuous monitoring of whether the emergency vehicle has been noticed by other road users.
5. Acquisition of a resource friendly and self-evaluative driving style.
6. Knowledge about the risks associated with particular road environments.
7. Effective teamwork and task-sharing between driver and co-driver.

The following manoeuvres were identified to be particularly important for training the outlined learning goals:

- negotiating the right of way at junctions;
- overtaking in different road environments;
- passing vehicles;
- clearing traffic – creating alternative paths in heavy traffic or traffic jams;
- use of irregular lanes, such as bus lanes, lay-bys or sidewalks; and
- pursuit driving.

In co-operation with a board of police driving experts, a catalogue of 32 training scenarios were described in different road environments (urban roads, rural roads and motorway) including possible situation developments. This catalogue was forwarded to the simulator manufacturer to further modify the existing simulator software according to training requirements (Kirmse, 2003). A small number of scenarios could not be realised in the simulator (e.g. pursuit driving) due to software limitations. These learning contents had to be conveyed by other educational methods within the framework of the comprehensive training programme.

## The simulator

The driving simulator employed in the pilot project was manufactured by Rheinmetall Defence Electronics GmbH. Installed on the motion platform with six degrees of freedom is a BMW 318 cabin (automatic), which is customised for emergency driving (lights, siren, radio). The projection system provides a  $210 \times 40$  degree view plus three rear-mirror views. The police instructor guides the training process and controls the simulator from a PC in the control room (right picture in Figure 1).

**Figure 1 The driving simulator with motion platform and projection system (left) and observation facilities (right)**

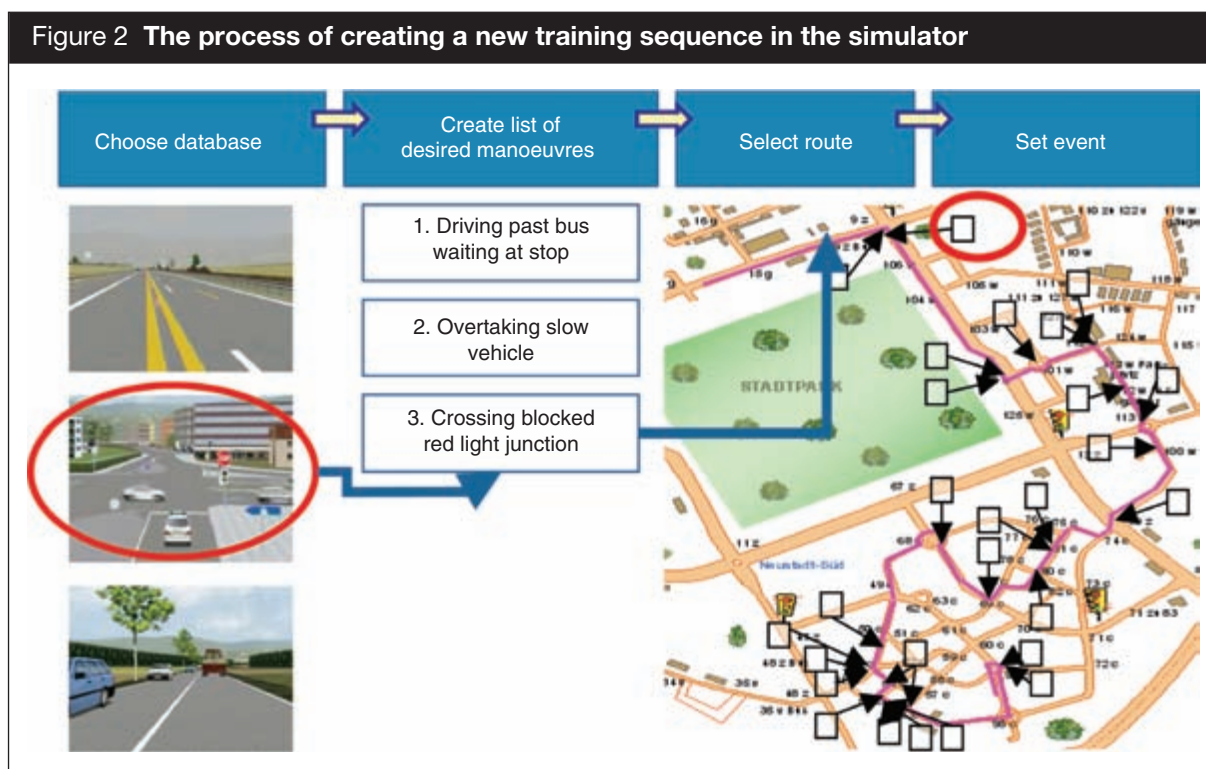


The simulator offers three independent fixed databases: rural roads, urban roads and motorway. Light, visibility and weather conditions can be manipulated for all road environments. The stochastic interactive traffic (including cars and vans only) generated by the traffic simulation can be modified with regard to the density of traffic (0–100% density) and the proportion of different behaviour profiles of road users (defensive, normal, aggressive driving styles). Once set, all manipulations mentioned are valid throughout the respective drive.

To create desired training scenarios, the simulation software provides an ‘event function’ which allows the setting of parameters for a number of predefined vehicles or single pedestrians at fixed geographical points of the route. These settings are only valid for the duration of the event.

## Development of training sequences

The procedure of creating a new training sequence is illustrated in Figure 2.

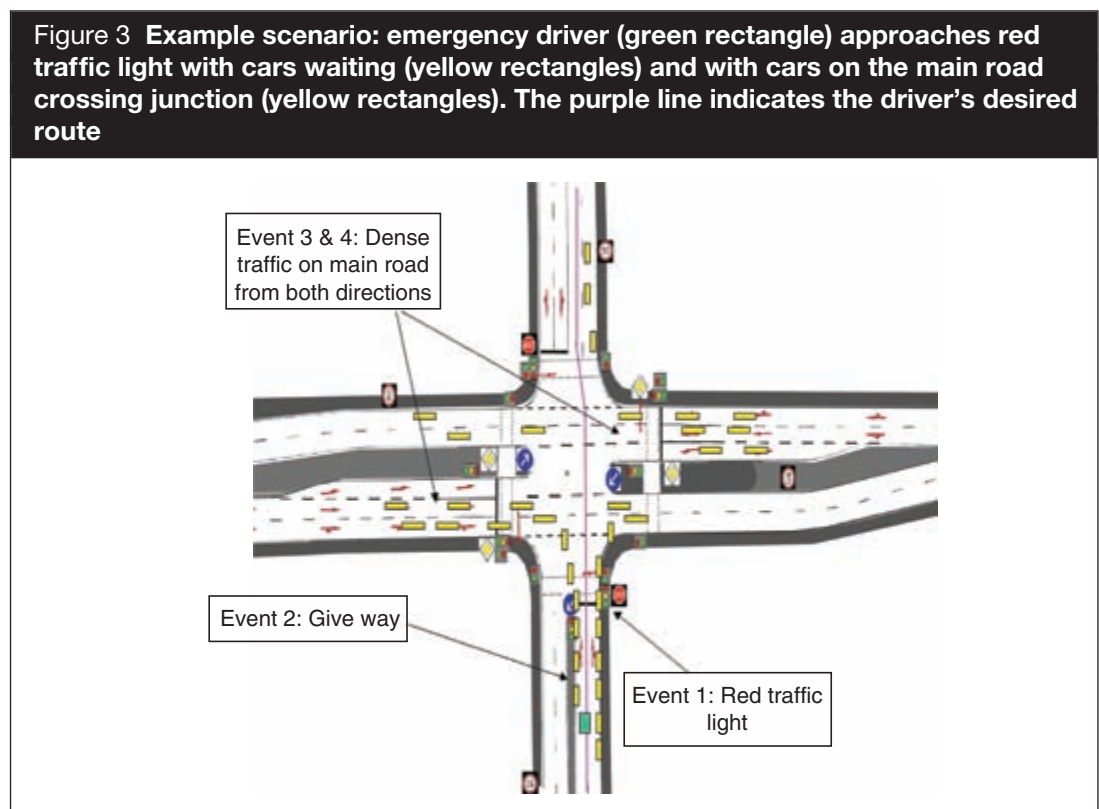


Firstly, one of the three databases has to be selected (e.g. urban roads). As the databases are independent, it is not possible to switch within drives (loading a different database takes a few minutes).

Secondly, a list of desired scenarios or driving manoeuvres has to be composed for each training sequence, which details the stationary feature requirements for each scenario included.

When planning the route for the training sequence in the third step, it has to be chosen in such a way that all stationary features required for the scenarios in the list are provided. In the emergency driving programme, drive time was restricted to a maximum of 10 minutes per training sequence to keep the incidence of simulator sickness low. When training time is limited in such a way, a fixed-based driving simulator is comparable to conventional driving training: valuable training time is lost through having to drive to the next stationary feature where a certain driving manoeuvre (e.g. crossing a junction) can be practised.

The last step is to create the training scenarios using the event function of the software. Figure 3 gives an example of how to create the scenario ‘crossing a red light junction with cars waiting before the lights and dense traffic on the main road’. The scenario is made up of four events that determine the status of the traffic light as well as the behaviour of the other road users when the emergency driver approaches the junction. Finding the right parameter setting for each event is very much a trial and error process. The same scenario has to be tested several times in order to achieve the desired effects.



## Structure of the training programme

Owing to organisational limitations, a group of 12 trainees has to be trained within the two days’ comprehensive training programme. Each police officer spends 90 minutes per day in the simulator, half of the time as the driver and half as the co-driver. The training is carried out in teams of two, with the co-driver being



positioned outside the simulator, in the control room, next to the instructor. He is connected to the driver via radio.

The structure of the simulator training is based on the following didactic principles:

- active mastery of the training scenarios as the driver;
- observational learning as the co-driver;
- increase of difficulty of training sequences over the training course; this is achieved through increasingly complex road environments, increasingly dense traffic and a greater number of training scenarios in later drives;
- decrease of guidance by the instructor over the training course;
- repetition of similar scenarios in different road environments; and
- replay of each emergency drive and provision of feedback through the instructor after the completion of each drive.

To ensure trainees focus on the learning goals rather than being preoccupied with vehicle control in the simulator, the training of emergency driving is preceded by a familiarisation drive on the motorway and handling training on rural roads. The trainee carries out simple driving manoeuvres in low traffic density as advised by the instructor.

As trainees drive in teams of two, a different set of five training sequences for emergency vehicle driving was developed for each team partner. Both sets include the same scenarios, but follow different routes. That way, neither of the trainees has the advantage of already being familiar with the route whilst driving. The five emergency drives are carried out in all three road environments: urban roads, rural roads and motorway. However, there is a particular focus on emergency driving on urban roads as these roads cover a large percentage of major accidents involving emergency vehicles.

## Development of training guidelines

In order to measure training success, the standards for adequate driving behaviour must be defined, against which the actual performance of a trainee can be compared. To develop training guidelines, and thus ensure standardised feedback across different driving instructors within the training programme, video samples of all training scenarios were extracted from the simulator and were discussed with a second board of police driving experts. For each training scenario, 'ideal' and 'worst' driving strategies were identified, and a list of scenario-related driving errors was collected.

# Evaluation of the training programme

## Sample

A sample of 44 (32 male, 12 female) young police officers completed the training in the evaluation period. On average, they were 22 years old ( $SD = 1.94$  years) and reported to have driven 90.451 km ( $SD = 69.927$  km) since having obtained their driving licence, and 28.6% reported to have participated in post-licence vehicle handling trainings and 14.3% had already gained experience with emergency driving outside the police force. All trainees had successfully completed stage one (vehicle technology and vehicle dynamics) and two (advanced vehicle handling course) of the police driver training curriculum.

## Training motivation

Self-reported training motivation was high, with mean = 4.36 ( $SD = 0.685$ ) on a five-point questionnaire scale (1 = very low to 5 = very high) and trainees very much thought that simulator training was good preparation for emergency vehicle driving (mean = 3.84,  $SD = 0.745$ ).

Instructor ratings (1 = very low, 5 = very high) of trainees' motivation to learn for each drive confirmed high overall motivation, but also identified some individuals who displayed risky driving behaviour and who showed great reluctance to take on board the learning goals of the simulator training.

## Simulator sickness

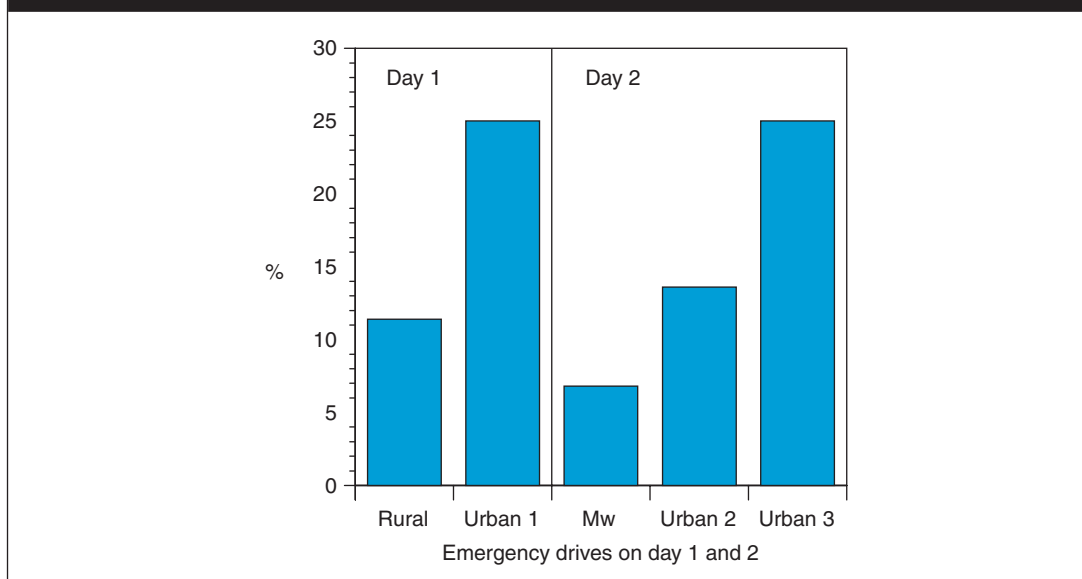
Simulator sickness is a well-known problem associated with virtual environments and can seriously affect both training acceptance and effectiveness. Figure 4 shows the drop-out rate for the whole training course. On both days the percentage of training sequences not completed rose over the course of the training, peaking with 25% at the end of both training days. The lower incidence at the beginning of training day two indicates trainees' recovery from simulator sickness over night. Altogether, 16.4% (36) of 220 emergency drives were not completed due to symptoms of simulator sickness within the evaluation period. The high incidence of simulator sickness in the emergency driver training might be explained by high exposure and the task characteristics:

- Experience from pilot simulator trainings shows that sickness rates are highest when multiple training sessions are carried out on the same day or one day apart (Kennedy *et al.*, 1993). However, due to organisational limitations, the police training has to be carried out in multiple drives on each of two consecutive days.
- The intensity of driving manoeuvres and scenario content have been identified as factors contributing towards simulation sickness (Watson, 1998).

High linear and rotational accelerations are characteristic of emergency driving and thus cannot be completely avoided in an emergency vehicle training programme.

Reduction of the sickness incidence, however, might also be achieved through improvement of the motion system configurations. Further work towards early detection of susceptible trainees and contributing factors is currently being carried out.

**Figure 4 Drop out from emergency drives due to simulator sickness on each training day**



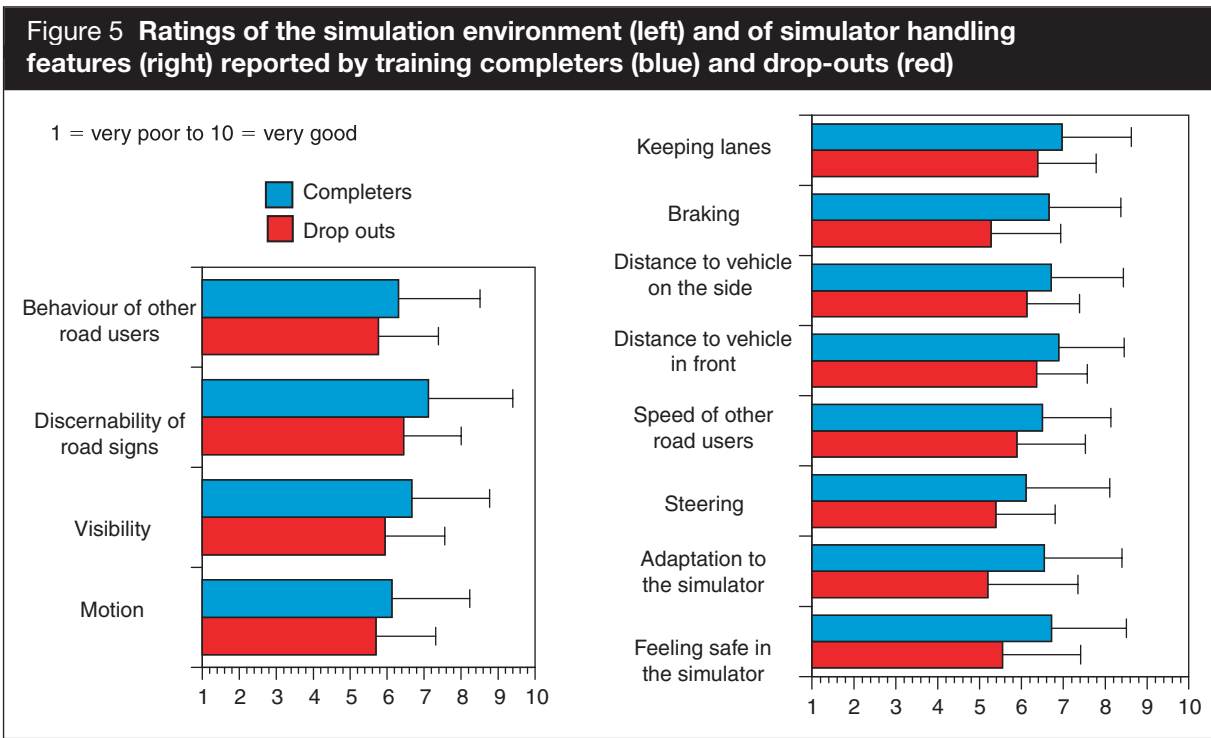
## Adaptation to the simulator

Sufficient adaptation to the simulator was regarded as a prerequisite for the training of adequate emergency vehicle driving. To assess handling difficulties, self-reported ratings of simulator handling and the simulation environment were collected on a 10-point scale (1 = very bad, 5 = neither good nor bad, 10 = very good).

Overall, the ratings of the simulation environment features ranged between the categories 'neither good nor bad' (6) and 'good' (7). Trainees who dropped out of the training due to simulator sickness rated the simulator features approximately half a point lower than trainees who had completed the training. These differences reached significance in 2-tailed t-tests for independent samples for the discernability of road signs ( $t(275) = -2.156, p < 0.05$ ) and general visibility in the simulator ( $t(275) = -2.473, p < 0.05$ ).

With regard to vehicle handling, overall ratings again ranged between the 'neither good nor bad' (6) and 'good' (7) categories. The differences between trainees who dropped out of the training and training completers were significant for all variables.

When looking at the changes of trainees' ratings of simulation features over the training course, no significant changes were found with regard to the simulation environment (training completers' ratings only). With regard to handling properties,



significant main effects by drive were found in one-way repeated measures ANOVA (ANalysis Of VAriance between groups) for the following variables:

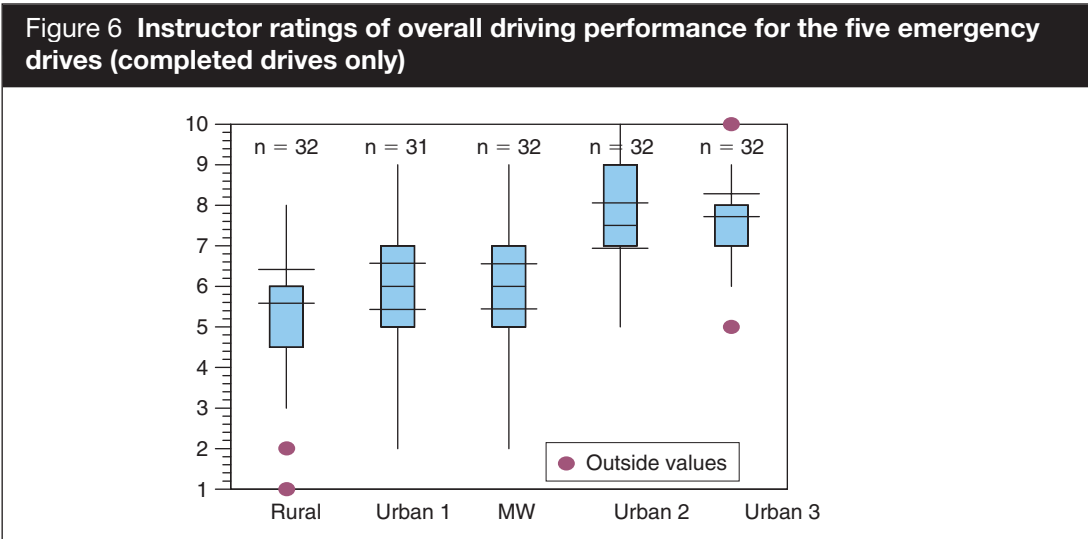
- keeping lanes ( $F(6, 120) = 4.439, p < 0.01$ );
- braking ( $F(6, 120) = 3.740, p < 0.01$ );
- steering ( $F(6, 120) = 4.653, p < 0.001$ ); and
- adaptation to the simulator ( $F(6, 108) = 3.152, p < 0.01$ ).

Pair-wise, post-hoc comparisons with Bonferoni adjusted alpha revealed that this was due to higher ratings in later drives than at the beginning of the training.

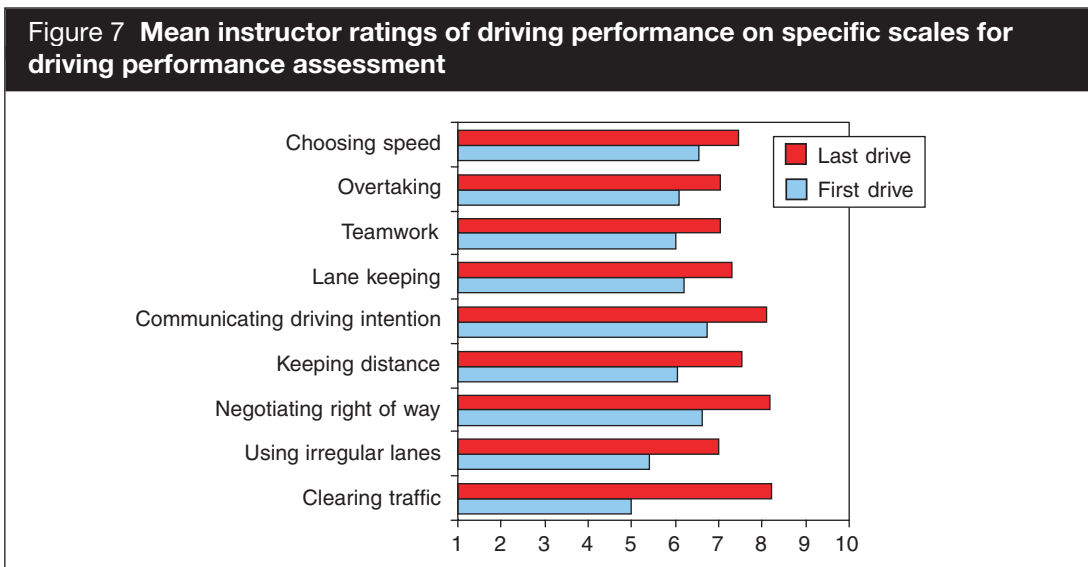
These self-reports suggested a growing adaptation of trainees to the simulator over the training course with regard to vehicle handling and control, whereas adaptation to the display characteristics did not take place in the same way.

## Driver improvement

A one-way repeated measures ANOVA was calculated for instructors' ratings of overall performance (10-point scale, with 1 = very bad to 10 = very good) across the five emergency drives. It indicated a significant improvement of overall driving performance over the course of the training ( $F(1, 30) = 44.355, p < 0.001$ ). Post-hoc, pair-wise comparisons showed that instructors' ratings for the last two drives were significantly higher than for the first three drives. As shown in Figure 6, an homogenisation of driving performance in terms of reduced variability of performance between trainees took place over the training course.



The comparison of instructors’ ratings of trainees’ performance in the first emergency drive in an urban environment with their last drive gave more insight as to which aspects of the trainees’ driving performance improved. The greatest improvement was found for clearing traffic, followed by the use of irregular lanes and negotiating the right of way (see Figure 7). The analysis of the frequency of driving errors showed that these improvements were mostly due to the emergency driver relying less on the correct behaviour of other road users and instead building more safety margins into his driving style.



More safety orientated driving behaviour was also reflected in the results of a MANOVA (Multiple ANalysis Of VARIance) on instructors’ ratings of the trainees’ driving style after the completion of each drive (five-point scales: 1 = very bad, 5 = very good). It showed a significant global effect (Wilks Lamda  $F(36, 511.392) = 1.577, p < 0.05$ ) that was due to a reduction of aggressive driving over the course of the training programme ( $F(1, 144) = 4.542, p < 0.01$ ) and a significant increase in the anticipation of a dangerous situation whilst driving ( $F(4, 144) = 5.841, p < 0.001$ ) as revealed by post-hoc, one-way repeated measures ANOVA.

# Summary and conclusions

This paper described the development of a simulator-based training programme on the basis of a thorough didactic analysis and explicitly defined learning goals. Scenario-specific performance criteria were defined that allow the assessment of trainees' performance on dedicated scales. The simulator training was successfully embedded in a comprehensive training programme that also includes computer-based training, practical driver training and classroom teaching. Currently 800 young police officers undergo the training every year.

The results of the formative evaluation indicate that the training was indeed effective in conveying the learning goals to the target group of young police officers. Training contents that could not be conveyed in conventional driver training, such as the successful interaction with other road users or the anticipation and negotiation of dangerous situations in complex traffic scenarios, were successfully implemented in the simulator, and thus an important gap in the training methods available was closed. Trainees' acceptance of this new training tool was demonstrated to be high.

Despite the positive results however, the initial evaluation of the simulator training programme also revealed areas for further improvements. One is the problem of simulator sickness. With an incidence of 15 to 20%, provisions have to be made for training participants that drop out of the training due to sickness symptoms. Furthermore, negative press due to frequent simulator sickness in trainees could undermine the programme in a wider organisational context. Screening procedures for an early detection of potential drop-outs are required.

The second problem concerns the elimination of software errors and the design of training scenarios in the simulator. To create an insight into other road users' behaviour in trainees, simulated road users have to behave reliably in a realistic manner. Even though considerable improvements of traffic simulation were achieved over the training development in co-operation with the simulator manufacturer, incidents of 'odd' behaviour were not completely eliminated. This can contribute to a devaluation of the training on behalf of the trainee by attributing blame for driving errors externally, even when they were clearly the driver's fault. With regard to training development, the scenario creation in a fixed database system proved to be a time-consuming process with limited flexibility due to a finite number of available stationary road features within the restricted driving time. A more trainee-tailored approach with scenario selection and repetition depending on the learning level of each trainee was not applicable within the set-up of this training.

The evaluation emphasised the importance of the instructor in the training process. At present, the simulator does not provide objective feedback to the trainee. As a result of this absence of automatic feedback, the full responsibility for guiding the learning process and conveying the training goals is left with the police instructor. The success of the programme very much depends on this person. As a police professional he is able to build the bridge between traffic scenarios presented in the simulator and the reality of emergency driving. He is also the one to ensure that trainees take the simulator training seriously. To support instructors in their role and

to ensure their co-operation, they should be drawn into the development process of the programme from early on. Consideration should also be given to their training and workload.

Further endeavours have to be made to ascertain the transfer effectiveness of the simulator training to real emergency driving. This will be part of the summative evaluation at the end of the pilot project, when police officers, who have participated in the conventional driver training programme, will be compared to those who have passed through the simulator training programme.

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