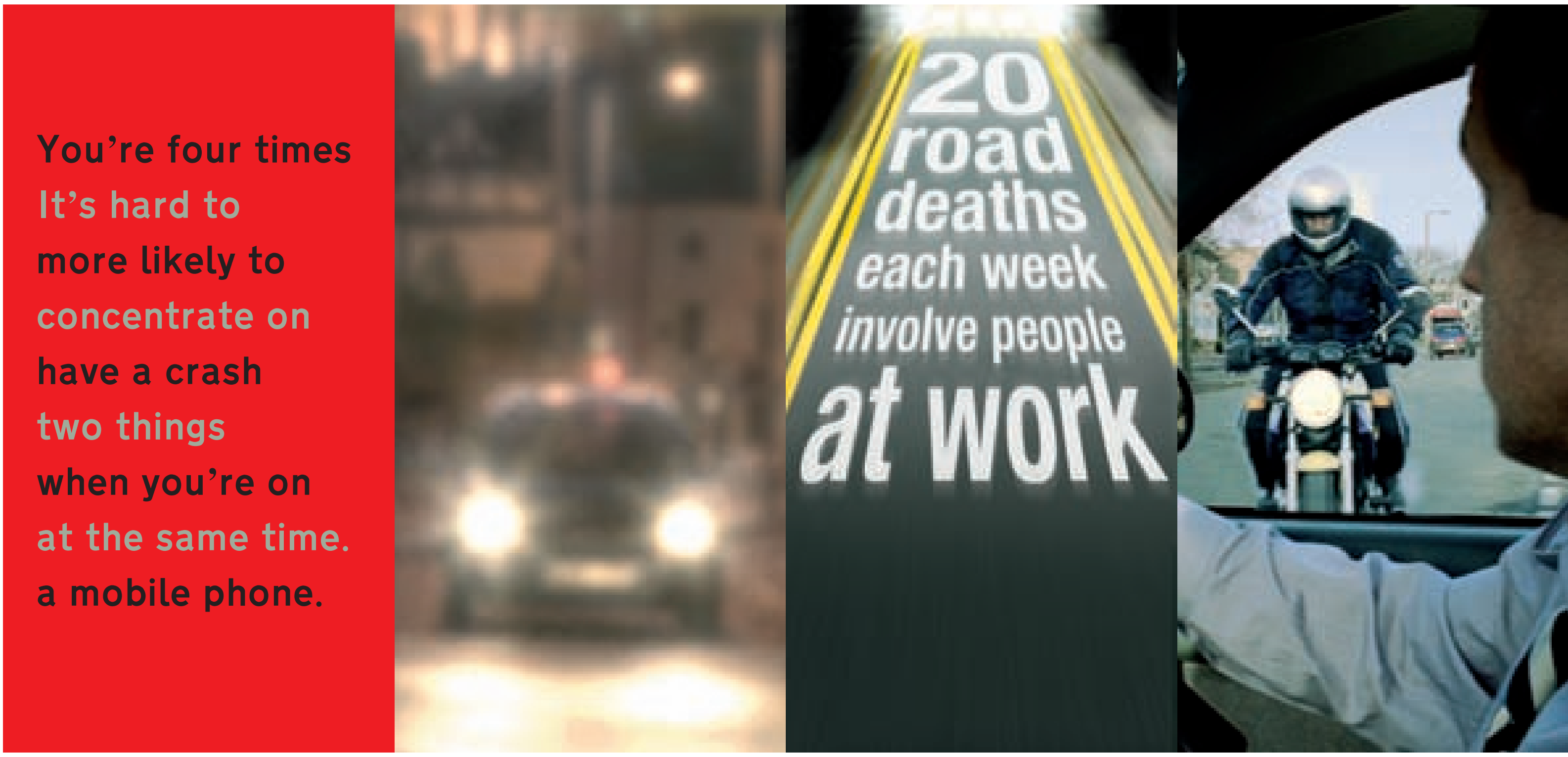
Department for
Transport

# Behavioural Research in Road Safety 2006

## Sixteenth Seminar




December 2006

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# Killer crashes: a multiple case-study of fatal road-traffic collisions

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## Abstract

We have completed five projects for the Transport Research Laboratory(TRL)/Department of Environment, Transport and the Regions (DETR)/Department for Transport, Local Government and the Regions (DTLR)/Department for Transport (DfT) on right-turning accidents, overtaking accidents, young drivers' accidents, motorcycle accidents, and work-related road traffic accidents, based on detailed case-by-case analysis of police files. Our latest project examined accident mechanisms in fatal road traffic collisions as part of a joint research project with TRL and University College London (UCL). Our contribution to the joint project was completed in April 2006, and the final report covering contributions from all three groups is expected to be published shortly. This paper reports findings from over 1,000 police case reports involving fatal road traffic accidents from 10 UK police forces. There are clear differences between the accidents caused by younger and older driver age groups. Issues such as speeding, the use of seat belts, driving with excess alcohol and car passenger fatalities are also discussed.

## Introduction

According to research conducted by TRL (Broughton, 2005), there has been a lack of progress with the reduction of the UK fatality total. This is impacting negatively with the long-term aim of reducing the numbers of killed and seriously injured (KSI) in accordance with 10-year casualty reduction targets set to be achieved by 2010

(DETR, 2000). One of the main problem areas has been revealed to be deaths of car occupants, which have risen since 2000.

Car occupant fatalities were found to have occurred predominantly among the young; the passenger fatalities tend to be even younger than the driver fatalities. Contributing significantly to these totals were weekend peaks in fatalities of both car drivers and passengers occurring between 9 p.m. and midnight. Such accidents show a high level of alcohol involvement. Previous research at Nottingham University (Clarke *et al.*, 2002) has shown similar increases in alcohol-related accidents at such times. Alcohol-related accidents, however, may not be the exclusive preserve of drivers under 25. Abdel-Aty and Abdelwahab (2000), using US state data, found that 'the 25–34 age group experience the highest rate of alcohol/drug involvement in accidents'.

There is also evidence that young male drivers take more risks when driving with passengers, particularly other male passengers. Preusser *et al.* (1998) found that the presence of passengers was associated with more at-fault fatal crashes for drivers aged under 25 years. This effect was particularly marked where teenaged drivers were carrying two or more teenage passengers.

Speeding as a factor in fatalities has been well-researched. Bédard *et al.* (2002) found that 'traveling at a speed of 112 kph (70 mph) or more was independently associated with a 164% increase in the odds of a fatality compared with speeds of less than 56 kph (35 mph)'. Bédard *et al*. also found that larger decelerations (i.e. larger impact velocities) were associated with more post-injury medical complications, independent of age and injury severity.

Authors such as Jonah (1997) have linked sensation seeking with other risky driving behaviours, such as failure to use a seat belt. Begg and Langley (2000), in a review of the literature, stated that 'failure to use seat belts is most common among young adults, and particularly males. There is also evidence that those who do not use seat belts … engage in other risky driving behaviors such as speeding and alcohol-impaired driving.'

Brouwer *et al*. (1991) found that older drivers, by contrast, were over-represented in crashes when turning at intersections, usually by failing to yield the correct right of way. Similarly, older drivers have been shown to be over-represented in junction accidents in many other studies over the last two decades (e.g. Moore *et al*., 1982; Viano *et al*., 1990; Verhaegen, 1995). With an ageing population which has greater susceptibility from side impacts (Viano *et al*., 1990), and an increased risk of fatality from side impacts as opposed to frontal impacts (Bédard *et al*., 2002), it seems that the human and financial cost of this type of accident will increase with time.

# 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 can prove 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 which had been customised to handle the information and search parameters required for this project. Data were entered describing the relatively objective facts of each case: time of day, speed limit, class of road, etc. A 'prose account' was also entered for each case, giving a step-by-step description of the accident. These accounts provided a detailed summary of the available facts, including information from witnesses that appeared to be sufficiently reliable. A minimum set of possible explanations for each accident was 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 fatal accidents stored as a series of case studies.

# Results

## Speed and loss of control on bends

Forty-four per cent of fatal accidents sampled involved a vehicle going out of control on a bend or curve. The mean age of drivers at fault in these bend accidents was significantly younger than the mean age of drivers in all other accidents in the sample (mean age 33 years versus mean age 45 years, $p < 0.01$). Fifty-four per cent of these accidents were single vehicle accidents (SVAs). There were approximately five times as many male drivers at fault in this fatality class as there were female drivers at fault.

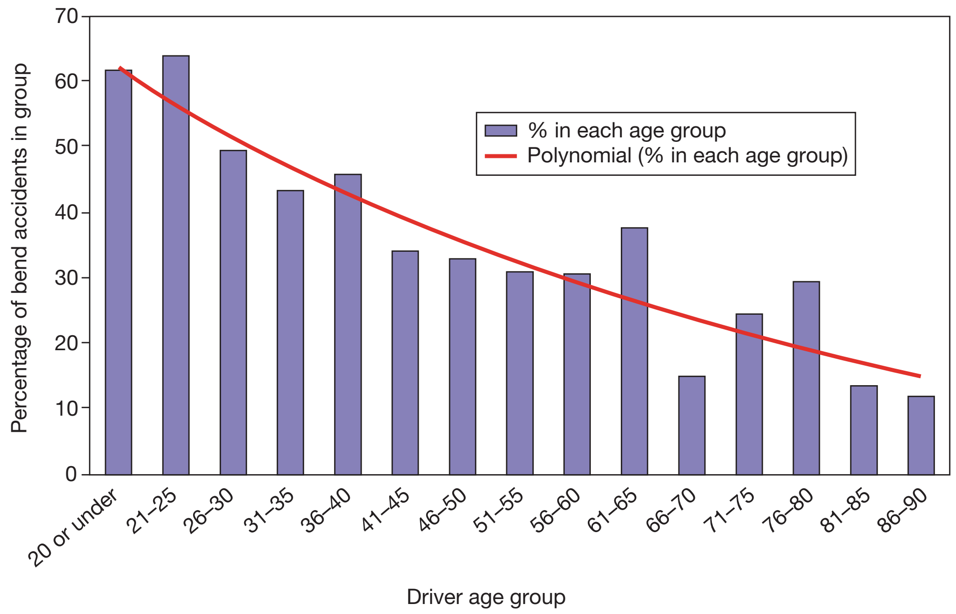
The majority of loss of control on bend accidents (74%) were, unsurprisingly, characterised by excessive speed for the bend in question, contributing to the loss of control by the driver. The age distribution of 'at-fault' drivers in bend accidents is shown in Figure 1. The figure shows the percentage of bend accidents in the total 'at-fault' accidents for each age band. A second order polynomial curve has been added to Figure 1 to show the pattern of the drop from the peak of 60+% of fatalities that occurred in loss of control bend accidents in the two youngest driver age groups (under 25 years).

Figure 1 clearly shows that, for drivers under the age of 30, a very large proportion of fatal accidents are caused by the loss of control on bends. As a whole, these fatal accidents occur over four times as often on rural roads as they do on urban roads. Over half (57%) occur during the hours of darkness.

There were two general patterns of bend control loss. The first, occurring in approximately 70% of such cases, seemed to occur where a driver approached at excess speed and was unable to make the bend at all. This usually resulted in the car leaving the road to one side or the other, and possibly hitting oncoming traffic before doing so (in the case of left bends).

In the second type (approximately 27% of such cases), the pre-accident sequence was somewhat more complex. The driver appeared to have made attempts to steer out of a skid and regain control, but ended up typically contributing to the loss of

Figure 1 **Percentage of fatal bend accidents by driver age band for all at-fault drivers**




control by inducing a yawing skid as the path taken during correction exceeded the available grip on the road surface. The vehicle then spun off either side of the road and/or into opposing traffic.

The average ages of the drivers involved in either of these two types of bend loss of control accidents were not significantly different from one another. The ratio of male/female drivers at fault is also the same in either case.

In both of the two causation patterns identified above, there appeared to have been a high number of side or non-frontal impacts to the car, although this was found to be more common in the second type (67%) than in the first (45%). Side impacts have been found to cause twice as many fatalities as frontal impacts (e.g. by Bédard *et al*., 2002)

# Alcohol and drugs

231 cases (19% of the total) involved a driver who was over the drink-drive limit. The average blood alcohol concentration (BAC), where this could be measured, was 176 mg/dl (which is more than twice the UK legal driving limit of 80 mg/dl). The highest blood alcohol level recorded was 384 mg/dl – nearly five times the legal limit. Drivers found to be above the alcohol limit were younger on average than those where alcohol was not a factor (mean age 31 years as opposed to 42 years; $p < 0.01$).

Forty-five cases (4%) involved drugs. Cannabis was the most widely found drug, but amphetamines, MDMA (ecstasy), cocaine and heroin were also found. The level of drug use is unfortunately likely to be an underestimate, as toxicology reports were not always performed, and/or the results were not always made available in the police reports. Drivers found to have used drugs were younger on average than non-drug using drivers (mean age 28 years, as opposed to 40 years; $p < 0.01$). In those cases where drivers were identified as driving while under the influence of drink and/or drugs, 18 drivers (8%) were found to have been under the influence of drugs and not alcohol, with a further 13 (6%) testing positive for both alcohol and drug intake.

Males were more likely to be driving under the influence of drink and/or drugs when involved in an accident than females. Twenty-three per cent of accidents when male drivers were to blame involved a driver impaired by drink and/or drugs, compared with 13% of females.

There were also very clear types of accident that impaired drivers were likely to have. A major group were 'loss of control' accidents, especially when attempting to negotiate a left- or right-hand bend, as discussed in the section above. Of these, 24.4% involved drivers who were under the influence of drink and/or drugs. There were fewer impaired drivers in other accident types, which could be broken down into three main categories:

- 10.3% of right of way violation (ROWV) accidents involved an impaired driver;
- 9.9% of overtaking accidents involved an impaired driver; and
- 8.8% of rear-end shunt (RES) accidents involved an impaired driver.

Of all the accidents involving an impaired driver, 68% were SVAs and these were nearly all (97%) 'lose control' accidents.

A year-by-year analysis covering 1994 to 2001 failed to show any significant differences across these years. The lowest percentage of fatal traffic accidents involving impaired drivers occurred in 1996, when 15.3% of the accidents involved drivers who tested positive for alcohol or drugs. The highest percentage occurred in 1995, when 22.8% of the accidents were alcohol or drug related. There were insufficient cases available for the years 2002–05 to draw any meaningful conclusions.

When days of the week were examined, there appeared to be more accidents on a Monday due to the fact that many of these accidents occurred as a result of people drinking on a Sunday. This increase as the week progressed suggested that drivers were drinking more towards the weekend and were consequently more likely to drink and drive and become involved in an accident. Comparing the lowest and highest results clearly demonstrates this. On Tuesdays a total of 140 accidents occurred across our sample, of which only 9% involved drivers that were found to be driving under the influence of drink and/or drugs. In contrast, 179 accidents occurred on a Sunday and, of these, almost a third (31%) involved impaired drivers.

Time of day analysis showed many alcohol- or drug-related accidents occurred, somewhat unsurprisingly, late at night or in the early hours of the morning. The percentage of impaired drivers within each time band increased with time, reaching a peak in the 2 a.m. to 4 a.m. time band. There were very noticeable increases after 8 p.m. Between the hours of 8 p.m. and 4 a.m. accidents involving impaired drivers accounted for over 40% of the total number of accidents. There was a significant drop in the number of accidents involving impaired drivers in the remaining period between 4 a.m. and 8 p.m. Of these accidents, only 8% involved a driver under the influence of drink or drugs.

Driver age also affected the probability of a driver being under the influence of drink or drugs when involved in a fatal traffic accident. As age increased there was a general tendency for the proportion of accidents involving impaired drivers to fall. The attitude of some younger drivers was demonstrated by comments made by two of them. Both accidents involved a 19-year-old male who was to blame for the accident and found to be over the legal limit. In both cases their front-seat passenger died as a result of the driver losing control on a right-hand bend. One of the drivers clearly knew he had done wrong, as he said:

‘I know I shouldn’t have been in the car and I had no licence and I’d had too much to drink but I still did it. It’s just one of those stupid things that you do.’

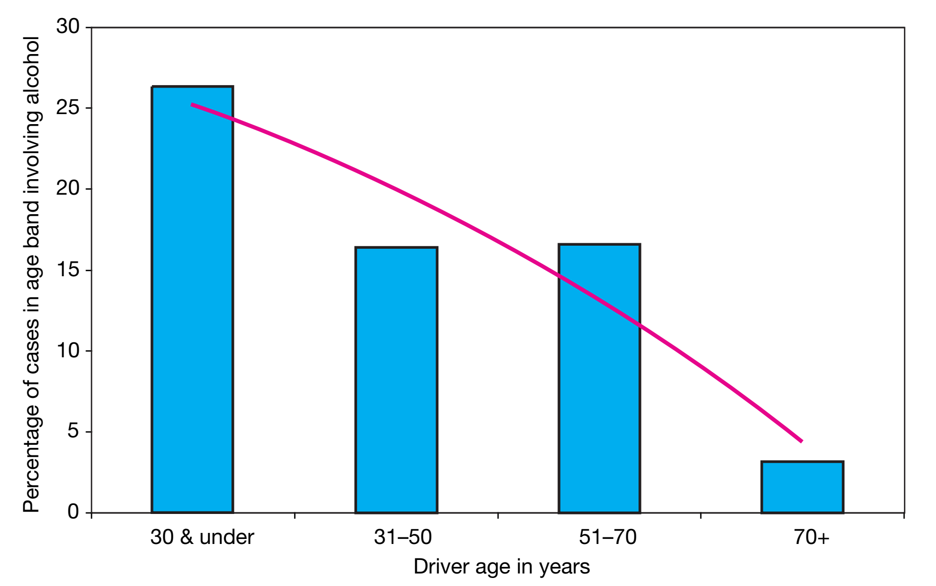
The other case involved a driver who appeared to have no concept of what a ‘safe’ amount of alcohol was, and claimed he had:

‘Only had three pints … and a couple of lines.’

Both drivers were charged with causing death by dangerous driving, jailed for approximately five years and banned from driving until they undertook an extended re-test.

An examination of four age groups covered by the sample showed the general downward trend in the data (Figure 2). Age bands were grouped together in large sets to remove apparent variations caused by small numbers of accidents in individual bands, particularly in the latter age groups.

Figure 2 **Percentage of accidents involving drivers impaired by alcohol and/or drugs, as a function of age**



Over a quarter (26%) of accidents with drivers aged under 30 involved a driver who was to blame for the accident and found to be under the influence of drink or drugs. In the age group 31–50, by contrast, only 16% of accidents involved impaired drivers, and similarly 17% of accidents in the age band 51–70 involved impaired drivers. This proportion fell very dramatically with elderly drivers. Only 3% of the accidents in this age group involved a driver impaired by alcohol and/or drugs.

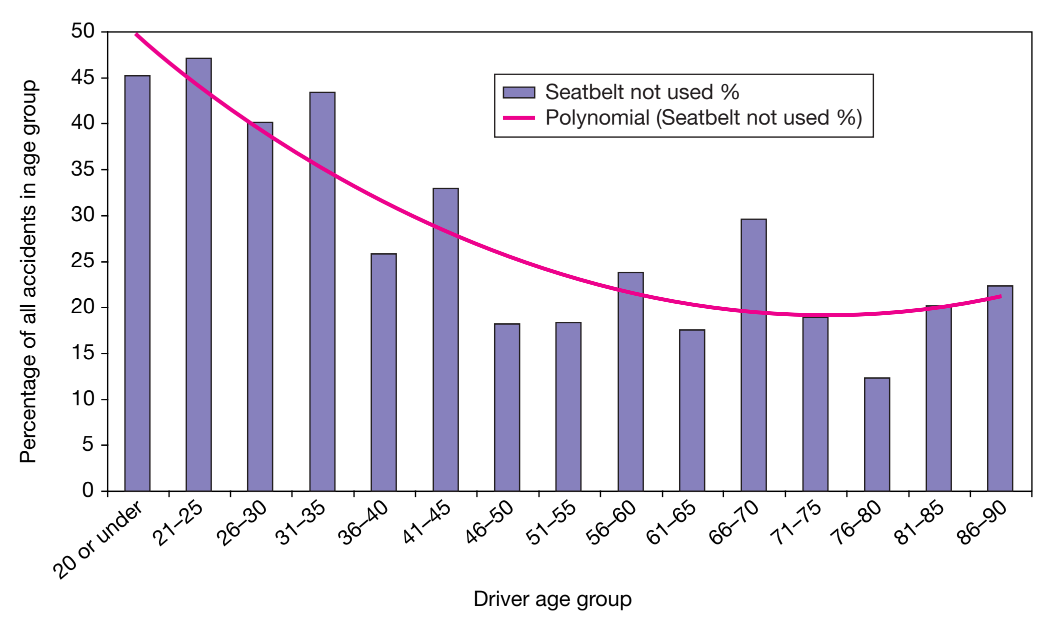
# Non-seat-belt wearing

399 cases (34%) involved a fatality **not** wearing a seat belt. 588 cases (50%) involved a fatality who **was** wearing a seat belt. The remaining 16% of cases occurred where seat-belt use was either 'unknown/unrecorded' or 'not applicable' (e.g. rear seats in pre-1987 cars).

Eight-five per cent of fatalities not wearing a seat belt were either driving or travelling in the front passenger seat. Fatalities were not wearing seat belts in 58% of accidents involving a rear-seat death.

Figure 3 shows that the percentage of accidents where the fatality was not wearing a seat belt fell with the age of the car driver, but still remained quite high throughout all age ranges. A second order polynomial curve has been added to Figure 3 to show the pattern of the drop from the peak of 45–48% of fatalities in the two youngest driver age groups who were not wearing a seat belt.

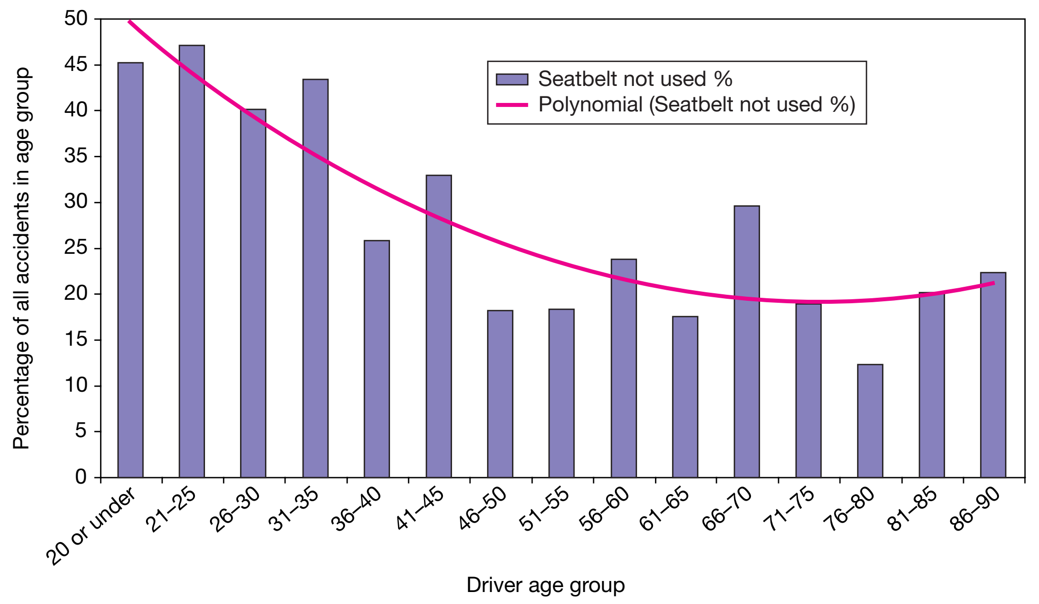
Figure 3 **Percentage of fatalities not wearing seat belts by driver age**




# Right of way violations

Fatalities resulting from drivers engaging in ROWVs formed approximately 16% of the total sample. The mean age of drivers at fault in these cases was significantly

Figure 4 **Percentage of ROWV accidents by driver age (all at-fault drivers)**




greater than the mean age of drivers in all other accidents in the sample (mean age 57 years, as opposed to mean age 37 years; $p < 0.01$). Seventy per cent of fatal ROWV accidents occurred in rural areas, which was perhaps a result of the higher speeds attainable by drivers on rural than urban roads.

Figure 4 clearly shows a rise in the proportion of ROWV accidents with driver age, and the greater part of this rise occurred after the age of 65 years. When fatal ROWV accidents caused by drivers aged 65 years and over were examined, over 70% of them involved a driver that 'looked but did not see' (LBDNS) or, alternatively, seemed not to have looked in the relevant direction at all before the crash.

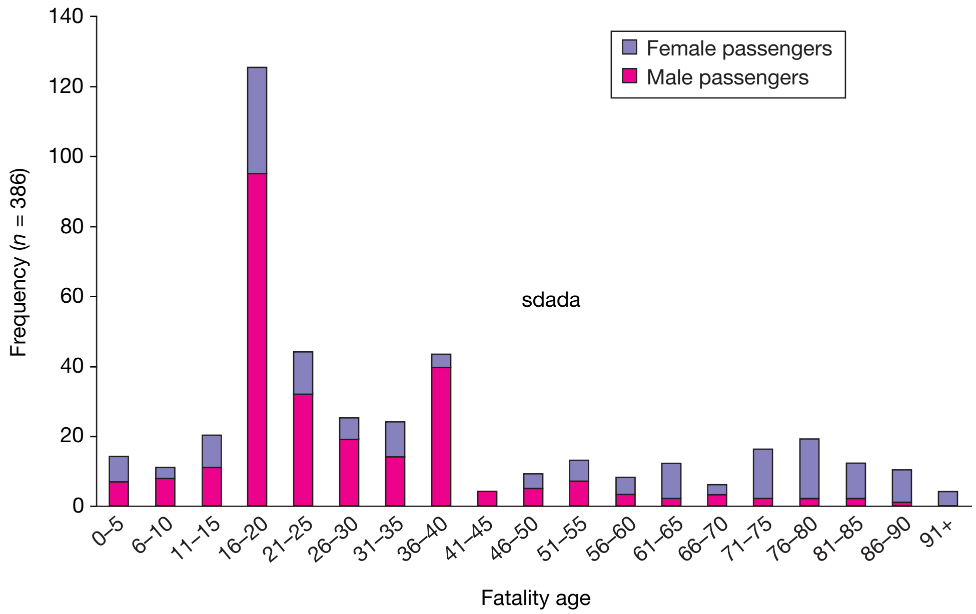
Fatal ROWV accidents considered as a whole appeared to be more frequent during daylight (68% in daylight conditions). 'At-fault' drivers aged 65 years and over had 83% of their ROWV accidents during the hours of daylight. The most common manoeuvre in the older group was a right turn onto another road, typically on a rural road. This commonly put the first point of impact at the driver's door, which is a relatively weak part of the car when compared to the crumple zone that typically protects drivers in a frontal collision. As with the bend accidents discussed above, side impacts have been found to cause twice as many fatalities as frontal impacts (e.g. by Bédard *et al*., 2002)

# Passenger fatalities

Figure 5 shows the frequency distribution of passenger fatalities in the sample by age and sex.

The highest incidence of passenger fatalities involved 16–20-year-old males. Fifty-eight per cent of these casualties were not wearing seat belts. They were usually travelling with a slightly older driver (mean driver age for this subset was 21 years, as opposed to the mean passenger age of 18). The majority (68%) of this subset

**Figure 5 Passenger fatalities by age and sex**




involved deliberate excessive speed by the driver concerned, and 36% involved deliberate recklessness, such as racing.

The drivers in this subset were almost always assessed as fully to blame for the accident. The driver was regarded as fully to blame in 95% of this subset, as opposed to 79% in the sample as a whole.

There was some evidence of a ‘commonality of behaviour’ between drivers and passengers, so if a driver had been drinking, taking drugs or not wearing a seat belt, it was likely that the passenger(s) had also been drinking, taking drugs or not wearing a seat belt. More than half of the group where the passenger was not wearing a seat belt also involved a driver not wearing one. The extent of this phenomenon was hard to quantify for actual levels of drink/drugs consumed, as it was rare to see a toxicology report on a passenger, but was reasonably common for a driver.

This 16–20-year-old passenger group had a peak in their accident involvement late in the evening, with the highest percentage of accidents occurring between 10 p.m and 2 a.m. This four-hour period accounted for 37% of all 16–20-year-old passenger fatalities. It is suggested that the 16–20-year-old male subset of passenger fatalities may have been essentially ‘younger versions’ of the drivers with whom they became involved in accidents. Two-thirds of the cases in this subset seemed to involve driving for what might be described as ‘recreational’ purposes, and over half involved a car that could be described as a ‘performance’ model (usually denoted by a variety of suffixes such as GTi/GTE/Turbo, etc.) To an extent, this group of 16–20-year-old male passenger fatalities appeared to have been travelling with drivers who were strikingly similar to a sub-group of drivers identified in the University of Nottingham’s previous ‘young driver’ study (Clarke *et al*., 2002).

# Discussion

This sample of fatal cases suggested two main problem areas. The first, and apparently bigger problem, concerns the behaviour of younger drivers and their passengers, who take more risks and travel at the highest speeds. They show a particular propensity for loss of control accidents on bends. It would seem that younger drivers in fatal accidents are ‘violators’, as described in the work of Reason *et al*. (1990).

The average level of blood alcohol found in impaired drivers who caused fatal accidents was over twice the current legal limit. This suggests that these drivers are not simply miscalculating their level of intoxication and ability to drive, having erroneously assumed that they were under the limit, but rather that they took a deliberate decision to drive while they knew themselves to be intoxicated.

Many fatalities in the sample were not wearing seat belts. This seemed to have been a particular problem with in-car fatalities where the driver was aged under 35 years, but there remained a high level of non-seat-belt wearing by fatalities throughout all age groups of driver. The DfT gives a figure of over 90% for drivers and front-seat passengers’ seat-belt usage, and 66% for rear-seat passengers (‘THINK!’ statistics; Department for Transport, 2004), so it would seem that non-belt wearing is much more prevalent in fatal accidents than it is in the general driving population.

‘Looked but did not see’ (LBDNS) fatal accidents appeared to show a similar pattern of accident causation to that found in accidents of all severities where older drivers have pulled out in front of motorcyclists (Clarke *et al*., 2004). There appeared to be little or no explanation for why a driver had failed to see another vehicle that should have been in plain view. The increased proportion of ROWV accidents found with age occurred at too great an age (65 years plus) to have been related purely to driver skill factors, which suggests an age-related deficit.

There are many possible reasons for such an increase in global visual defects with age. Isler *et al*. (1997) analysed the effect of reduced head movement and other deteriorations in the visual system on the useful field of view for drivers aged 60 years plus, and found that there was an evident restriction on the distances at which approaching traffic could be brought into the central, stationary field. Even at maximum head rotation plus one saccadic eye movement, approaching vehicles would not be clearly perceived beyond a distance of 50 metres. They also pointed out the large number of visual deficits, such as scotomata, that occur naturally with ageing, and may not be appreciated by drivers owing to their gradual onset. This is an area of potential concern due to the aging population of the UK and of the European Union as a whole.

# Conclusions

The unholy trinity of speed, alcohol and lack of safety restraint was a factor in nearly two-thirds of the fatal accidents examined in this study. These are all factors that have been subject to both legal sanctions and extensive campaigns in the past (such as the Department for Transport's 'THINK!' campaigns on seat belts, drink-driving and speeding in current and recent years). It would seem that, in the case of fatal accidents at least, certain groups of drivers cannot be told often enough of the dangers to which they can expose themselves and their passengers.

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# 2

# A critical review of SARTRE

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## Introduction

SARTRE (Social Attitudes to Road Traffic Risk in Europe) is a questionnaire-based research project conducted by a consortium of European researchers across participating countries at three different time periods. Its main aims were:

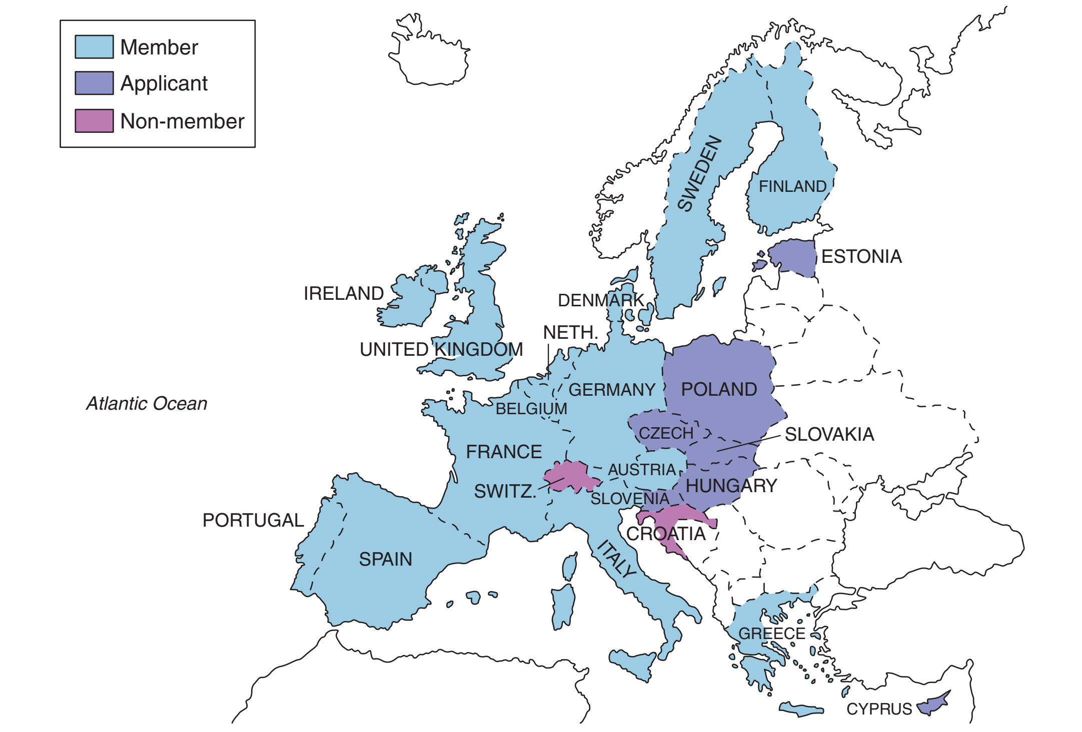
- to measure car drivers' reported behaviours and attitudes;
- identify the range of support for traffic regulations and safety measures; and
- search for underlying social and cultural factors that might influence road behaviour (SARTE 3 consortium, 2004).

The research design enabled comparisons between the participating countries and, separately, with a European 'average' as well as the measurement of change across time. This paper will review the methodology involved, compare some of the UK reported behaviours against actual observed behaviours, identify some interesting trends that have not previously been reported, and comment on the overall utility of the data produced.

The first SARTRE survey was conducted between October 1991 and June 1992, across 15 countries, 10 of which were members of the European Union at that stage. The second was undertaken from October 1996 to April 1997, across 19 countries. The third (subsequently referred to as SARTRE 3) was completed between September 2002 and April 2003, and was expanded to include 23 countries as depicted in Figure 1. Fifteen of the countries were members of the European Union, seven were 'applicant' countries at that stage (and have since become full members), while two were non-members.

The specific timing of each survey in the series is important, since events in the different countries may well have had an impact on drivers' attitudes. For example, in Ireland the third SARTRE survey coincided with the introduction of a licence

Figure 1 **Countries participating in SARTRE 3 identified by status within the European Union during the timing of the survey (September 2002 to April 2003)**




penalty points system. During this period there was an increased compliance with traffic laws and reduction in road fatalities to a 38-year low (NSC, 2006).

# Methodology

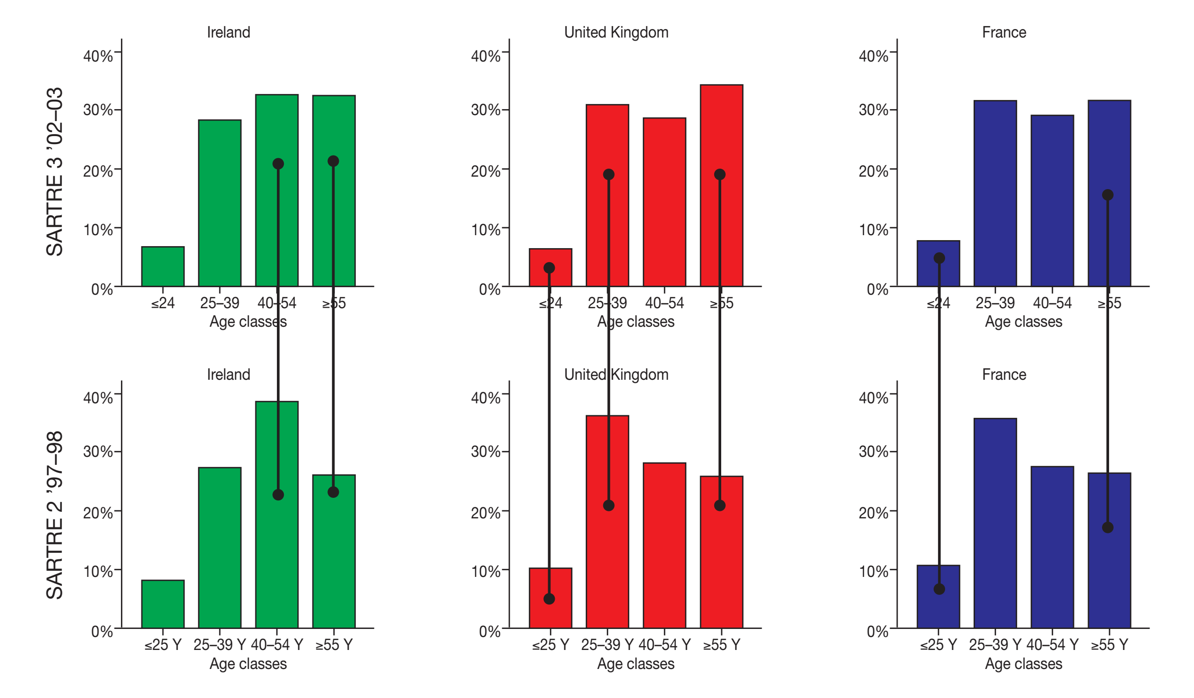
With any questionnaire-based research, two important factors govern the validity of the research, notably the sampling methods used and the interpretability of the questions.

## Samples used

Across all time periods and countries a sample of 1,000 respondents was considered optimal. This target number of respondents meant that the sample represented a different percentage of the driving population in each country, with smaller countries having larger representations. For example, the Estonian sample represented $2.5 \times 10^{-3}$% of the 0.4 million estimated driving population, while a similar sized sample in Germany only represented $2.2 \times 10^{-5}$% of the 45.6 million estimated drivers.

The actual sampling methods used appear to have varied across countries, although this is difficult to verify due to the non-standardised descriptions given by each country. Most countries used stratification of some sort. For example, the Czech Republic used random sampling stratified by region, gender, age, occupation and education. The French and UK samples included all of these strata, except for education. Many samples were created using stratification based on region only, for

**Figure 2** **Breakdown of samples across the four age-categories for three selected countries**




example Croatia, Finland, Greece, Poland and Spain. In other countries, stratification was not used, with simple random sampling being utilised instead (e.g. Denmark and Germany).

Going beyond sampling methods, it is possible to compare how the respondents are distributed across the different strata that have been used. Figure 2 depicts three countries (France and Ireland were chosen due to their geographical closeness to the UK) and illustrates how their samples were distributed across the four age-bands during both the second and third SARTRE surveys.

Just as the average age of a population differs between countries, so the age of the driver populations should also differ. Since samples reflect the parent populations, it is not surprising that the distributions across these three countries should differ. A more pertinent comparison relates to possible changes between the samples produced from a specific country across the second and third versions of SARTRE. Using a chi-square test of independence, it can be determined whether the distribution of respondents across the four age-categories differs between the two time-periods. For all three countries these differences were significant [Ireland, $\chi^2(3, n = 2{,}072) = 14.47$, $p < 0.01$; UK, $\chi^2(3, n = 2{,}266) = 29.24$, $p < 0.001$; France, $\chi^2(3, n = 2{,}011) = 12.26$, $p < 0.01$]. Using a chi-square goodness of fit test it can further be established in which age categories there were statistically significant differences between the two surveys. Such differences are depicted by the black lines in Figure 2. Essentially, for all three countries the samples are older in the third survey as can be depicted by the mean age. For Ireland this increases from 45.20 years ($SD = 14.24$) to 46.64 years ($SD = 14.97$), while for the UK it increases from 43.89 years ($SD = 15.71$) to 47.16 years ($SD = 15.91$) and for France from 43.57 years ($SD = 15.02$) to 46.05 years ($SD = 15.88$). The implications of these differences is that any change in attitudes within a country between the second and third survey needs to be interpreted in light of the fact that older drivers tend to be more conservative and compliant with respect to regulations (Evan, 1991).

A similar analysis conducted on the distribution of respondents across the 11 occupation categories shows that for each of the **three** countries the samples differ between the two times periods [Ireland, $\chi^2(10, n = 2{,}063) = 41.99, p < 0.01$; UK, $\chi^2(10, n = 2{,}256) = 29.80, p < 0.01$; France, $\chi^2(10, n = 2{,}011) = 44.0, p < 0.001$]. The differences are too numerous to list here. However, it is important to note that, consistent with the finding above, as these samples are becoming older there were significant increases in the number of retired respondents between the second and third surveys for all three countries. It is also important to clarify that this analysis merely indicates that for the three countries chosen, the samples are getting older. These countries are not meant to be representative of what is happening across the remaining 20 countries, some of which may well have driver populations that are getting younger. The important issue is that, if comparisons are being made between the different surveys, it is necessary to establish whether the samples themselves might be influencing the results through changes in demographics such as age and occupation.

# Data collection

The collection of survey data poses numerous challenges. The first is that certain criteria must be established with which a respondent must comply in order to be included. In this instance drivers were only included if they had a full driving licence, thus excluding unlicensed drivers. This is unlikely to be problematic in the UK given that the proportion of total driving hours per month that can be accounted for by unlicensed drivers is estimated to be between 0.19 and 0.64% (Knox *et al*., 2003). However, it does become problematic in a country such as Ireland where the proportion of provisional licence holders is just under 17% of the driving population (DoE, 2003). This problem is exacerbated by the fact that such drivers are the ones most likely to participate in risky or inappropriate driving behaviour. The second challenge is that the surveys were conducted in the respondents' own homes. This means that individuals who are frequently away from home, such as long distance lorry drivers, are likely to be under-represented in the sample. The third difficulty is that the nature of the face-to-face interview used to collect the data is likely to produce socially desirable answers and therefore make the results look more conservative than they might otherwise have been (Paulhus, 1991). Of these three problems, only the first was not recognised by the SARTRE consortium (SARTRE 3 consortium, 2004).

# Difficulties with questions

Clark and Schober (1992) give a good account of the inherent difficulties in trying to produce the optimum wording of survey questions: 'Surveyors cannot possibly write the perfect questions, self-evident to each respondent, that never need clarification' (p.29). Having said this, three main types of difficulty with the SARTRE questions remain. The first relates to translation issues, the second to the interpretability of the question unrelated to language issues, while the third relates to the response options given. Conducting a survey across 23 European countries is inevitably going to cause translation difficulties. The SARTRE 3 report states that 'coherence verifications' (2004; p.21) had to be made for several countries, indicating that local changes were required to make the questions easier to understand and to ensure that they did not appear insulting to the respondents. The report further states that 'no systematic back-translation test was conducted' (2004; p.21). This suggests that if surprising differences were found between countries then it would be essential to establish whether different language versions of the questions might have contributed to these differences.

With regard to the interpretability of the questions, some required further qualifications before their meaning became clear. For example, one of the questions relating to alcohol consumption asks 'How many days a week do you drive after drinking even a small amount of alcohol?' The question cannot be answered meaningfully because the period between cessation of alcohol consumption and the start of driving is not stipulated. Furthermore 'a small amount of alcohol' is not defined and, therefore, is open to subjective interpretation. It is therefore conceivable that someone who finishes a glass of wine four hours before driving may give the same response to the question as someone who drank three pints of larger just before stepping into their car. Both of these acts have very different consequences on driving ability and, since the question cannot differentiate between them, the interpretability of the data is necessarily compromised. Similar difficulties occur in other questions that also require subjective interpretation. For example, the question 'On a typical journey, how likely is that you will be checked for speed?' again requires the respondent to make a subjective interpretation, this time as to what constitutes 'a typical journey'. The result will be ambiguity in the mind of the respondent, thus reducing the validity of the answers given.

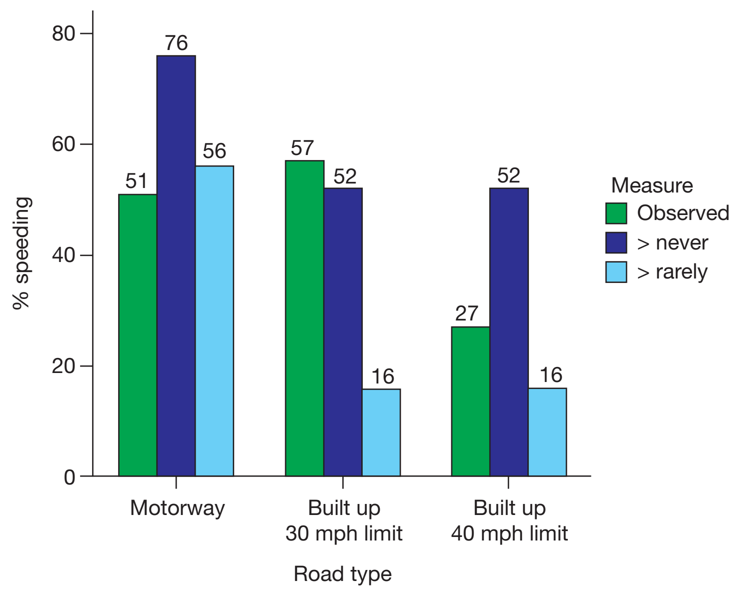
A further issue relates to the response options provided for some of the questions. For example, in questions that related to how frequently the respondent speeded, one of the responses was 'always'. Clearly no matter how aberrant one's behaviour, it is physically impossible to speed all the time one drives. The fact that 3.9% of the UK sample and 5% of the entire sample for all 23 countries chose this option when asked about their prevalence of speeding on motorways demonstrates that some respondents will choose responses that are logically impossible. It should be noted that this does not make the results of these questions uninterpretable, since the answer can be taken as meaning 'very often' which was the adjacent response on the Likert scale. Similar difficulties arose with questions which tried to identify beliefs about causes of accidents. For example, the question that tried to elicit how often respondents believed speed contributed to accidents also had 'always' as a response option. It is impossible for any one factor always to be implicated in the cause of an accident and therefore 'always' should not have been included as a response option.

# Comparing reported behaviours to objective measures of the same results for UK data

The SARTRE surveys are a rich source of data relating to reported driving behaviours. Where possible, there is value in comparing these reported behaviours to measures of actual behaviours. The expectation is not that these two measures will give the same results. Indeed, the most interesting findings may come from the differences found. Such comparisons can be made in relation to seat-belt wearing and speeding. For example, respondents were asked how often they wore their seat belts on each of four road types (motorways, main roads between towns, country roads and built-up areas). When these responses are averaged across all four road types for the UK respondents, the number who indicated that they 'always' wore their seat belt was 92.8%, which compares very favourably to the 91% figure quoted in the comparable *Think!* 2003 road statistics (Think!, 2003). The reported behaviours relating to speeding do not compare so favourably.

Figure 3 represents the reported speeding behaviour across two roads types, motorways and built-up areas. It further depicts the actual instances of speeding which have been calculated from the annual speeding statistics (DfT, 2003).

Figure 3 **Comparing reported speeding behaviour with actual speeding behaviour across two different road types**




The interesting aspect of these data is not that actual and reported behaviours are different but that the difference between them is dependent on road type. Taking motorways first, the actual percentage of vehicles breaking the speed limit (labelled 'observed' in Figure 3) is estimated to be 51%. For the reported behaviour, if we exclude only those participants who indicate they never speed, the figure for breaking the speed limit is 76%. It could be argued that excluding only those people who indicate that they never speed is quite conservative and that, in fact, respondents who indicate that they rarely speed should also be excluded. If this approach is adopted, the figure for reported speeding decreases to 56%. This is closer to the actual figure of 51%, leading to the interpretation that reported speeding behaviour is just slightly above actual speeding behaviour. However, when looking at the data for built-up areas with a 30 mph limit, the pattern is quite different. The actual speeding behaviour has been estimated at 57%. For the reported behaviours, if we exclude only those respondents who indicate that they never speed in built-up areas, we are left with 52% that do. However, if the data are treated in the same way as for motorways, such that respondents who indicate that they rarely speed are also removed, then the percentage reporting that they speed drops to 16%.

Clearly the patterns across the two road types are different. On motorways, reported speeding is in excess of actual speeding, while in built-up areas (with 30 mph limits) reported speeding is below actual speeding. Two possible explanations can be offered for this. Either speeding in built-up areas is less morally acceptable to admit to, or many motorists are breaking the limits in these zones without actually knowing it. This pattern is slightly disrupted when built-up areas with 40 mph limits are considered. The SARTRE survey did not make a distinction between built-up areas with different speed limits and therefore the comparison must be made to the generic built-up area with no specified limit. However, if all those individuals who indicated that they either 'never' or 'rarely' speeded are excluded, then the reported instances of speeding behaviour (16%) is still lower than that of the actual speeding (27%). It is also interesting to look at UK drivers' beliefs about how often they think other drivers speed (independent of road type). When the 'never' and 'rarely' responses are removed, 98.4% of drivers indicate that they think other drivers speed. It is obvious that the observed data do not corroborate this. It appears, therefore, that others' speeding behaviour is much exaggerated in most people's eyes.

# Investigating beliefs

The SARTRE surveys are also a rich source of data on beliefs about issues such as the legal blood alcohol limit (BAL) and the causes of road accidents. These beliefs are particularly interesting because, in the case of BAL, they can be compared across gender and countries which have the same legal limit. In the case of causes of road accidents, comparisons can be made to research findings. It should be stated that since blood alcohol concentration (BAC) depends on many factors such as gender, weight, age and health, the amount of alcohol required to put someone over the legal limit is unique for every individual and can vary across time. The consequence of this is that the legal BAL cannot be communicated precisely in terms of quantity of alcohol consumed with the result that there is likely to be some confusion surrounding the issue within the general public.

In SARTRE 3, the respondents were asked 'In your opinion, how much alcohol can we drink before driving and still remain under the legal limit?' The answers given by each respondent were subsequently converted into units by the interviewer. In the UK, the mean response for males was 2.02 units with the 95% limit for the driving population as a whole ranging from 1.94 to 2.12. For females the value was lower at 1.80 (1.75, 1.85). From a communication perspective, these data at least indicate that the influence of gender on BAC has been assimilated by UK drivers. It is useful to compare these figures with those from another country that shares the 0.8g/l blood alcohol limit presently in place in the UK. In 2003, one such country was Italy where figures for males and females were 3.32 (3.24, 3.40) and 3.10 (3.03, 3.17) respectively. This indicates that Italians think that they can drink more and remain under the legal BAL. Although possible, it is highly unlikely that this is caused by a difference in tolerance levels. One conclusion, therefore, is that the information available relating to the legal BAL (or lack of) in these two countries is having a differential impact on their citizens' understanding of the legal BAL.

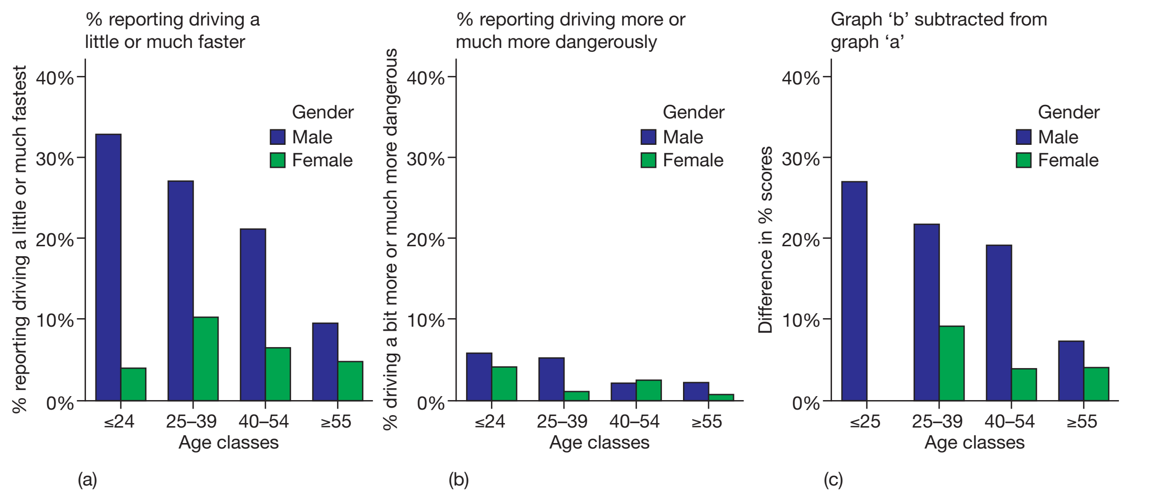
Turning to the causes of road accidents, respondents were asked 'How often do you think each of the following factors are the cause of road accidents?' A number of potential contributory factors were then rated on a six-point scale that ranged from 'never' to 'always'. For the UK respondents, the top three ranked ordered contributing factors to road accidents were drinking and driving, driving too fast, and following too closely to the vehicle in front. These three factors were also selected by the overall SARTRE 3 sample in this order. However, at least one piece of research evidence indicates that the actual picture is somewhat different. Mosedale *et al*. (2004) identified the percentage of road accidents that involved different contributory factors. These data suggest that by far the biggest contributory factor was not in fact drink driving but speed. It found that in 12% of accidents speed was a contributory factor, while in 23% of accidents failure to judge someone else's path or speed was identified as a contributing factor. Although the latter figure includes a component unrelated to speed, it is evident that these figures suggest that speed is a contributory factor on more that 12% of road accidents. This can be compared to the finding that only 6% of accidents were contributed to by impairment due to alcohol. These findings suggest that speed is a much bigger problem than drink driving, yet the UK driving public's beliefs do not reflect this difference. Two further points are worth making. Firstly, the Mosedale *et al*.'s data also indicate that the second highest contributory factor is bad weather (with slippery roads contributing to the 8% of accidents and weather such as mist or sleet contributing to 2%). In the SARTRE 3 data, bad weather is ranked ordered as the ninth most frequent contributor to road accidents. Again, beliefs seem to be inconsistent with the emerging evidence. Secondly, the Mosedale *et al*.'s data identify many other causes of road accidents that are not addressed by the SARTRE questionnaire. These data indicate that inattention contributed to 25% of accidents, while careless behaviour contributed to 18%. This suggests that if the SARTRE questionnaire is to properly evaluate drivers' beliefs about the causes of road accidents, the number of factors covered by the questionnaire needs to be extended.

# Selected findings

During the lifetime of the project the SARTRE data have yielded a wealth of findings. A few examples pertaining to the UK will be expanded upon here that have not, to our knowledge, been documented elsewhere. The dissociation between reported speeding behaviour and reported dangerous driving has been demonstrated for the entire SARTRE 3 sample (Quimby, 2005). For example, Quimby highlighted that although 14% of UK respondents indicated that they drove 'a little' or 'much faster' than other drivers in the UK, only 3% indicated that they drove 'a bit more' or 'much more dangerously'. The implication of this is that many drivers do not consider their own speeding to be dangerous. It is interesting to look at the UK data broken down by gender and age category as is done in Figure 4.

Graph 'a' in Figure 4 depicts the percentage of respondents who report driving 'a little' or 'much faster' than other drivers. It conveys that this is much more prevalent among males and that it decreases from 32% within the under-24 age category to 10% for the over 55s. When the reporting of driving 'a bit more' or 'much more dangerously' than other drivers is considered (graph 'b') the instances are much lower. The effect of gender is much less clear and there is only a slight impact of age, such that reporting decreases with age. If graph 'b' were subtracted from graph 'a', a potential depiction of those drivers who think their speeding is unrelated to

Figure 4 **Instances of reported speeding and dangerous driving**

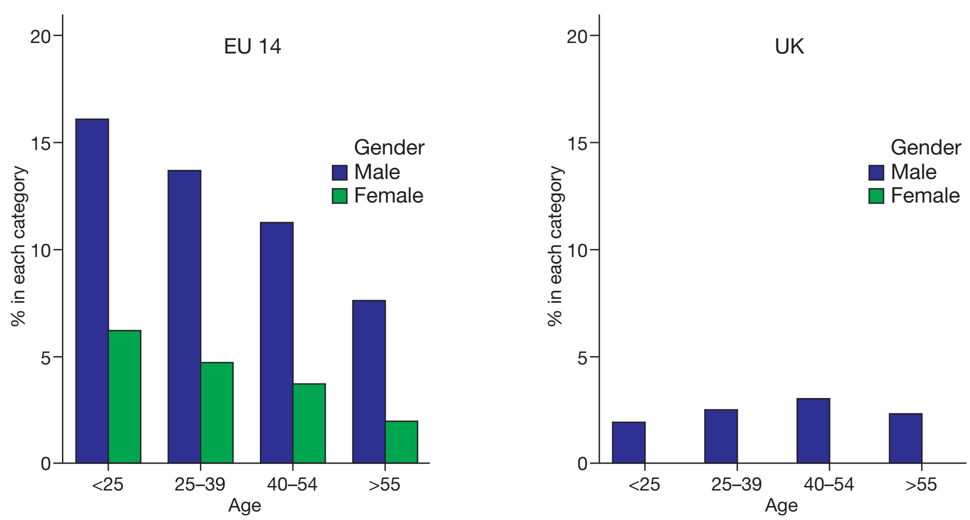



dangerous driving is obtained and is presented in graph 'c'. Here the patterns of age and gender are very clear. It is more of a problem for males and one which decreases with age. Worryingly, it is not just a phenomenon associated with young males, since the figures are high among both the 25–39 age category (22%) and the 40–54 category (19%).

Further interesting findings relate to reported instances of driving while over the legal BAL. Figure 5 depicts the percentage of respondents who report driving while they may have been over the legal limit for drinking and driving in the previous week more than zero times (includes respondents who chose less than one but not zero). The left graph depicts the trend for the 14 countries with full member status at the time of SARTRE 3 while the right graph represents the pattern for the UK.

Figure 5 indicates that within Europe there is a definite problem with drinking and driving while over the legal limit. However, this needs to be interpreted in light of

Figure 5 **Percentage of respondents, broken down by age and gender, who report driving while over the legal limit at least occasionally**



the fact that most of the countries (with the exception of Italy and Ireland) have lower BALs than the UK. The implication is that, in Europe, the more stringent laws are more difficult to comply with. The pattern in Europe indicates this behaviour is reported more by males and decreases with age. In the UK, the numbers are too small to identify a clear pattern. What is clear is that no females report this behaviour and that all age categories of males are likely to report this behaviour.

# Conclusions

Given that there is likely to be a SARTRE 4, some important conclusions can be reached from this review.

- The sampling difficulties identified create some problems for comparisons across time and country. However, these are likely to be small. From a practical perspective, it is unlikely that one company could be sourced to undertake the data collection in all the participating countries. Nonetheless, it should be possible to give specific instructions on how the sample should be obtained, for example stratify according to age, region, gender and occupation, thus creating more uniformity in the sampling methods.

- Some of the questions need to be changed. Although changes have occurred across the three surveys, many difficulties still remain and these need to be removed. There is no point in being able to compare responses across different time periods when the responses themselves have no validity.

- SARTRE remains a good source of data for reported behaviours and research should continue to try to determine why it is that for some measures there are such deviations between reported and actual behaviours.

- SARTRE gives a good insight into beliefs about issues such as the causes of road accidents. With respect to this, it is important that the number of contributory factors addressed within the SARTRE questionnaire is expanded.

SARTRE has yielded some valuable findings relating to the reported behaviours and attitudes of European drivers. When interpreting these data one should always bear in mind the potential weaknesses that are inherent in this research. Nevertheless, this should not prevent one from using the data to produce informative findings. With respect to SARTRE 4, simple changes can be made to the process that would improve many of its aspects, thus producing data with more validity and potential utility.

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# 3

# Interventions to promote safe driving behaviour: lessons learned from other health-related behaviours

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## Introduction

In this presentation we examine the utility of interventions that address, or fail to address, relevant psychosocial targets of driver safety programming. By applying the empirical evidence gathered from years of intervention research in other health-related behaviours, we hope to identify new directions for developing practical driver safety programmes that are both effective and reach a large majority of those in need.

We examine two sets of psychosocial factors, described in greater detail in our earlier paper (Strecher *et al.*, 2006). The first set includes psychosocial factors that influence intention to drive safely and include perceived threat, affective beliefs, subjective norms, personality traits and identity. The second set includes psychosocial factors that inhibit the relationship between intention to drive safely and actual driving behaviour. We believe that these factors include difficulty of the specific driving task and habitual aspects of driving.

## Summary of relevant psychosocial factors

Table 1 presents our estimate of:

(a) the relative strength of the predictors of safe driving behaviour; and

(b) their respective utility in driver safety programming.

By 'programming utility' we are referring to either the potential of changing the predictor or of tailoring effective programming to the predictor. Rationale for these estimates are discussed in our previous paper (Strecher *et al*., 2006).

Table 1 **Psychosocial predictor strength and programming utility**

| Psychosocial predictor | Strength estimate | Programming utility | Programming focus |
|---|---|---|---|
| **Perceived threat** | High | Low | **Low** |
| **Affective beliefs** | High | High | **Moderate** |
| **Subjective norms** | High | High | **High** |
| **Personality** | High | High | **High** |
| **Identity** | High | High | **High** |
| **Task difficulty** | High | High | **High** |
| **Habit** | High | Moderate | **Moderate** |

We are therefore recommending that driver safety programming focus on subjective norms, personality, identity and task difficulty. We conditionally recommend a focus on affective beliefs and habitual aspects of safe driving behaviour. Finally, we do not recommend a focus on threat-based messaging.

# Intervention modalities

The utility of intervention modalities are examined with respect to their efficacy in addressing the psychosocial foci of the programme, but also in terms of their potential to reach a large proportion of the population in need, and their potential for adoption, implementation and long-term maintenance. These criteria are highlighted in the RE-AIM framework (Glasgow, 1999) and are described as follows (www.re-aim.org):

1 **Reach** – the absolute number, proportion, and representativeness of individuals who participate in a given initiative, intervention or programme.

2 **Efficacy/effectiveness** – the impact of an intervention on important outcomes, including potential negative effects, quality of life and economic outcomes.

3 **Adoption** – the absolute number, proportion and representativeness of settings and intervention agents (people who deliver the programme) who are willing to initiate a programme.

4 **Implementation** – at the setting level, implementation refers to the intervention agents' fidelity to the various elements of an intervention's protocol, including consistency of delivery as intended and the time and cost of the intervention. At the individual level, implementation refers to the clients' use of the intervention strategies.

5 **Maintenance** – the extent to which a programme or policy becomes institutionalised or part of the routine organisational practices and policies. Within the RE-AIM framework, maintenance also applies at the individual level. At the individual level, maintenance has been defined as the long-term effects of a programme on outcomes after six or more months after the most recent intervention contact.

# Mass communication

When used alone, mass communication modalities such as television advertisements or public service announcements (PSAs), billboards, radio announcements and social marketing campaigns demonstrate high reach, but limited, efficacy. The inability of mass communication messages to tailor health education messages relevant to individuals varying in educational attainment, socio-economic status and racial/ethnic identification limits the efficacy of this approach. Mass media appears to work better when used in conjunction with other prevention activities (Elder *et al*., 2004).

Mass communication modalities may be readily implemented once the communication materials are funded and created. The costs associated with high-quality mass media development, however, are extremely high. For television and radio, the costs of airing messages at specific times to the adolescent audience can be exorbitant. In other words, the costs of implementing and maintaining a television and radio campaign can be very high; the expenditure in human resources, however, is fairly low.

# Primary care providers

While adult-based smoking cessation and alcohol treatment programming by primary care providers has produced small but consistent effects (e.g. Ballesteros *et al*., 2004; Anderson and Jane-Llopis, 2004; Bertholet *et al*., 2005; Lancaster and Stead, 2004), interventions administered by primary care providers to adolescents have consistently demonstrated little or no effect. Reviewing medical or dental provider-based interventions for youth, Christakis *et al*. (2003) found very little evidence for short-term effects and no evidence for long-term effects. This is not surprising given the limited training and reimbursement health care providers receive for such counselling.

Inconsistencies in the delivery of messages create low fidelity in implementing preventive programming via health care providers. Poor implementation has been attributed to variations across providers' communication styles and to variations across patients' medical and behavioural risk profiles. Similarly, low maintenance may be observed if providers do not receive boosters, such as patient communication workshops and monitoring.

# Parents

Family dynamics and characteristics are related to driving as well as substance abuse behaviours, and therefore may be a relevant channel of intervention (Bingham and Shope, 2004; Ashery *et al*., 1998). In a large, well-controlled trial, Bauman *et al*. (1991) used a combination of health educator, tele-counselling and printed materials to successfully influence both tobacco and alcohol use among a national sample of 12–14-year-old adolescents. The intervention targeted a broad spectrum of possible predictors of substance use and communication, including risks substance abuse, normative beliefs, social support, and peer and media pressure. In addition, the intervention focused on family rules and sanctions related to substance use. Using a similar intervention strategy of nurse counselling (rather than health educators) and printed materials for parents, Werch *et al*. (2003) found significant reductions in drinking intention.

High reach and adoption rates in parent-delivered health education programmes, however, cannot be assumed. Parents may decide to not participate in health promotion activities or may lose interest during the implementation of a programme due to competing demands on their time (e.g. having a job or being the sole financial provider for a household; having more than one child to care for; participating already in extracurricular activities; caregiving an elderly family member; among others). The implementation of parent-delivered programmes may be inconsistent due to different parent–adolescent communication patterns, beliefs about youth autonomy and parental involvement in adolescents' decision-making, as well as in the synchronicity between what parents ask their children and how parents behave themselves. Finally, the maintenance of successful parent-led behaviour change programmes may have diminishing returns as the strength of parental advice may decrease as youth strive for greater autonomy.

# Peers

Peer-based health education programmes have found moderate to high reach in school and community settings. Meta-analyses of peer-led programming among adolescents demonstrate a small but consistent advantage over teacher-led, didactic programming (e.g., Posavac *et al*., 1999). Peer-led programmes generate greater rapport between adolescents and greater openness around sensitive topics than when addressed by an adult.

Peer-led programmes may face varying degrees of adoption barriers. Depending on the setting and outcome, peer-led interventions may encounter resistance from programme stakeholders. Similar to provider- and parent-delivered programming, peer-led interventions may suffer from inconsistent message delivery. Peer-education programmes supported by schools and community centres report moderate to high maintenance in their behavioural outcomes. Given the brevity of the school experience, however, there is invariably high yearly turnover between peer educators.

# Teachers

With the growing pressure to focus teacher attention on specific maths, science and reading skills, time and resources devoted to health promotion programming has dwindled. While offering high reach, school-based curricula, health promotion programmes have had difficulty getting adopted, implemented or maintained. Many school-based curricula, even when found to be effective in a research study, are unlikely to be implemented as intended. Teachers tend to minimise interactive experiences, even when part of the planned curriculum, in favour of more traditional didactic approaches (Ennett *et al*., 2003; Ringwalt *et al*., 2002).

A Cochrane meta-analysis of school-based smoking prevention programmes found mixed results: half of the best-designed studies failed to show an effect of the intervention. The well-designed and long-running Hutchinson Smoking Prevention Project found no differences in rates of smoking between intervention and control groups at eight-year follow-up. With the notable exception of Botvin's Life Skills Training (Botvin *et al*., 1995), effects of school-based curricula have been small (Ennett *et al*., 1994; Murry *et al*., 1988). Life Skills Training is a highly resource-intensive, comprehensive cognitive-behavioural programme.

# Theatre

This non-traditional educational method uses live drama to convey knowledge-, attitudinal-, environmental-, and skills-based messages in a vivid manner. Conveying messages through case histories and testimonials has consistently been found to be more vivid and persuasive than presentation through statistical or didactic methods (Taylor and Thompson, 1982). From a cognitive load perspective, messages linked to archetypal images and stories from abundant long-term memories, require less active processing of limited cognitive resources (Khalil *et al*., 2005). Moreover, children are involved in the development of the theatre stories, providing peer, coping modelling.

Theatre production has received little attention from researchers, though one study in particular stands out. Perry *et al*. (2002) evaluated theatre production for eating behaviour among children. The production messages focused on social cognitive factors 'that seemed most predictive of eating behaviours in elementary-aged children and most amenable to change' (p. 257). These included self-efficacy, knowledge, perceived benefits, perceived barriers and motivation to change. Social environmental factors included influence from peers and family. Using a delayed intervention design, significant improvements were found in knowledge, food choices and food recall.

## Interactive communications technologies

While still an emerging area, randomised trials of Internet-based programs have demonstrated positive results for:

1 smoking cessation (Strecher *et al*., 2005; Etter and Lazlo, 2005);

2 weight management (Williamson *et al*, 2005; Tate *et al*., 2003);

3 hazardous drinking (Kypri *et al*., 2004);

4 insomnia (Strom *et al*., 2004); and

5 multiple risk factors (Kypri and McAnally, 2005).

A number of these studies were conducted with adolescents and young adults (Williamson *et al*., 2005; Kypri and McAnally, 2005; Kypri *et al*., 2004). Johnson *et al*. (in preparation) used a randomised trial design to compare a tailored, interactive, story-based, Internet programme for asthma control ('Puff City') against a existing set of Internet sites for asthma control among African-American adolescents with asthma. At the 12-month follow-up, significant reductions in emergency room visits, hospital visits and absenteeism from school were found among subjects assigned to the 'Puff City' condition.

As a generation, adolescents and young adults are accessing the Internet as a tool in their daily lives, whether to communicate with one another, look for information, buy products, or keep track of their school assignments and financial records. Given the high proportion of adolescents with access to a computer terminal, computer-based modalities have the greatest potential to reach a high number of adolescents. Most costs associated with computer-based modalities occur during the development and initial implementation of the intervention. Computer-based health programs generally have high fidelity due to the scalability and stability of the programming.

# Recommended intervention modalities

The evaluation of population-based communications modalities by their potential for influencing recommended psychosocial targets is presented in Table 2. Psychosocial targets are divided into factors likely to predict safe driving intention, and those likely to inhibit the relationship between safe driving intention and behaviour. As stated previously, personality is not considered directly modifiable by any of the communications modalities examined. Messages can, however, be created that are tailored to personality traits. By 'utility' we are referring to either the potential of changing the predictor or the potential for tailoring effective programming to the predictor.

Table 2 **Utility of psychosocial target by communications modality**

| | Psychosocial target | | | | | |
|---|---|---|---|---|---|---|
| | Predictors of intention | | | | Intention-behaviour inhibitors | |
| **Modality** | **Affective beliefs** | **Subjective norms** | **Personality** | **Identity** | **Task difficulty** | **Habit** |
| **Media** | Moderate | Low | Moderate | Moderate | Low | Low |
| **Providers** | Moderate | Low | Low | Low | Low | Low |
| **Teachers** | Low | Low | Moderate | Moderate | Low | Low |
| **Peers** | High | High | High | High | Low | Low |
| **Parents** | High | High | High | High | Moderate | Moderate |
| **Theatre** | High | Moderate | Moderate | Moderate | Low | Low |
| **Computers** | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |

The evaluation of population-based communications modalities by RE-AIM criteria is summarised in Table 3. Please note that the 'Reach' and 'Efficacy' criteria of this summary have been based, when available, on empirical evidence. To evaluate less traditionally studied 'Adoption', 'Implementation' and 'Maintenance' criteria, we used a combination of empirical evidence, discussions with practitioners and our own experience.

Table 3 **Communications modality by RE-AIM criteria**

| | RE-AIM criteria | | | | |
|---|---|---|---|---|---|
| **Modality** | **Reach** | **Efficacy** | **Adoption** | **Implementation** | **Maintenance** |
| **Media** | High | Low | Moderate | Moderate | Moderate |
| **Providers** | Moderate | Low | Low | Low | Low |
| **Teachers** | High | Low | Low | Low | Low |
| **Peers** | High | Moderate | Moderate | Moderate | Moderate |
| **Parents** | High | Moderate | Moderate | Moderate | Moderate |
| **Theatre** | High | Moderate | Low | Low | Low |
| **Computers** | High | Moderate | Moderate | High | High |

What is the right programme modality for driver safety education? Our conclusion is that no single solution will be completely satisfactory. No single modality creates uniformly high efficacy in changing all relevant psychosocial predictors. No single modality completely addresses all RE-AIM criteria for long-term population-based health programming. More likely is that a judicious orchestration of modalities will produce the greatest impact on driver safety. We make the following recommendations:

1 While not evaluated in the driver safety area, we recommend that interactive computer technologies receive serious consideration as a new driver safety intervention strategy. Evidence supporting the efficacy of interactive computer programs in other areas is strong and growing. Moreover, this modality offers a very high reach to adolescents, and can be readily scaled to large populations with high quality.

2 Another recommended modality is parental-based interventions. These interventions have received strong initial support in driver safety and in both smoking and alcohol prevalence. Effects on behaviour from parental interventions are likely mediated by personality, identity, affective beliefs and subjective norms. This is clearly a high-reach intervention though adoption, implementation and maintenance on a large-scale need to be demonstrated. One option to facilitate adoption, implementation and maintenance is to integrate parental interventions with interactive computer technology (creating a tailored contract on the basis of an assessment completed by the novice driver and parent(s)).

3 We also recommend peer-based interventions, which have consistently demonstrated small but finite outcomes. Peers are probably most effective in addressing identity and social norms, both considered important predictors of safe driving behaviour. Again, while reach is high for these interventions, significant attention to implementation and maintenance (due to turnover through high school) is required.

4 We conditionally recommend mass media as a modality that can be effectively combined with other interventions. One-size-fits-all mass media interventions that run independently of other strategies have demonstrated little or no behavioural improvement. Moreover, the costs of developing high-quality mass media programming, combined with the very high costs of paying for specific segments of time on particular media channels, is prohibitive.

5 Theatre-based programming shows promise but has not been evaluated in the area of driver safety and has only been minimally evaluated in other areas. Theatre-based programming, however, has many appealing features, likely influencing identity, affective beliefs and social norms, and can probably establish vivid messages for sensation seekers. This type of programming, however, is very time consuming and is likely to have implementation and maintenance challenges. A recent guide supported by the Department for Transport provides excellent, detailed suggestions for adoption, implementation and maintenance.

There are two modalities that we are not recommending: the primary care provider and the teacher. With the exception of resource-intensive cognitive-behavioural curricula (e.g. Life Skills Training), these two communications modalities have consistently failed to demonstrate long-term effectiveness in randomised trials. These two professions are increasingly beleaguered by competing demands for their time; both professions also lack serious training in preventive health counselling.

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# 4

# Predictors of safe driving behaviour: towards an integrative model

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## Introduction

As part of a review of the traffic safety literature, we developed a conceptual framework of safe driving behaviour (Figure 1). This framework is not intended to supersede current models of driving behaviour; it is being used for the purpose of organising psychosocial constructs for review and discussion. The conceptual framework incorporates elements of Fuller's Task-Capability Interface (TCI) model (Fuller, 2005), Wilde's Homeostasis Theory (Wilde *et al*., 2002), Deery's model of crash risk perception (Deery, 1999), Bandura's concept of reciprocal determinism within his Social Learning Theory (Bandura, 1978), Fishbein and Ajzen's Theory of Reasoned Action (Fishbein and Ajzen, 1975), and Rosenstock's Health Belief Model (Rosenstock, 1974). The conceptual framework also includes a physiological perspective related to separate influences of neuroendocrine and pre-frontal cortical activity on psychosocial, judgement and decision-making constructs. The framework is examined for both adolescent/young adult drivers and for serious offenders.

# Conceptual framework of safe driving behaviour

## Behaviour intention – driving behaviour relationship

By ‘safe driving behaviour’ we refer to a set of practices, including:

- driving within the speed limit;
- non-aggressive manoeuvring;
- maintaining a safe braking distance;
- seat-belt use; and
- avoidance of driving when impaired by alcohol or other substances, or sleep deprivation.

If every driver who intended to drive safely actually did so, there would be no need to include the concept of behavioural intention in the framework. The utility of the conceptual separation between intention and behaviour is two-fold:

1. it also focuses attention on factors that get in the way of intention, such as the difficulty of the task or the habitual nature of the task; and
2. it focuses consideration on predictors of behavioural intention.

### INTENTION-BEHAVIOUR INHIBITORS: TASK DIFFICULTY

The interaction of driving ability and demands of the driving task expresses itself as task difficulty: the difficulty of driving the car in a safe manner. This concept is central to Fuller’s TCI model, a general theory of driver behaviour (Fuller, 2005). Task demands include actual hazards of the road as well as distractions such as mobile phones and other people in the car. Task difficulty moderates the likelihood that behavioural intention will result in actual safe driving behaviour. For example, an individual who intends to engage in safe driving behaviours, but finds the particular driving task exceptionally difficult (a function of the driving demand-ability interaction), will not necessarily drive safely. When task difficulty is low, the intention-behaviour relationship will be strong.

This relationship is similar to the intention-behaviour-perceived behavioural control relationships of the Theory of Planned Behaviour (Ajzen, 1985), and is strongly supported in other health-related behaviours. Web and Sheeran (2006) found that the intention-behaviour relationship is strongest among those with higher levels of self-efficacy. In other words, intention can be turned into action among those with high self-efficacy and skills.

Self-efficacy may be a two-edged sword in traffic safety, since overconfidence could lead to an underestimate of risk, resulting in reckless driving behaviour. On the other hand, enhanced self-efficacy may also lead to greater focus on implementing behavioural intentions. Since actual driving skills improve with age, it is likely that this mechanism would result in a stronger intention-behaviour relationship over time.

## INTENTION-BEHAVIOUR INHIBITORS: HABIT

Yates (1993) points out that, in many instances, unsafe driving behaviour may occur when no semblance of risk-taking is made. He uses the example of a person getting into a car who, with no consideration of risk acceptance,

fails to use the seat belt. Routines that become habituated with driving experience may have very little to do with the other processes presented in the conceptual framework. Regardless of whether a person intends or does not intend to drive in a safe manner, habitual processes, similar to thoughtlessly lighting a cigarette, supersede cognitive processing.

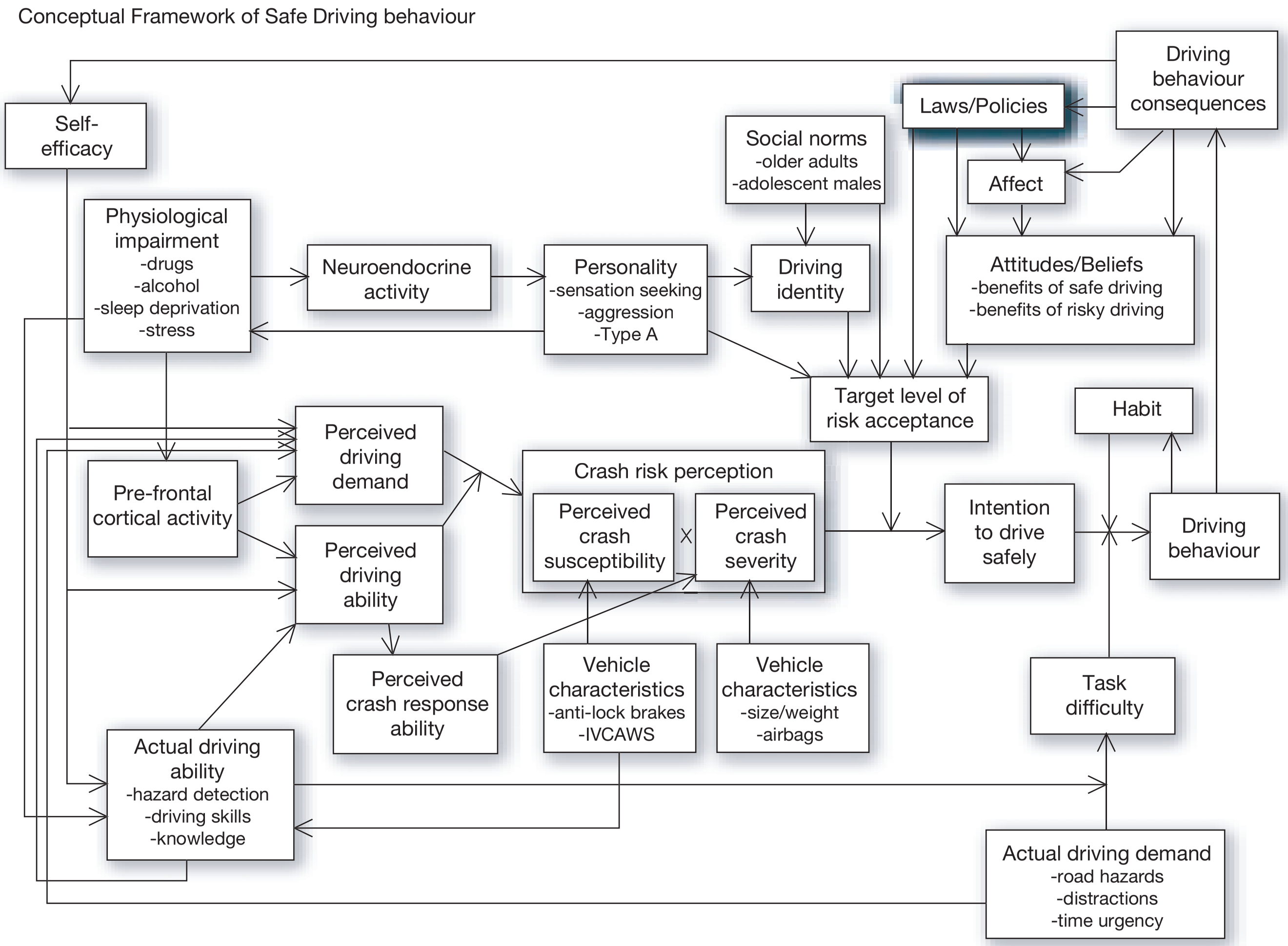
A large body of research in other behavioural areas now supports Yates' comments: that the relationship between intention and behaviour are not as strong among behaviours that are largely habitual, such as seat-belt use or cigarette smoking (Web and Sheeran, 2006; Wood *et al*., 2002; Ouelette and Wood, 1998). Web and Sheeran's (2006) recent review of research found that among behaviours conducted frequently and in stable contexts, past behaviour was the strongest predictor of future behaviour, whereas among less frequent behaviours conducted in unstable contexts, intention was the stronger predictor of future behaviour.

## PREDICTORS OF BEHAVIOURAL INTENTION: CRASH RISK PERCEPTION

What predicts intention to drive safely? We suggest that an important pathway involves an interaction between the driver's perception of crash risk and a targeted threshold of risk that the driver is willing to accept. Specifically, crash risk perception will predict safe driving intention when the driver has a high threshold of risk acceptance (e.g. unwilling to take risks). Risk perception is a central construct in a number of theoretical models of health-related behaviours, particularly the Health Belief Model (Rosenstock, 1974). It is also a component of other models of human behaviour, including the Theory of Planned Behaviour and Social Cognitive Theory.

Deery (1999) suggests that this perceived crash risk is in part the result of perceived driving ability (DeJoy, 1989; Delhomme, 1991). In a recent study, Harre *et al*. (2005) found that the perception of superior driving ability was correlated with crash-risk optimism. An enhanced perception of driving ability, and subsequent crash risk perception, may be the result of previous experiences (e.g. speeding), where negative outcomes (e.g. car crash) did not occur (Weinstein, 1989). Young males are more

Figure 1 **Conceptual framework of safe driving behaviour**



likely to push 'the envelope' of driving speed with their higher threshold of risk taking (Clark *et al*., 2005). While this type of driving results in more crashes (Clark *et al*., 2005), more often it does not for the individual driver. These experiences could be interpreted in a manner that would lead to greater self-efficacy, leading to an enhanced perception of driving ability.

Driving-related self-efficacy, and even some types of risky driving, however, may not only have negative consequences. Higher self-efficacy as a result of pushing the driver performance envelope may also result in enhancements in actual driving ability. We could find no research in this area, possibly due to concern that enhanced self-efficacy may also result in inflated perception of driving ability and lead to detrimental effects.

Deery (1999) emphasises that perceived driving ability alone does not explain perception of driving risk; rather, it is the interface between driving ability and the perceived hazards of the driving environment. Deery (1999) refers to perceived hazards as both the ability to identify hazards while also perceiving its potential. This interface between the demands of the driving environment and the person's capabilities is also central to Fuller's Task Capability Interface (TDI) model (Fuller, 2005) and results in a perception of task difficulty.

In our conceptual framework we make a distinction between perceived and actual driving demand. Perception of driving demand interacts with perceived ability to create a crash risk perception. Similar to our hypothesised relationship between actual driving demand and actual driving ability, we believe that perceived driving ability moderates the relationship between perceived driving demand and crash risk perception. In other words, the relationship between perceived driving demand and crash risk perception would be strong only when perceived driving ability was in accordance with, or lower than, actual driving ability.

In our conceptual framework, physiological impairment, including alcohol or drug intoxication, sleep deprivation or stress, diminishes pre-frontal cortical activity, which is likely to have an affect on both perceptions of driving demand and driving ability. Moreover, pre-frontal cortical regions are not fully developed until early adulthood (Steinberg, 2004). Steinberg suggests that this region influences self-regulatory functioning, which would include adolescents' and young adults' judgement and decision-making processes, including perceptions of driving demand and driving ability.

Finally, it is important to reconsider the conceptualisation of risk perception with respect to driving behaviour. The Health Belief Model (Rosenstock, 1974; Strecher and Rosenstock, 1997) specifies risk perception as a combination of perceived susceptibility to the deleterious outcome and perceived severity of the outcome. The perceived risk of getting in a car crash focuses on susceptibility but not severity.

Zuckerman *et al*. (2004) found that unrealistic beliefs of control (control over an uncontrollable situation) was related to high-risk sexual behaviour. Similarly, we believe that unrealistic beliefs of control during a crash (what we have termed 'perceived crash response ability') would be related to perceptions of crash risk severity. For example, during the event of a crash, the individual might believe that, in many cases, they could engage in behaviours that would minimise the severity of the crash (e.g. locking arms to brace for impact, falling the right way in the car).

Particular equipment or characteristics of the car, such as the size or weight of the car, or presence of airbags, may also influence perceived crash severity. Note that car equipment that influences perceived severity (e.g. airbags, size and weight of the car) is different from equipment that influences perceived susceptibility (e.g. anti-lock brakes). Even though certain vehicle characteristics have been found to improve driving ability, they may also reduce perceived crash risk susceptibility. Future research should distinguish causal influences of different vehicle characteristics on perceived susceptibility and severity.

## PREDICTORS OF BEHAVIOURAL INTENTION: RISK ACCEPTANCE THRESHOLD

In our conceptual framework, crash risk perception predicts intention to drive safely. We believe that the strength of this relationship is moderated by the driver's acceptable level of risk. For example, a person may perceive a high crash risk, but will not intend to adjust his or her driving behaviour due to a high level of risk acceptance. As Turner and McClure (2004) state: 'Potentially, people with a "high" risk acceptance may perceive risk differently and therefore engage in more risky driving/riding behaviours that lead to a crash resulting in injury. A "high" risk acceptance itself is neither a sufficient nor necessary cause for an injury outcome but it is a part of the causal relationship' (p. 388). This interaction is very similar to the central relationship of Wilde's homeostasis theory, which views an individual's driving decisions as a function of the target level of risk and perceived level of risk.

Our conceptual framework also suggests that the target level of risk acceptance is influenced by relatively stable attitudes and beliefs. Attitude is a central construct of the Theory of Reasoned Action and the Theory of Planned Behaviour, and is the product of an individual's beliefs and the evaluative assessment of the belief. While not always the case (e.g. Assum, 1997; Kennedy *et al*., 1997), a large body of research supports the influence of attitudes on safe driving behaviour (Augustyn and Simons-Morton, 1995; Baum, 2000; Martinez *et al*., 1996; Chliaoutakis *et al*., 2000; Gibbons and Gerrard, 1995; Ulleberg and Rundmo, 2002)

An area just beginning to receive attention in driver safety research is **perceived benefits of unsafe driving**. A recent study by McKenna and Horswill (2006), combined with evidence from Lawton and colleagues (in press) suggest that positive beliefs regarding unsafe driving are associated with driving behaviour. Recent evidence from Lawton (in press) also suggests that affective beliefs (e.g. fast driving evokes worry, guilt, anxiety, enjoyment) predict driving speed to a greater extent than do instrumental beliefs (e.g. fast driving is harmful, safe, timely). A second study in the area of smoking (Lawton et al., in press) confirms the importance of emotions on behaviour.

Sensation seeking also strongly predicts preferred driving speed (Sümer, 2003) and a range of personality traits predict future unsafe driving behaviour (Caspi *et al*., 1997). An increased need during adolescence for the type of stimulation provided by risk taking is possibly due to developmental changes in neuroendocrine activity. In animal models, development of the limbic system during adolescence may, in part, account for changes in reward-seeking behaviour (Spear, 2000). This limbic-controlled process is probably naturally selected, as animals must gain competence through taking risks (e.g. baby birds jumping from their nests). Steinberg (2004) posits that the temporal gap in physiological development between puberty-triggered limbic activity and slower-maturing pre-frontal cortical development forms a ‘window of vulnerability’ where propensity to accept risk is high and self-regulatory processing is low.

Finally, the identity an adolescent is developing is likely to be influenced by social norms and by their personality. For many individuals, driving is simply a utilitarian endeavour; for others, driving is a personally relevant activity. Ego involvement in a particular behaviour could influence chronic dispositions toward the behaviour (West, 2006) and the response to messages attempting to influence the behaviour (Freeman *et al*., 2001).

Stronger identification as a smoker predicts both lower intentions to quit (Falomir and Invermizzi, 1999) and poorer cessation outcomes (Shadel and Mermelstein, 1996). A recent study of Irish adolescents (Stewart-Knox *et al*., 2005) found smoking uptake often to be driven by a desire to conform to the norms of a peer group as opposed to being through direct persuasion. As West (2006) states, identity is a set of mental representations we have of ourselves as we both **are** and **we could be**. Markus and Nurius (1986) call these future states our ‘possible selves’ – what we ‘would like to become … could become … or afraid of becoming’ (p. 954).

# Summary

As part of a review of the traffic safety literature, we developed a conceptual framework to provide a foundation for organising psychosocial constructs for review and discussion. This review is intended to stimulate discussion regarding the importance of the constructs in the framework as well as the relationships between the constructs. Our framework builds on a number of existing models of health-related behaviour and of driving behaviour specifically.

Central to our conceptual model is the distinction between intention to drive safely and actual safe driving behaviour. Factors inhibiting a perfect relationship between intention and behaviour include the difficulty of the driving task and the habitual nature of driving behaviour. Predictors of intention focus on two dynamics: the perception of crash risk and a threshold of risk the driver is willing to take. We believe that these two concepts interact to predict safe driving intention.

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# 5

# Do emotional appraisals of traffic situations influence driver behaviour?

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## Abstract

Although it is widely assumed that the emotions experienced while driving influence driving behaviour, there are few empirical studies which support this supposition. This study explored the relationship between emotional appraisals of anger, calmness and frustration and driver behaviour in a simulated driving task. Few relationships emerged between trait measures of anger and anxiety and driving behaviour in the simulator. However, several findings showed that situational fluctuations in emotion were associated with driving behaviours. Among these, the related findings that drivers when angry drove at faster speeds, and those drivers experiencing higher levels of anger and frustration made more extreme use of the accelerator and brake pedals than those same drivers did in circumstances where they reported more calmness. While a relationship is apparent between state emotion appraisals and car control, it remains unclear to what extent these changed behaviours pose, or are intended to pose, a danger to the driver or to other road users.

## Introduction

The concept of the angry driver and undesirable driving behaviour is often sensationalised in the media under the guise of 'road rage'. However, the extent to which episodes of anger lead to negative driving behaviours is unclear. Researchers in the psychological domain have identified a link between mood and driving behaviour, particularly in terms of the negative consequences of angry mood on self-reported driving behaviour. Drivers who report a tendency to become angered in the car also report more aggressive driving behaviours and, to some extent, engage in these on the road (Lajunen and Parker, 2001). Drivers' self-reported anger levels have also been shown to be positively related to near accidents (Underwood *et al*., 1999). However, few studies have examined the relationship between the mood experienced while actually driving and the manner in which the driver drives.

One study to investigate mood and assessed driver behaviour was that of Groeger (1997). Groeger measured experienced drivers' ($n$ = 100) anxiety, depression and hostility, using the Multiple Affect Adjective Checklist (MAACL; Zuckerman and Lubin, 1985). Mood was tested three weeks prior to, then before and towards the end of a driving test undertaken in real traffic conditions, and was supervised by an experienced driving instructor. Drivers displayed a noticeable increase in anxiety levels between the first administration of the MAACL (completed in participants' own homes) and the one taken immediately before the driving test. Drivers also reported greater degrees of hostile, anxious and depressed mood after being subjected to critical feedback during the drive. However, no relationships were evident between mood during the drive and driving performance (as rated by the driving instructor), nor between mood change and driving performance. Although Groeger found that mood change in drivers could be effected, there was no indication that this change influenced driver performance.

In contrast, in an observational study of frustration levels and aggressive driving responses in real traffic situations, Shinar (1998) identified a relationship between provocation and driver performance. Shinar performed a series of experiments, in one of which participants' vehicles were observed at intersections when stopped behind a research vehicle. The vehicle moved off less promptly in response to a green signal in order to manipulate levels of frustration. Observed drivers' use of the car horn was regarded as an indication of an aggressive response. Shinar found that drivers positioned at traffic intersections with shorter green cycles (higher frustration) were quicker to sound their horn at the research vehicle (more aggressive). Drivers were more aggressive when traffic congestion was greater, and when the driver in front appeared distracted. In these studies, Shinar was able demonstrate a clear relationship between expressions of aggression and frustration.

Driving anger has also been shown to influence reported driving behaviour. Lajunen and Parker (2001) surveyed 270 British motorists with regard to their trait anger and aggressiveness and self-reported responses to anger-provoking scenarios on the road. Participants were given the Driving Anger Scale, UK version (DAS; Deffenbacher *et al*., 1994), and measures of aggressiveness (Aggressiveness Scale; Buss and Perry, 1992) and impulsiveness were recorded. Participants reporting a tendency for driving anger also reported a tendency for aggressiveness, but this relationship did not generalise across all of the traffic scenarios evaluated. Nevertheless, Lajunen and Parker found that, at least in relation to self-reported measures, anger while driving had a negative influence on reported driver behaviour.

Underwood *et al*. (1999) examined anger while driving using a more qualitative self-report method; gathering data from questionnaires and driving diaries. Participants ($n$ = 100) were asked to keep a driving dairy over a two-week period, recording journey descriptions, episodes of near accidents and feelings of anger after each journey on a micro-cassette recorder. The DAS, Driving Behaviour Questionnaire (DBQ; Reason *et al*., 1990) and Social Motivation Scale (SMS; West *et al*., 1993) were also administered. From a total of 1,778 recorded journeys, anger was experienced on 318 occasions and 85 of the 100 participants reported feeling angry while driving at least once throughout the two-week period. Anger tended to occur in higher congested situations and was found to relate to the frequency of near accidents. Interestingly, when the total anger from the diary reports was compared to trait anger tendencies (i.e. total DAS scores), there was no significant relationship between the two. Only when anger was separated into anger relating to a near accident miss and anger unlinked to a near accident did a relationship appear between unlinked anger and trait anger tendencies. This finding questions the extent to which DAS can adequately predict anger as experienced in a variety of traffic situations.

Despite the lack of consistency in findings for relationships between the DAS and driving anger in various traffic situations, there appears broad agreement that trait anger should relate to what is felt, perhaps even what is done, on the road. A recent study by Deffenbacher *et al*., (2003) of simulated driving makes an even clearer connection between trait driving anger and actual driving behaviour.

Deffenbacher *et al*. (2003) used driving simulators to examine driving behaviours of self-reported angry drivers. The participants ($n$ = 121) were selected as high anger or low anger drivers, according to DAS scores from a prior study. The participants completed the DAS, Driving Anger Expression Inventory (Deffenbacher, Lynch, Oetting & Swaim, 2002), State Anger Scale (Speilberger, 1989) and Trait Anger Scale (Speilberger, 1989). Driving surveys regarding crash-related outcomes for the past three months, and driving logs rating frequency and intensity of anger and aggressive and risky behaviours across a three-day period, were also completed. After completion of the surveys, participants underwent three drives on a PC-based driving simulator. The drives consisted of a four-minute familiarisation drive, a 10-minute open road drive and a 10-minute high-impedance drive. In the latter, the drivers' progress was obstructed by slower vehicles. Deffenbacher *et al*. (2003) found that those with a high predisposition for anger while driving reported more usage of their vehicle to express anger. Throughout the simulated drives, high anger drivers drove at higher speeds and had a lower minimum time and distance to collision in periods of high impedance. Although there are many strengths of the approach used by Deffenbacher *et al*., this study relied on state emotion appraisals gathered before and after each drive. Therefore, the degree of emotion experienced during the drive and how this relates to any immediate behaviour is unknown. Questions of this sort need to be answered if we are to understand the mechanism underlying the emotion–behaviour axis, and how road users can be protected against its negative effects.

The aim of the current study is twofold. First, to capture trait emotional appraisals and assess how these relate to self-reported driving behaviour. Second, to obtain state appraisals of changing traffic circumstances and to assess how these relate to driving behaviours both preceding and subsequent to appraisals of traffic circumstances. The key research questions addressed in this study are:

- do trait-measures of emotion relate to self-reported driving?
- do trait-measures of emotion relate to appraisals of traffic circumstances?
- do emotional appraisals of traffic situations relate to preceding and/or subsequent driver behaviour?

# Method

## Participants

The participants were 12 males aged between 19 and 52 (*M* = 28.92, *SD* = 8.61) and 12 females aged between 18 and 33 (*M* = 22.00, *SD* = 4), and were UK licensed drivers either employed or studying at the University of Surrey.

All participants held a current UK drivers licence permitting them to drive a manual transmission car. The average period of licensing varied between one month and 32 years (*M* = 5.78, *SD* = 7.11). In terms of miles driven, participants reported a weekly mileage ranging from zero to 600 (*M* = 92.40, *SD* = 160.49) and a yearly mileage of zero (for the new driver) to 30,000 (*M* = 5,772.17, *SD* = 7,267.90).

## Driving simulator

Driving took place in a state-of-the-art STISIM 400W driving simulator with full car body and manual transmission (Figure 1). The simulator has a 180 degree field of view, resulting from image projection onto three wall-to-floor screens. These screens are approximately 1 to 1.5 metres from the car body. Drivers can use the car pedals, indicators and horn as well as speedometer and rev counters to adjust and monitor their progress through the simulated traffic environment. Their position, heading, speed and time to collision data in this environment are tracked continuously, as are all uses of the car controls and actions of objects in the environment. A small web camera, placed on the dashboard, captures drivers' facial expressions throughout the simulation.

Figure 1 **University of Surrey driving simulator – simulator and experimenter monitors**

# Procedure

Prospective participants were screened for motion sickness. Screening entailed completing a 20–30 minute familiarisation drive in the simulator and two motion sickness questionnaires, one issued before and one after the familiarisation drive. Those who reported feeling unwell after the familiarisation drive were excluded from the study.

Prior to the test drive, the participants completed a battery of questionnaires to ascertain demographic information and propensities for anger and anxiety. The participants provided information on age, gender and driving experience (weekly and annual mileage and duration of being licensed). The participants also completed the DAS (Deffenbacher *et al*., 1994) to measure self-reported tendencies towards anger while driving and the DBQ (Reason *et al*., 1990) to capture self-reported driving behaviour. The state and trait anxiety inventories (STAI; Speilberger *et al*., 1983) were also administered to assess state and trait anxiety levels.

The test drive consisted of a 10.2 mile drive through open road, residential and retail areas. Throughout the drive, drivers encountered various scenarios designed to interrupt their driving journey (Figure 2). These scenarios included the following:

- Oncoming vehicle (ON) – an ON vehicle moves across into the driver's lane. This commences when the driver is six seconds away and moves back to the opposite lane when the driver is three seconds away from it. The event has cleared by the time the driver is one second from the vehicle. ON events occur at 30 mph, 40 mph, 50 mph and 60 mph zones.

- Following event (FO) – a vehicle pulls out on front of the driver when the driver is three seconds from the vehicle. The FO vehicle drives 10 mph less than the posted speed limit for 1000 ft until pulling over to the left side of the road and clearing the driver's path. ON vehicles prevent the driver from overtaking the FO vehicle. FO events occur at 30 mph, 40 mph, 50 mph and 60 mph zones.

- Slow vehicle event (SL) – two versions of SL exist. First, a slow bus, which pulls out of a bus stop in front of the driver when the driver is three seconds away. The bus slows to 15 mph until the driver is +/-1 second from it, at which point the bus moves laterally back to the road side clearing the driver's path. The second SL event is a slow motorbike. The motorbike appears 30 ft behind the driver in the driver's lane, overtakes the driver on the inside lane then slows in front of the driver to 15 mph, before removing itself from the driver's path. All SL vehicle events occur in 30 mph zones.

- Pedestrian event (PED) – a pedestrian appears on the left side of the road and walks across the driver's path. The PED begins moving when the driver is three seconds away and continues (at a velocity of 4.47 ft/s) to the other side of the road, not stopping for the car. Not all pedestrians in the scenario are PED events. PED events occur only in 30 mph zones.

- Car emerge event (CE) – a parked car emerges (rear bumper first) from a driveway into the driver's path. The CE event commences when the driver is three seconds from the vehicle. The CE is programmed so as, theoretically, the rear bumper of the car would be positioned in the same position as the pedestrian, when the time to collision between the driver and emerging vehicle was zero. However, when the driver is 2.5 seconds away from the vehicle, CE moves back to its initial position, having cleared itself from the driver's path by the time the driver is one second from impact. The CE event occurs only in 30 mph zones.

- Amber event (AM) – amber light decision events occur as the green traffic signal changes to amber when the driver is three seconds away from the traffic intersection. AM events occur in 30 and 40 mph zones.

- Unimpeded (UN) – sections of unimpeded drive were also included. These occurred in rural, residential and retails areas, and in 30, 40, 50 and 60 mph zones.

Figure 2 **Examples of traffic situations – pedestrian and slow bike events**

Throughout the drive, participants were asked to rate levels of frustration, calmness and anger. Ratings were scaled from one to five, with one being 'not at all', three being a 'moderate amount' and five being 'a lot'. Ratings were prompted by the sound of a bell and each emotion read out with a lapse for participants to respond verbally. The same audio file was used in each rating point. Reponses were recorded manually by an experimenter seated behind the screened-off car and were also recorded by the in-car web camera. The rating time points are listed in Table 1.

The participants completed a wellness questionnaire before and after the drive, to assess comfort levels. State anxiety was also measured pre- and post-drive.

Table 1 **Rating time points throughout the drive**

| Rating | Distance (feet) | Code | Scenario | Speed limit: mph |
|---|---|---|---|---|
| 1 | 2,200 | ON (60) | Oncoming | 60 |
| 2 | 5,800 | FO (60) | Following | 60 |
| 3 | 7,580 | ON (40) | Oncoming | 40 |
| 4 | 11,332 | PD (30) | Pedestrian | 30 |
| 5 | 13,970 | AM (30) | Amber light | 30 |
| 6 | 16,588 | UN (40) | Unimpeded | 40 |
| 7 | 20,500 | SL (M)(30) | Slow motorbike | 30 |
| 8 | 22,980 | FO (40) | Following | 40 |
| 9 | 24,960 | UN (30) | Unimpeded | 30 |
| 10 | 26,500 | ON (30) | Oncoming | 30 |
| 11 | 28,495 | AM (40) | Amber light | 40 |
| 12 | 33,330 | FO (30) | Following | 30 |
| 13 | 35,800 | ON (50) | Oncoming | 50 |
| 14 | 39,480 | UN (50) | Unimpeded | 50 |
| 15 | 41,376 | SL (B) (30) | Slow bus | 30 |
| 16 | 42,960 | FO (50) | Following | 50 |
| 17 | 47,730 | CE (30) | Car emerge | 30 |
| 18 | 50,010 | UN (60) | Unimpeded | 60 |

# Results

## Trait-measures of emotion and self-reported driving

The means and standard deviations of trait measures for anger (DAS), anxiety (STAI) and self-reported driving (DBQ) are listed in Table 2. In general, participants did not display high tendencies towards driving anger, with a total driving anger mean of 2.34 ($SD$ = 0.39). This is lower than Deffenbacher *et al.*'s (1994) original cohort ($n$ = 1,526; $M$ = 3.20, $SD$ = 0.79), but is comparable to reported anger in recent studies (Lajunen *et al.*, 1998; n = 280, $M$ = 2.15, $SD$ = 0.93; O'Brien *et al.*, 2004; $n$ = 166, $M$ = 2.52, $SD$ = 1.05). The participants in the current study did not report elevated levels of trait or state anxiety, although there was a tendency for higher anxiety post-drive. So too, DBQ scores were relatively low, with ordinary violations being the highest scoring behaviour. Current DBQ scores are also comparable to previous studies (Özkan *et al*., 2006; $n = 622$; aggressive violations $M = 0.50$, $SD = 0.68$; ordinary violations $M = 0.88$, 0.61; errors $M = 0.50$, $SD = 0.40$; Lapses $M = 0.86$, $SD = 0.48$).

Table 2 **DAS, STAI and DBQ means and standard deviations**

| | | *M* | *SD* |
|---|---|---|---|
| DAS | Discourtesy | 3.02 | 0.57 |
| (scale 1–5) | Traffic obstructions | 2.15 | 0.79 |
| 1 = not at all | Hostile gestures | 2.86 | 0.95 |
| 5 = very much | Slow driving | 2.18 | 0.50 |
| | Police presence | 1.48 | 0.58 |
| | Illegal driving | 2.38 | 0.82 |
| | Total DAS | 2.34 | 0.39 |
| STAI | Trait | 1.88 | 0.44 |
| (scale 1–4) | State (pre) | 1.76 | 0.44 |
| 1 = not at all | State (post) | 1.96 | 0.55 |
| 4 = very much so | | | |
| DBQ | Aggressive violations | 0.53 | 0.79 |
| (scale 0–5) | Ordinary violations | 1.13 | 0.73 |
| 0 = never | Errors | 0.45 | 0.37 |
| 5 = all the time | Lapses | 0.88 | 0.43 |

Relationships between trait measures and self-reported driving behaviours, DAS total, DBQ four factors and STAI were assessed using Pearson product-moment coefficients (see Table 3). Two of the five statistically reliable correlations show relationships between the measures used: DAS total and DBQ error, $r\ (22) = 0.42$, $p > 0.05$ and DBQ lapses and Trait anxiety, $r\ (22) = 0.51$, $p > 0.05$. These imply that participants reporting higher levels of trait driving anger were more likely to report driving errors, and those higher in trait anxiety were more likely to report driving lapses.

# Trait-measures of emotion and appraisals of traffic circumstances

Emotional appraisals of traffic circumstances were obtained by averaging the 18 ratings for anger, calmness and frustration. Means for anger ($M = 1.78$, $SD = 0.71$) and frustration ($M = 1.89$, $SD = 0.65$) were relatively low for the sample, suggesting that, on average, participants felt only a little to some anger or frustration throughout the drive. Calmness levels averaged 3.13 ($SD = 0.88$), indicating participants felt moderately calm during the driving task. A Pearson product-moment correlation of these averages revealed only one statistically reliable relationship, which was between anger and frustration, $r\ (22) = 0.91$, $p > 0.001$. No significant relationships were found between calmness and frustration, $r\ (22) = –0.22$, $p = 0.31$; nor between calmness and anger, $r\ (22) = –0.30$, $p = 0.15$).

To investigate the relationship between drivers' emotional appraisals and trait measures, anger, calmness and frustration averages were correlated with DAS (total), STAI scores and the four DBQ factors (see Table 3). Three significant relationships were found. Anger appraisals were related to total DAS scores, $r$ (22) = 0.58, $p$ = <0.001 and DBQ errors, $r$ (22) = 0.51, $p$ = <0.05, and frustration scores were related to DAS (total), $r$ (22) = 0.42, $p$ = <0.05. Therefore, drivers with higher trait-anger tended to report higher levels of anger and frustration throughout the drive task.

Table 3 **The relationship between DAS, STAI, DBQ and emotional appraisals**

| | DBQ O. Viol | DBQ A. Viol. | DBQ Error | DBQ Lapse | STAI Trait | STAI State (pre) |
|---|---|---|---|---|---|---|
| **DAS (total)** | 0.30 | 0.35 | *0.42** | 0.34 | 0.22 | 0.13 |
| **DBQ ord** | | *0.50** | 0.26 | 0.16 | –0.00 | –0.18 |
| **DBQ agg.** | | | 0.06 | –0.32 | 0.01 | –0.15 |
| **DBQ error** | | | | **0.62†** | 0.40 | 0.12 |
| **DBQ lapse** | | | | | *0.51** | 0.20 |
| **Trait anxiety** | | | | | | **0.67†** |

* $p < 0.05$
† $p < 0.01$

# Emotional appraisals and driver behaviour

To investigate the relationship between emotional appraisals and driver behaviour, driver behaviour was considered in two ways: vehicle motion (consisting of longitudinal speed and lateral position) and driver actions (consisting of acceleration due to throttle usage, steering wheel usage and deceleration due to braking – an index of brake usage). For each of these, means (representing the average tendency) and standard deviations (the variability around the average tendency) were calculated.

Relationships between trait measures, emotional appraisals and the various driving behaviour measures were quantified using Pearson product-moment correlations (see Table 4). Only one statistically reliable relationship was revealed: frustration and steering wheel usage, $r$ (22) = 0.49, $p$ = < 0.05, indicating that drivers who engaged in more steering activity reported higher levels of frustration.

These analyses ignore differences between the ratings of, and behaviour in, individual traffic situations, and reveal only whether general tendencies towards evaluating situations as anger-provoking are related towards general tendencies to drive fast, steer more and use the brake and accelerator pedals more. As such, the extent to which particular emotions lead to particular behaviours is obscured. Measuring the relationships between specific emotions and behaviours is essential for understanding how emotion influences behaviour emotion and vice versa. In order to address this issue directly, correlations were calculated for each driver

Table 4 **Emotional appraisals and driver behaviour**

| | | Emotional appraisal | | | | | |
|---|---|---|---|---|---|---|---|
| | | Anger | | Calm | | Frustration | |
| | | *M* | *SD* | *M* | *SD* | *M* | *SD* |
| Vehicle motion | Longitudinal speed | 0.08 | 0.09 | –0.18 | 0.20 | 0.25 | 0.13 |
| | Lateral position | 0.09 | 0.32 | –0.14 | –0.24 | 0.06 | 0.39 |
| Driver behaviour | Steering wheel usage | 0.31 | 0.35 | –0.18 | 0.01 | *0.49** | 0.32 |
| | Accelerator usage | –0.03 | –0.00 | 0.32 | 0.21 | –0.08 | –0.08 |
| | Brake usage | 0.24 | 0.02 | –0.15 | 0.05 | 0.22 | 0.11 |

* $p < 0.05$, d.f. = 22

between ratings given and behaviour in each of the 18 simulated traffic scenarios. These correlations were subsequently averaged, to identify the extent to which the relationships between individuals' ratings and behaviour were consistent across participants. Furthermore, driver behaviour was separated into the three-second period before and the three-seconds after a rating was required. Behaviour change values were calculated (post-rating behaviour minus pre-rating behaviour) to identify changes in behaviour before and after the traffic situation was appraised. The resulting average correlation co-efficients are presented in Table 5.

There were a number of reliable relationships between the motion of the vehicle in the three seconds before a rating was made and the rating subsequently made. Drivers, whose lateral position changed relatively little before a rating was made, subsequently rated themselves higher in calmness. Higher longitudinal speed was also related to appraisals of calmness, and negatively related to appraisals of anger and frustration. In the three seconds before a rating was made, higher standard deviations of longitudinal speed correlated with higher levels of anger and frustration. Thus, when drivers were driving at lower speeds and having to change speed, feelings of anger and frustration increased.

For the three seconds after the rating was required, relationships between emotional appraisals and vehicle motion were similar to those found prior to the rating. The extent to which behaviour changed between the behaviour measurements made before and after the rating was related to the rating given. Drivers who rated themselves as more angry and less calm were likely to have more erratic speed control after rating, Interestingly, although anger and frustration ratings were consistently associated with each other, only anger relates to changes in speed control.

In the three seconds before a rating was required, drivers who made more small steering wheel corrections, put less pressure on the brake, but used the brake and the accelerator more, were more likely to subsequently report being angry and frustrated. Greater amounts of steering, but fewer changes, less use of the brake and accelerator pedals, but greater pressure on the brake were associated with higher levels of calmness. Similar patterns of relationships were obtained between ratings and the driver behaviour in the three seconds after ratings were required. Drivers reported less anger and frustration if they accelerated more forcefully after a rating was required. Drivers reported higher levels of anger, but not frustration, if their

Table 5 **Emotional appraisals and driver behaviour – individual correlations averaged**

| | | | Pre-rating | | | Post-rating | | | Change | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pre-anger | Pre-calm | Pre-frustration | Post-anger | Pre-calm | Pre-frustration | Change anger | Change calm | Change frustration |
| Vehicle motion | Longitudinal speed | ***M*** | **–0.20†** | **0.19†** | **–0.30†** | **–0.21†** | **0.18†** | **–0.31†** | 0.00 | –0.02 | 0.01 |
| | Longitudinal speed | ***SD*** | **0.14†** | –0.07 | **0.23†** | **0.27†** | **–0.27†** | **0.24†** | **0.14†** | **–0.14†** | 0.01 |
| | Lateral position | ***M*** | 0.08 | -0.05 | 0.05 | *0.09** | -0.02 | *0.10** | 0.05 | 0.04 | 0.07 |
| | Lateral position | ***SD*** | 0.03 | **–0.15†** | *–0.02* | 0.04 | -0.08 | 0.04 | –0.01 | 0.03 | 0.07 |
| Driver behaviour | Steering wheel usage | ***M*** | **–0.13†** | **0.18†** | *–0.09** | –0.07 | 0.05 | *–0.10** | 0.07 | **–0.13†** | 0.03 |
| | Steering wheel usage | ***SD*** | **0.23†** | **–0.32†** | **0.20†** | **0.18†** | **–0.23†** | **0.20†** | *–0.11** | **0.14†** | –0.08 |
| | Accelerator usage | ***M*** | 0.06 | 0.02 | 0.01 | **0.15†** | **–0.12†** | *0.12** | *0.11** | **–0.13†** | *0.11** |
| | Accelerator usage | ***SD*** | **0.17†** | **–0.12†** | **0.15†** | 0.06 | 0.02 | 0.09 | –0.07 | 0.11 | –0.03 |
| | Brake usage | ***M*** | **–0.12†** | *0.10** | **–0.18†** | **–0.20†** | **0.17†** | **–0.20†** | –0.02 | 0.04 | 0.07 |
| | Brake usage | ***SD*** | **0.16†** | *–0.09** | **0.14†** | **0.22†** | **–0.15†** | **0.17†** | 0.02 | -0.03 | –0.06 |

* $p < 0.05$; d.f. (408)
† **$p < 0.01$**

steering behaviour was more constrained after rating. In general, the opposite pattern of relationships held for calmness than for anger and frustration.

# Discussion

The aim of this study was to measure certain emotional traits and state-based emotional appraisals, and to assess how these relate to self-reported driver behaviour (for the former) and actual driver behaviour (for the latter). This was done by examining the extent to which trait-measures of emotion relate to self-reported driving (DBQ) and how driving behaviours before and after ratings were required relate to the emotional appraisals of different simulated traffic conditions.

The question was posed, 'Do trait-measures of emotion relate to self-reported driving?', and it appears from the data set that the answer is, for the most part, no. Of the trait measures for anger, captured with the DAS scores, only one relationship was apparent. This was between anger and self-reported driving errors on the DBQ. Trait anger was not significantly related to self-reported violations (aggressive or ordinary), nor related to lapses. Trait anxiety was positively related to self-reported lapses, suggesting, consistent with previous literature, that anxious people are likely to self-report driving lapses.

Despite being unable to find significant relationships between trait measures and self-reported driving behaviours, a relationship was identified between trait-measures of emotion and appraisals made during the drive. Thus, the second research question posed, as to whether trait measures of emotion relate to appraisals of traffic circumstances, was answered in the affirmative. Participants experiencing more anger and frustration throughout the drive task also tended to have higher trait-anger. Furthermore, drivers who had previously reported committing more errors when driving tended to appraise situations as more anger inducing. These findings differ from those of Underwood *et al*. (1999) who, in their sample of 100 drivers, did not find a reliable relationship between total DAS scores or DBQ error scores and total reported anger recorded after the driving journey.

The difference between the current findings and those of Underwood *et al*. (1999) may be due to methodological differences in measuring anger appraisals. Participants in the Underwood *et al*. study self-reported levels of anger experienced in near-miss situations, outside these situations and overall. They did so at some point after they had finished driving. In that study, no relationship was apparent between total DAS scores and total anger or anger associated with near misses. In the current study, while several of the scenarios encountered by drivers would have lead to near misses or collisions, the emotional appraisals were required immediately after the particular situation was encountered. Capturing emotional appraisals throughout the drive, rather than after a drive, may provide more sensitivity to the emotional state. It may be that feelings of anger dissipate over time, and it is also possible that feelings of risk, promoted by near misses, serve to make some situations rather than others more memorable. Feelings of risk may or may not relate to anger as experienced, or anger as remembered.

The answer to the third question which motivated the present study, 'Do emotional appraisals of traffic situations relate to preceding and/or to subsequent driver behaviour?', also appears to be yes. Significant relationships were identified between preceding driver behaviour and emotional appraisals of traffic situations and between emotional appraisals and behaviour change post-appraisal.

Before drivers made the required emotional appraisals, those travelling more slowly, or who adjusted their speed more, tended to subsequently report being more angry, frustrated and less calm. Although this pattern fits well with the concept of the angry driver – as someone who wants to drive faster and becomes angered and/or frustrated when constrained to lower driving speeds – it is important to recognise that the drivers in this study were not unusually high in trait-anger. Furthermore, the relationship between current activity and ensuing emotional appraisals was reliable for across all of those taking part.

Drivers' behaviours after emotional appraisals were made were also reflected in what they subsequently did. Those who rated situations as anger provoking tended to increase their speed afterwards. Again, this is characteristic of the stereotype of the 'angry driver'. However, it is worth emphasising once again that the approach adopted here suggests that such reactions are rather more widespread. Whether these reactions are sufficient to endanger themselves or other users is a matter which will be addressed in future research.

# Conclusion

Emotions such as anger, frustration and calmness can be reliably measured during simulated driving. Although only weak relationships were found between trait-anger and some self-reported driving behaviours, stronger relationships were apparent for emotional appraisals made in traffic situations and driver behaviour. An increase in negative affects such as anger, frustration and lower levels of calmness are associated with higher driver activity and greater variability in the use of car controls, possibly leading to more dangerous and erratic driver behaviour. Further research is needed to examine a wider range of emotional appraisals including the threat or self-assessment of driving workload and how these relate to driver behaviour, as well as stronger manipulation of a variety of traffic situations.

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# 6

# Cutting down and slowing down: changes in car use and speeding on Scotland's roads

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## Introduction

This paper presents data on cutting car use and on reducing driving speed from two recent studies in Scotland.

Over the past two decades the locus of road transport policy in the UK has moved from 'predict and provide' to 'demand management', from providing tarmac to accommodate the ever increasing number of cars to restraining car use to cut congestion, toxicity and depletion of planetary resource.

Scotland, like other developed countries, is currently a car-dependent society. 2001 Census figures show Scotland with a population of just over 5 million people in 2.2 million households, with 2.0 million cars or vans owned or available for use by these households and ownership varying markedly between rural and urban areas. Table 1 (from Stradling, 2005) shows the distribution by Scottish Parliamentary Region.

While there were overall 93 cars for every 100 households in Scotland, one-third (34%) of Scottish households did not have access to a car and this proportion varied with location. It also varied substantially with annual household income. Figure 1, from Stradling *et al*. (2005) shows the proportion from households with access to a car for each of the five income quintiles, using Scottish Household Survey data from 1999–2003.

Crosstabulation by location and income reveals even greater variability in Table 2, which shows the variation in the proportion of Scottish households **without** access to a car for private use, ranging from 1% of households from the top income quintile living in accessible rural areas to three-quarters (74%) of those from the lowest income quintile in large urban areas.

Table 1 **Cars or vans available to households in Scotland 2001 (adapted from Scottish Census data, Table KS17)**

| Area | None | One | Two or more | Cars per 100 households |
|---|---|---|---|---|
| Scotland | 34 | 43 | 23 | 93 |
| Highlands & Islands | 26 | 49 | 26 | 106 |
| Mid-Scotland & Fife | 27 | 46 | 27 | 106 |
| South of Scotland | 28 | 46 | 27 | 105 |
| North-east Scotland | 31 | 44 | 26 | 101 |
| West of Scotland | 33 | 42 | 25 | 96 |
| Central Scotland | 34 | 43 | 23 | 94 |
| Lothians | 36 | 44 | 20 | 88 |
| Glasgow | 55 | 35 | 10 | 57 |

Figure 1 **Percentage of respondents from households with access to a car for each of the five annual household income bands**

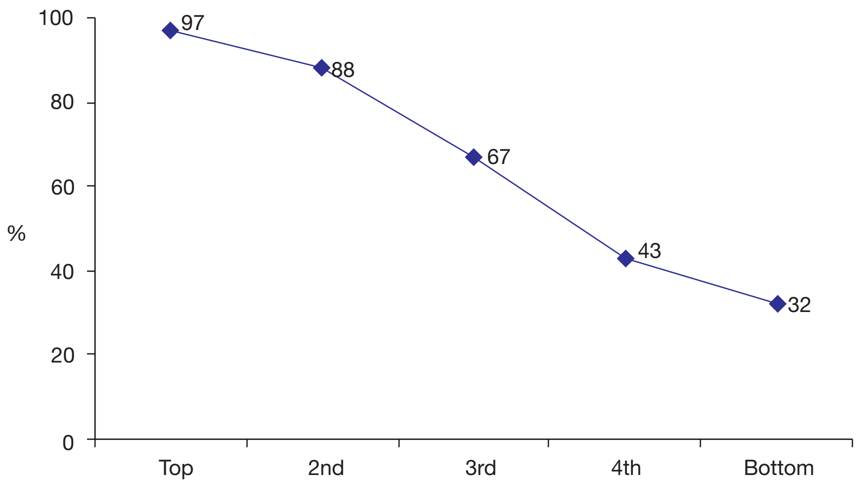


Table 2 **Per cent of Scottish households without access to a car for private use location and income quintile**

| Income quintile | Lowest | 2 | 3 | 4 | Highest | Total |
|---|---|---|---|---|---|---|
| Location | | | | | | |
| Large urban | 74 | 72 | 51 | 28 | 8 | 44 |
| Other urban | 68 | 64 | 38 | 17 | 4 | 33 |
| Small remote towns | 66 | 60 | 37 | 19 | 5 | 34 |
| Small accessible towns | 65 | 55 | 31 | 12 | 3 | 26 |
| Accessible rural | 48 | 44 | 21 | 8 | 1 | 18 |
| Remote rural | 44 | 38 | 19 | 6 | 2 | 19 |
| Total | 65 | 62 | 39 | 18 | 4 | 33 |

Mobility is the potential for movement and accessibility is the potential for interaction with desired social and economic opportunities, so reduction in or absence of either mobility or accessibility is a reduction in a person's potential. One attraction of the car is that it may be seen as amplifying a person's potential mobility and access to desired locations. Transport-related social exclusion occurs where individuals or households are unable to fully participate in society as a result of inadequate or unaffordable transport.

Despite the power of the car, recent research in Scotland for the Scottish Executive has shown that most people are multi-modal travellers, meeting their transport needs via a mix of modes, and that transport patterns and choices vary with a number of person characteristics, such as age, gender and disability, with a number of household characteristics, such as income, location and transport availability, and with journey purpose (Stradling, 2005; 2006). Access to places varies with access to transport.

# Cutting car use

Dudleston *et al*. (2005) in a study for the Scottish Executive, using cluster analysis of attitudinal and demographic items, identified four driver types and three non-driver types:

- die-hard drivers, comprising 26% of Scottish drivers (20% of Scottish adults);
- complacent car users – 28% of drivers (21%);
- malcontented motorists – 24% of drivers (18%);
- aspiring environmentalists – 24% of drivers (18%);
- car sceptics – 35% of non-car users (8%);
- reluctant riders – 30% (7%); and
- car aspirers – 35% (8%).

While the average annual car mileage for the four driver groups was similar, the segments were differentiated by the extent to which they exhibited attachment to the car, were willing to consider alternative modes, were already multi-modal, felt willing and able to reduce their car use, and were aware of transport and environmental issues.

**Die-hard drivers** (DHD) like driving and would use the bus only if they had to. Almost none of them believe that higher motoring taxes should be introduced for the sake of the environment and there is overwhelming support for more road building to reduce congestion. There are slightly more males than females in this group.

**Car complacents** (CC) are less attached to their cars but currently see no reason to change. They generally do not consider using transport modes other than the car and, faced with a journey to make, will commonly just reach for their car keys.

**Malcontented motorists** (MM) find that current conditions on the road, such as congestion and the behaviour of other drivers, make driving stressful and they would like to reduce their car use but cannot see how. They say that being able to reduce their car use would make them feel good, but feel there are no practical alternatives for the journeys they have to make. They were over-represented in accessible rural areas of Scotland.

**Aspiring environmentalists** (AE) are actively trying to reduce their car use, already use many other modes and are driven by an awareness of environmental issues and a sense of responsibility for their contribution to planetary degradation.

Of the non-car owning households **car sceptics** manage without a car, are travel aware, environmentally aware, are more likely to use bicycles, and support environmental taxation and constraints on unfettered car use.

**Reluctant riders** tend to be older and poorer, dependent on public transport and, where possible, travel as passengers in others' cars.

**Car aspirers**, more of whom are unemployed, of lower social class and environmentally unaware, need better access to destinations than their current high bus use provides and for this, and other reasons, aspire to car ownership.

In a survey for the Lothian & Borders Safety Camera Partnership (field work conducted in 2005 by NOP) of 800 car drivers in Edinburgh, the Lothians and the Borders, 67% agreed or strongly agreed that 'I feel car driving can be stressful sometimes' and is thus not an unalloyed pleasure, and 49% that 'I am trying to use the car less'.

The car driver typology was replicated in the Lothian & Borders study and Table 3 shows the per cent of each type strongly agreeing or agreeing with 'I am trying to use the car less' and the per cent strongly disagreeing or disagreeing with 'Overall I am in favour of speed cameras'.

Table 3 **Differences between die-hard drivers, car complacents, malcontented motorists and aspiring environmentalists in current attempts at cutting car use and opinion of speed cameras**

| *n* = 765 | DHD | CC | MM | AE |
|---|---|---|---|---|
| Per cent strongly agree + agree | | | | |
| I am trying to use the car less | 26 | 15 | 69 | 80 |
| Per cent strongly disagree + disagree | | | | |
| Overall I am in favour of speed cameras | 23 | 23 | 14 | 8 |

# Slowing down

Three questions in the Lothian & Borders survey asked drivers about slowing down. Table 4 shows the distribution of responses and Table 5 the intercorrelations of these three items.

Half (51%) agree – though few strongly – that they are presently making an effort to reduce their driving speed, approaching a half (46%) concur that they are trying to

**Table 4 Distribution of responses to slowing down items**

| *n* = 781–795 | SA | A | NAD | D | SD |
|---|---|---|---|---|---|
| Row per cent | | | | | |
| At the moment I am making an effort to reduce my driving speed | 5 | 46 | 14 | 31 | 4 |
| I am trying to speed less often than I used to | 8 | 38 | 14 | 33 | 7 |
| I have recently reduced my usual driving speed | 4 | 30 | 13 | 49 | 4 |

**Table 5 Intercorrelation of slowing down items**

| *n* = 764<br>Pearson product-moment coefficients.<br>All $p = 0.000$ | At the moment I am making an effort to reduce my driving speed | I have recently reduced my usual driving speed |
|---|---|---|
| I am trying to speed less often than I used to | 0.46 | 0.39 |
| At the moment I am making an effort to reduce my driving speed | | 0.44 |

speed less often than they did, and a third (34%) say they have recently reduced their usual driving speed.

A scale was constructed by combining these three items, giving a range of 0–12, a mean of 6.08 with a normal distribution and a Cronbach's alpha of 0.69 for $n = 774$.

Linear regression was used to identify correlates of variability on this scale using Stepwise entry of items from a long list of potential predictors. Five variables met the retention criteria:

1. responses to the item 'Those flashing speed limit signs slow me down';
2. having current penalty points for speeding on their licence;
3. responses to the item 'I am trying to use the car less';
4. number of years driving; and
5. whether they had been flashed by a speed camera in the past three years.

Amongst the variables that did **not** significantly covary with scores on the 'Slowing Down' scale were:

- gender;
- engine size;
- overall opinion of speed cameras;

- road traffic accident involvement; and
- recall of local camera partnership logo.

Other variables which did covary with scores on the 'Slowing Down' scale in univariate comparisons but did not retain a place in the regression equation in the presence of other variables included:

- age;
- social class;
- annual mileage;
- car-driver typology; and
- having ever had penalty points for speeding on their licence.

Table 6 gives the 'Slowing Down' scale scores for the values of those variables that did contribute to the regression equation.

**Table 6 Distribution and univariate significance for variables predicting 'Slowing Down' scale scores**

**Scale mean 6.08**

| | **SA** | **S** | **NAD** | **D** | **SD** | **Significance** |
|---|---|---|---|---|---|---|
| Those flashing speed limit signs slow me down | 14% | 62% | 6% | 16% | 2% | |
| 'Slowing Down' score | 6.93 | 6.28 | 5.17 | 5.19 | 3.62 | $F(4,767) = 13.011$, $p = 0.000$ |
| | **None** | **Some** | | | | |
| Current penalty points for speeding | 84% | 16% | | | | |
| 'Slowing Down' score | 5.87 | 7.18 | | | | $F(1,772) = 28.615$, $p = 0.000$ |
| | **SA** | **S** | **NAD** | **D** | **SD** | |
| I am trying to use the car less | 9% | 40% | 10% | 37% | 5% | |
| 'Slowing Down' score | 7.15 | 6.39 | 6.08 | 5.59 | 5.28 | $F(4,769) = 7.952$, $p = 0.000$ |
| | **0–3** | **4–10** | **11–25** | **26–40** | **41+** | |
| Years driving | 10% | 18% | 34% | 21% | 18% | |
| 'Slowing Down' score | 6.25 | 6.35 | 6.62 | 5.55 | 5.24 | $F(4,768) = 9.288$, $p = 0.000$ |
| | **No** | **Yes** | | | | |
| Flashed by speed camera in last three years | 77% | 23% | | | | |
| 'Slowing Down' score | 5.85 | 6.83 | | | | $F(1,772) = 21.237$, $p = 0.000$ |

# Conclusions

It has been suggested (Stradling, 2003) that all individual travel and transport decisions vary with obligation (What journeys do I have to make?), opportunity (How can I make these journeys?) and inclination (How would I like to make these journeys?). The data here suggest there may be some current changes in inclination amongst Scottish car drivers, a number of whom would appear to be keen to cut their car use, and some of whom are currently slowing down on the road. A range of factors appear to be influencing these two developments, with some degree of overlap between them such that trying to use the car less is statistically associated with trying to cut current driving speed. Further research examining the relative role of fuel price in both these phenomena would be of interest.

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# 7

# Inappropriate high speed: who does it and why?

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## Introduction: speed and the difficulty of the driving task

A collision or road run-off occurs where the demands of the driving task exceed the driver's capability and the driver loses control of the task. There are many determinants of the level of task demand on the driver, some very remote (such as choice of vehicle) and some less remote (such as choice of route). In contrast, others are very immediate, such as the actions of other road users. However, the key determinant of task difficulty, which is under the direct control of the driver, is speed. Speed is important because it determines the 'time window' of opportunity for the driver to detect and recognise what is going on, decide what to do about it and to execute any action decisions (see review by Aarts and van Schagen, 2006).

High speed means a short 'time window' and, if it is too short, it will push the task demand beyond the capability of the driver. Thus level of speed is associated with crash frequency, a relationship which is described as either a power function (Maycock *et al*., 1998; Quimby *et al*., 1999) or an exponential function (Fildes *et al*., 1991; Kloeden *et al*., 1997, 2001). Therefore those who drive fast are more likely to have been recently involved in a crash (Lassarre and Stradling, 2005). Level of speed is also associated with crash severity, which tends to increase exponentially with vehicle speed (Federal Highway Administration, 1998).

## Defining inappropriate high speed

Inappropriate high speed (IHS) – driving too fast for the conditions – can be defined in at least three ways. One way is retrospective and this is used to explain the contributing factor of speed to a collision outcome: 'He was driving too fast on a wet road, lost control of the vehicle and collided with a tree'. Speed has, in such instances, contributed to raising the task demand beyond the capability of the driver.

Note that, even if the driver had remained in control of the vehicle at this high speed, we might still describe the speed as inappropriately high, despite the absence of a crash outcome. This is because at such a speed the driver is driving close to the threshold where task demand might exceed capability. Under these conditions there is no room for error or unexpected events, there is no margin of safety, for example taking account of varying road surface conditions. This is the second way of defining inappropriate high speed. It is encompassed by descriptions such as 'reckless' or 'dangerous' driving. The only real difference between these two definitions of IHS is **outcome**. In the second definition the driver escapes from crashing, in the first he does not.

The third definition is in terms of **violation of traffic law**. An inappropriate high speed is simply one that exceeds the legal speed limit. The important point to note with this third definition is that, although speed may be inappropriate legally, unlike with the other two definitions, it is not necessarily unsafe in the sense that it pushes drivers close to the threshold where task demand might exceed capability. Approximately one in five drivers exceed the speed limit by more than 10 mph on motorways, a proportion that has remained stable from 1998 to 2004 (Broughton, 2005). Eighty-five per cent of UK drivers report exceeding the speed limit when the road is quiet and clear (Carthy *et al*.,1993).

Three points may be made as regards the definition of IHS as exceeding the speed limit. The first is to note that compliance with a speed limit often involves the switching of control decisions from one key mode to a rather different one: in our conceptualisation, from control by task difficulty or feelings of risk to control by speedometer read-out. From the driver's perspective, the speed limit system has the advantage of providing information about the demands of the environment the driver is driving in, of reducing variance in upper speeds and of reducing the severity of the consequences of collisions as well as their frequency. However, the speed limit system requires a kind of 'double standard' in driver control. Speed limits provide only a rough guide to the speed at which the driver can maintain control of the driving task. In fact, the system relies heavily on the ability of drivers to downwardly adjust their speed from the legal limit in order to take account of road and traffic conditions. (Thus, in fact, an IHS may be well below the legal limit.) However, where the speed limit is actually lower than the speed which road and traffic conditions would dictate, drivers are forced into conflict with the law – unless, of course, they switch control to feedback from the speedometer.

In relation to this conflict, Stradling *et al*. (2003) found in a sample of 1,000 Scottish drivers that only 30% of male drivers and 45% of female drivers agreed that speed limits on motorways should not be broken at all. The figures for 'other roads' were, respectively, 43% and 55%. Furthermore, as concluded by the Federal Highway Administration (1998): 'In general, changing speed limits on low and moderate speed roads appears to have little or no effect on speed and thus little or no effect on crashes. This suggests that drivers travel at speeds they feel are reasonable and safe for the road and traffic, regardless of the posted limit.' Similarly, Larsen (1995) concluded that 'drivers to a certain extent assess what speed level they find reasonable in a specific situation. And if the road design more or less invites to drive faster than the speed limits allow, which was in fact the case on some of the road sections where we found the highest speeds, it is an important factor behind speed choice' (p. 9). Thus it is no surprise that Silcock *et al*. (2000) found that three of the eight most common reasons given by UK drivers to justify their speeding were:

- 'It was unintentional';
- 'I think the limit is wrongly set for this location'; and
- 'I don't think the same speed limit should apply at all times (the empty road, at night)'.

These reasons all suggest that the drivers considered they were driving at an appropriate speed at the time their violation was detected.

The second point to be made as regards the definition of IHS as exceeding the speed limit is that the safety problem here is likely to be more as a result of significant deviation from average speeds as opposed to the absolute value of average speeds themselves. What might underpin the relationship between speed and crash involvement, at least in part, is not the absolute level of flow speed *per se* but the impact of drivers who are significantly above mean flow speed who both raise the mean flow speed and collision frequency. In their recent review, Aarts and van Schagen (2006) conclude that driving faster than the surrounding traffic does increase the risk of crashing. Speeds 5 km/h above the average in urban areas and 10 km/h above the average in rural areas double the risk of a casualty crash. According to the Australian Transport Safety Bureau (www.atsb.gov.au/publications/2001/rural_speed_1.aspx), vehicles travelling 20 km/h above the average speed on rural roads have about six times the casualty crash involvement of vehicles travelling at average speed.

The last point to be made as regards the definition of IHS as exceeding the speed limit is that there is good evidence for a relationship between the degree to which a driver violates driving regulations and accident involvement. Parker *et al*. (1995) obtained information from 1,373 UK drivers on their accident record over a total of six years and self-reports of driving behaviour, collected in the middle of the period. The frequency of committing driving violations (which included disregarding the speed limit late at night or very early in the morning, overtaking a slow driver on the inside lane and tailgating a driver to signal s/he should go faster or get out of the way) was associated with involvement in active loss-of-control accidents, independently of age, sex and years with a full licence. The strength of the relationship declined with increasing age and experience. In a study focusing exclusively on the behaviour of women drivers (Dobson *et al*., 1999), the same pattern of violations was found for young women drivers (mean age 21.8 years). In fact, the younger women scored higher than older women drivers (mean age 48.7 years) on all eight items of the Driving Behaviour Questionnaire (DBQ) violations scale. They also had three times as many accidents in the previous three years and the number reporting more than one accident was seven times greater.

Notwithstanding this observed relationship between driving violations in general and accident involvement, it should be noted that because measures of speeding behaviour (e.g. 'Do you exceed the speed limit in built-up areas?' 'Do you exceed the 70 mph speed limit during a motorway journey?') were not clearly associated with particular types of active accident in the Parker *et al*. study, it was suggested that active loss-of-control accidents owe more to **a failure to adjust speed to the prevailing conditions** rather than to high speeds per se. The same conclusion was reached in relation to young male driver accidents by McKnight and McKnight (2003) in their analysis of over 2,000 police narrative descriptions of non-fatal accidents in two states of the US. Consistent with this is the conclusion from a study, in which participants drove a 50 km route in an instrumented car, that accident-involved males adjusted their speeds to changing conditions less than accident-free males (Wilson and Greensmith, 1983).

# Are there different types of driver with regard to speed choice?

Turning now to the definition of IHS in terms of driving close to the threshold where task demand might exceed capability (that is driving at such a speed that there is a high workload, little capacity for coping with unexpected events, little room for error – where there is, in brief, no margin of safety), we would like to ask the question: are there different driver types? Accumulating evidence suggests, indeed, that there are and there appears to have been a disproportionate emphasis in the published research literature concerning the first type described below: the high risk threshold driver.

## High risk threshold drivers

In our conceptualisation (see Fuller, 2005) drivers drive in such a way as to keep feelings of risk below some threshold level (which may be a zero risk feeling). If the behaviour of other road users, or the driver's own behaviour (such as an increase in speed) should stimulate an increase in feelings of risk above this threshold level, then the driver will take action to bring the level of felt risk back down, such as by reducing speed. Thus the driver's risk threshold may be defined as the point above which risk is felt to be too great. (Note that risk threshold is not the same as the target of **statistical** risk, advocated, for example, by Wilde (2001)). There appears to be a category of drivers who typically drive with a very high risk threshold.

Clarke *et al*. (1999), using a procedure of 'structured case interpretation', analysed the police files of 973 overtaking accidents which occurred in Nottinghamshire from 1989 to 1993 inclusive and found that 41% of overtaking accidents of inexperienced drivers were associated with travelling at excess speed. In a later study, Clarke *et al*. (2005) analysed 1,296 detailed reports of the accidents of 17–25-year-old drivers which occurred in the years 1994 to1996 in the UK. They found that these accidents were frequently the result of voluntary 'risk-taking' factors rather than caused by 'skill deficit' factors. Speed dominated the risk-taking factors, being involved in approximately 26% of the 'to blame' cases and contributing to an even larger proportion of accidents in the hours of darkness. In contrast, alcohol was a factor in only about 7% of 'to blame' cases. Recklessness, as in racing or exceptionally high speed, appeared in approximately 6% of 'to blame' cases (which also increased in the hours of darkness) and risky overtaking in about 2%. Clarke *et al*. (2005) concluded that: 'Darkness seems not to be especially dangerous in itself, rather it is the young drivers' reasons and attitudes towards driving in the evening that put them at increased risk of accident. Deliberate speeding, recklessness and excessive alcohol consumption seem to be the main problems' (p. 528).

In the McKnight and McKnight (2003) study, over 20% of accidents for drivers aged 16–19 years were attributed to inappropriate speed, with younger drivers having a greater proportion of their accidents associated with driving too fast for the conditions. A similar picture was reported from an analysis of the 1995 database of 225,589 crashes in Florida. Young drivers were found to be over-involved in crashes related to speeding, crashes on curves that resulted in an overturn or were head-on or involved running-off-road (Abdel-Aty *et al*., 1999). They were also over-involved in crashes at weekends and crashes at night. Dobson *et al*. (1999) found that 11% of young women (mean age 21.8 years) who were involved in accidents in the previous three years said that they were driving too fast at the time of their most recent accident. This contrasted with 4% in a group of older women (mean age 48.7 years).

As suggested by Evans (1991) to be 'almost a law of nature', the young speed-related crashing driver is more likely to be a male. Monarrez-Espino *et al*. (2006) found that in the first year of licensing, the Swedish male single-vehicle crash rate was five times that of females. Furthermore, males have a personal injury crash earlier in this first year and male crashes were more likely to be fatal, indicating higher speeds at the point of impact. The majority of these crashes occurred during non-working hours.

Males are also more likely to become persistent risky drivers (Begg and Langley, 2004), defined as those individuals who sustained engagement in risky driving between the ages of 21 and 26 years. In fact, there was very little evidence of any persistent risky driving amongst the 26-year-old females. The most prevalent risk behaviours were exceeding the open road speed limit by at least 20 km/h (males 17%, females 2%) and driving fast for the thrill of it (males 7%, females 1%).

The consequences of these risky driving behaviours are perhaps illustrated by a study of self-reported risky driving and injury variables in a sample of over 21,000 New Zealand drivers (Blows *et al*., 2005). Drivers who reported frequently racing a motor vehicle for excitement and driving at 20 km/h over the speed limit in the previous year were two to four times more likely to have been injured in the same time period. They also had a higher number of traffic convictions. Similarly, Stradling (2005) found, in his analysis of speeding behaviour and collision involvement of Scottish car drivers, that twice as many males were speeders (i.e. had ever been stopped by the police for speeding or flashed by a speed camera in the previous three years) and nearly twice as many speeders had been involved in a collision as a driver.

Despite the increased participation of female drivers over the past two decades, the differences in accident patterns between female and male drivers has remained stable (Laapotti and Keskinen, 2004). Young male driver fatal crashes are more likely to be associated with speeding. Laapotti and Keskinen found that the speed limit was exceeded in nearly half of all cases and in 47% the driver crashed off the road.

A recent study by Musselwhite (2006) also highlighted the propensity of young male drivers to adopt inappropriate speeds. In his study, 1,686 drivers approached at motorway service stations and local garages along a holiday route in the south of England during summer months completed a questionnaire concerning the frequency with which they engaged in various, mainly unsafe, driving behaviours in 30 mph zones. Questionnaire items were based on the findings of 47 semi-structured interviews. Using hierarchical cluster analysis, Musselwhite was able to identify four clusters of drivers, two of which were strikingly contrasted. One group he labelled 'continuous risk takers' and would be equivalent to the driver type we have labelled high risk threshold drivers. The behaviour of this group included fast acceleration and heavy braking, driving faster than 30 mph even if it felt unsafe to do so and overtaking a slow vehicle even if it meant an oncoming vehicle had to slow down or take some other avoiding action. They were also the least likely to reduce their speed if they realised they were travelling faster than they thought they were. This group drove the most number of miles per week (mean of 143 miles per week – 43% more than a contrasting group), but the striking point here is that 90% were male and they were the youngest group with a mean age of 26.4 years. This group comprised 14.4% of the total sample.

Clarke *et al*. (2005) present a striking image of the fundamental 'illusion of control' error made by young drivers in assuming that they can drive safely at a level where task demand is so high that it is dangerously close to the limits of capability. Young drivers 'talk and behave as if this envelope – the dividing line between accident-free driving and collision – is visible, precise and stable … But … they are prancing on a crumbling cliff, not a hard edge. If this gives way, it will do so without warning, without apparent cause, and without the chance of recovery. No one can tell exactly where the danger zone begins. There is no clear line between safety and catastrophe. And what division there is, is constantly changing.' Clarke *et al*. conclude that 'Given that "the envelope" works like that, the **only** requirement is to keep well away from the edge' (p. 529).

A key question in relation to understanding the behaviour of these drivers further is whether or not their objectively high levels of task difficulty and risk threshold are intentional or not. If they overestimate their capability, then task difficulty will be subjectively lower than it should be and the task will appear more controllable than it actually is – a similar result arises if their feelings of risk are lower than ought to be warranted by the situation. These drivers would be surprised when the cliff crumbled away from beneath them. On the other hand, perhaps these drivers are deliberately driving close to the upper level of their capability and thus have a high risk threshold. Perhaps these drivers are knowingly throwing caution to the wind, for whatever motive(s), approaching the edge of the cliff and taking the chance that it might give way at any moment. The most dangerous scenario is when both of these interpretations apply: the driver deliberately accepts a high level of risk but is simultaneously poorly 'calibrated' – the risk accepted is objectively higher than the driver realises. The unstable cliff extends much further inland than the driver perceives.

# Attitudes and behaviour in relation to high risk thresholds

Ulleberg and Rundmo (2002) explored the relationship between self-reported attitudes and self-reported risk-taking behaviour in a sample of 3,942 Norwegian participants aged 16–23 years. Eleven dimensions of risk-taking attitudes were identified, including speeding ('I think it is OK to speed if the traffic conditions allow you to do so'), progress-motivated non-compliance with traffic rules ('sometimes it is necessary to break the traffic rules in order to get ahead') and joyriding ('driving is more than transportation, it is also speeding and fun'). The highest correlation amongst all dimensions ($r$ = 0.68) was between speeding and progress-motivated non-compliance with traffic rules. Males scored significantly higher than females on the three dimensions identified here and all three dimensions correlated significantly with self-reports of risk-taking behaviour ($r$ = 0.45 in all cases). The global measure of driver risk-taking behaviour included items on fast driving, speeding, running red and amber lights, tailgating and responsiveness to peer pressure.

# Relationship to near accidents and actual collisions

Iversen and Rundmo (2004) examined the relationship between attitudes to traffic safety issues and self-reported risk behaviour in traffic and the relationship between these variables and involvement in near accidents and actual accidents in a representative sample of 2,614 Norwegian drivers. Principal component analyses identified three underlying **attitude** dimensions. The first and the one most relevant to this review they labelled 'attitude towards rule violations and speeding'. Component attitudes loading highly on this factor are:

- speed limits are exceeded because they are too restrictive;
- when road conditions are good and nobody is around driving at 100 mph is ok;
- it makes sense to exceed speed limits to get ahead of 'Sunday drivers';
- taking chances and breaking a few rules does not necessarily make bad drivers; and
- if you are a good driver it is acceptable to drive a little faster.

Such attitudes were endorsed (agree or strongly agree) by 11% of the entire sample and rejected (disagree or strongly disagree) by 28% of the sample. Twenty-three per cent believed that, when road conditions are good and nobody is around, driving at 100 mph is fine and 28% that it makes sense to exceed speed limits to get ahead of 'Sunday drivers'.

Seven dimensions were found to underlie risk-taking **behaviour**, the first two of which were entitled 'violation of traffic rules and speeding' and 'reckless driving/fun-riding'. These were the most strongly correlated of the dimensions ($r$ = 0.63). Component behaviours loading highly on these two factors are listed in Table 1. Males, younger respondents and those holding a licence for a shorter time (less than 10 years) were more likely to both hold unsafe attitudes and admit to unsafe behaviour in traffic.

With regard to near and actual accidents, over 15% of respondents had experienced an injury accident and 68% had been involved in a damage-only accident. Eighty-two per cent had experienced a near-accident as a driver. Structural equation modelling (LISREL analysis) revealed that risk behaviour was strongly linked to driver attitudes, independently of driver sex, age and experience (period the licence held). Similarly, risk behaviour was found to be strongly linked to involvement in near accidents and actual collisions, explaining 21% of the total variance.

# Psychosocial functions of speeding

Table 1 **Component behaviours loading on the dimensions 'violation of traffic rules and speeding' and 'reckless driving/fun-riding' (rank order)**

| |
|---|
| **Violation of traffic rules and speeding** |
| Break 80–90 mph speed limits by more than 10 mph |
| Drive faster to make up for delays in making an appointment |
| Overtake the car in front, even when it keeps appropriate speed |
| Ignore traffic rules to proceed faster |
| Break 50 mph speed limits by more than 10 mph |
| **Reckless driving/fun-riding** |
| Drive too close to the car in front to be able to stop if it should brake |
| Drive without enough safety margins |
| Keep driving when you are tired and actually need a break |
| Create dangerous situations because you are not attentive enough |
| Are distracted because of things happening around you while driving |

Moller (2004) explored the psychosocial functions of driving using focus groups of young Copenhagen drivers (*n* = 29) representing two broad education exit levels, roughly equivalent to secondary and tertiary education. Driving was used as a means to attract attention, to identify with adult status and to assimilate status through fast and assertive driving, as an opportunity to express and demonstrate mastery of the task, particularly under conditions of high task demand, and as a means to express and exploit a new-found mobility. An early departure from full-time education was associated with 'driving as a shared and worshipped activity thereby creating the basis for the use of the car as a tool for self-expression, show-off, competing and entertainment with friends through risk-taking behaviour' (p. 1086). It was concluded that the driving behaviour of young drivers is influenced by motives other than driving safely and that norms within the peer group influence the manner and extent to which these motives are expressed in driving behaviour.

Exploring the relationship between 'life-style factors' and types of aberrant driving behaviour, Chliaoutakis *et al*. (2005) found that 'driving without destination' was the most significant predictor of driving errors (measured with a modified version of the DBQ, the one of only two factors associated with violations. About 10% of respondents reported they often drove with no destination in mind and almost one third reported driving this way more often than 'rarely'.

# Personality

Looking at more distal personality type factors, sensation-seeking is a trait defined in part by the seeking of intense sensations and the willingness to take physical, social, legal and financial risks for the sake of such experiences (Zuckerman, 1994). Scores on Zuckerman's Sensation Seeking Scale strongly predict preferred driving speed (Sümer, 2003; Jonah *et al*., 2001). Drivers who score relatively highly are more likely to receive higher scores for risky driving (Dahlen *et al*., 2005), commit driving violations and to crash (Jonah, 1997). Of the 40 studies reviewed by Jonah (1997), only four did not find a significant positive relationship between sensation-seeking and some aspect of risky driving, a relationship which has been observed among drivers in the UK, Finland, the Netherlands, Norway, Sweden, Canada and the US. High sensation-seekers are also more likely to report aggressive driving habits (Jonah *et al*., 2001).

High sensation-seekers are clearly opting for a higher level of task difficulty or a higher acceptable feeling of risk than other drivers. They are also less likely to take account of impaired capability in managing task difficulty (McMillen *et al*., 1989). Thus, in terms of exposure to risk, the sensation-seeker is perhaps doubly disadvantaged, on the one hand disposed to seek the thrill of operating close to the threshold where the level of task demand meets the upper level of capability, at the same time making no adjustment in task demand to compensate for impaired capability. High sensation-seekers perceive less danger in risky driving behaviour (Jonah, 1997).

Begg and Langley (2004) found that drivers who persisted with fast driving for thrills and exceeding the speed limit by more than 20 km/h at age 26 years were typified by low scores in self-control, harm avoidance and traditionalism at age 18 years, as well as a disposition to aggressive behaviour, as measured on a self-report delinquency scale. Using video sequences of potential hazards and a measure of the latest point at which drivers were prepared to take avoiding action, Arendasy *et al*. (2005) claim to have identified a one-dimensional latent personality trait, which can be interpreted as 'subjectively accepted amount of risk'.

# Low risk threshold drivers

The second group in Musselwhite's (2006) study, who contrasted dramatically with the high risk threshold group, were labelled 'unintended risk takers'. They were characterised by a relatively low frequency of unsafe behaviours, consistent with sustaining a low level of risk threshold. These drivers were the most likely to reduce their speed if they realised they were travelling faster than they thought they were and they were least likely to change their behaviour when there was a motive to raise their task difficulty or risk threshold (such as when in a hurry). This group had slightly more females (53%) than males but was the oldest of the four groups, with a mean age of 41.9 years. The group comprised 38.7% of the total sample.

# Opportunistic drivers

One of the two remaining groups identified by Musselwhite (2006) was labelled ‘calculated risk takers’ (here labelled ‘opportunistic’), comprising about 23% of the total sample of drivers. This group, who were mainly male (69%), did not let negative feelings affect their speed or risk threshold when late. Nevertheless, they were quite likely to use a different lane from other traffic going in the same direction to avoid being held up and to go faster than the 30 mph limit if it felt safe. Their behaviour seems somewhat consistent with the driving styles identified in two earlier studies. Adams-Guppy and Guppy (1995) found that company car drivers who more frequently exceeded the speed limit on UK motorways were more likely to rate themselves as confident, aware and impatient drivers and to rate speeding as less important as a risk factor. They also felt under more time pressure. Larsen (1995) found that drivers who were observed to drive faster than others report that they often exceeded speed limits, felt uncomfortable driving behind a speed-compliant vehicle through a town or one that was going slower than themselves and regarded it as more important to adjust their speed to that of faster others or to the physical road environment than to comply with the speed limit. Thus they do not check their speed on their speedometers, which they saw as a distraction from attention to other road users. They considered that speed limits should be higher, especially on major urban roads, and they saw no special importance for safety to exceed the limit by 15 km/h.

# Reactive drivers

The last group identified by Musselwhite (2006) was labelled ‘reactive risk takers’, again comprising about 23% of the total sample of drivers. These drivers were, in some respects, like the high risk threshold group (continuous risk takers) in responding to motives to drive faster (e.g. driving faster when in a hurry and increasing the gap if a car was close behind) and, in particular, they were also likely to exceed the 30 mph limit when feeling angry, annoyed or irritated. Unlike the continuous risk group, however, they did not drive faster than 30 mph when it felt unsafe, neither did they engage in dangerous overtaking or use other lanes to get ahead. This group was mainly female (73%).

With regard to driving faster when in a hurry, Adams-Guppy and Guppy (1995) questioned 572 British company car drivers and found that around 20% agreed with the statement that it was important to be punctual for appointments, even if it meant breaking the speed limit. This variable accounted for 13% of the variance in reported speeding behaviour. Stradling (2005) found, on the basis of in-home interviews of quota samples of drivers in Scotland, that the most prevalent reason given for driving faster than usual was ‘when late for a meeting or appointment’ (55%). Silcock *et al*. (2000) found that ‘being in a hurry’ was one of the eight most common reasons given by UK drivers for speeding. The important point for our purposes, however, is that compared to normal, when in a hurry drivers are significantly more likely to use fast acceleration and hard braking and overtake dangerously (Musselwhite, 2006). Unweighted mean ratings of speed-related behaviours associated with being late are rank ordered in Table 2.

Anger as a factor influencing speed has also been identified in a number of other studies. Thus, Sümer (2003) found that self-ratings of aggressive tendencies are positively correlated with driving speed. Furthermore, in a representative sample of

US drivers, self-reported levels of angry/threatening expressions of road rage were significantly associated with habitually exceeding the speed limit, receipt of moving-violation tickets in the previous year and crash experience (Wells-Parker *et al*., 2002). Angry/threatening behaviours included speeding past others to express displeasure, preventing others from

entering a lane or from overtaking, chasing another driver or making a sudden threatening move, tailgating and trying to cut another car off the road. In a sample of mainly female young drivers, Dahlen *et al*. (2005) found links between self-reported

Table 2 **Unweighted mean ratings of speed-related behaviours associated with being late (after Musselwhite, 2006)**

| Speed-related behaviour | Unweighted mean (1 = never, 7 = always) |
|---|---|
| Use other lanes to get ahead | 5.17 |
| Use faster accelerating and heavy braking | 4.77 |
| Go faster than 30 mph limit | 4.73 |
| Tailgate | 4.05 |
| Overtake dangerously | 3.33 |

feelings of anger (and impulsiveness) while driving and a self-reported measure of risky driving, which included speeding.

# Conclusions

We should, of course, recognise that there is some considerable degree of overlap between the ratings of the different groups identified by Musselwhite (2006). Nevertheless, this study has important implications for our understanding of the process of IHS. First it appears that there is one group of drivers who drive more or less continuously with a high risk threshold, relative to others. These are mainly, but not exclusively, young, male and inexperienced drivers. Their behaviour is associated with particular attitudes, which may be supported by a particular lifestyle and culture of driving, and the use of a car simply for pleasure and self-expression as opposed to transport. They may be poorly 'calibrated' in the sense that there are important discrepancies between their perceived and actual levels of capability and driving task demand. Some of this group, especially those who are low in self-control, harm avoidance and traditionalism, who are disposed to more aggressive behaviour and sensation-seeking, will continue to drive fast just for the thrill of it and will exceed the speed limits by significant amounts. These may be defined as continuing high risk threshold drivers. Such people are unlikely to be female. Others, as they mature into a different lifestyle and culture, as their uses of driving necessarily become more functional, and as they gain more experience of the contingencies of speed and its consequences, will move into one of three other groups. One group will sustain a low risk threshold level and will not allow motives that might raise it (such as being in a hurry) or that might reduce their safety margin to influence them. They will also actively comply with the speed limit. These are the low risk threshold drivers. In contrast, there is another group, the 'opportunistic drivers', who are prepared to increase their speed as the task demand decreases, even if this means going over the speed limit. Nevertheless, they too do not allow motives that might reduce their safety margin (such as being in a hurry) to influence them. Finally there is a group of 'reactive drivers' who do allow feelings to influence speed choice and who are prepared to raise the difficulty level and reduce their safety margin if they are angry, annoyed or irritated, in a hurry or to escape a close follower. However, this group is sensitive to feelings of risk and avoids exceeding their personal risk threshold.

These emerging distinctions raise a number of questions, apart from the obvious issue of replicability. There must be some sort of developmental shift in driver behaviour, with drivers moving out of the high risk threshold group as described above. What would be particularly useful in understanding this process further are longitudinal studies, such as that reported by Begg and Langley (2004). Furthermore, are there drivers in the low-risk, opportunistic and reactive categories who actually start out that way? Are their different driver characteristics stable over time, and are their differences of constitutional origin or the result of accumulated experience or some transaction between these two influences? How do the different groups contribute to collision frequency and severity and crash type? And finally what might be the implications of identifiable driver types for the design and focus of different safety interventions?

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# 8

# Should speed awareness courses be only about speed?

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Within professional circles the relationship between speed and crash involvement is uncontroversial. It is fairly clear that if drivers obeyed the speed limits there would be a significant reduction in the number of casualties. The issue then is what should be done about speeding. The issue of action is complicated by the sheer numbers of people who break the law. For example, in 2000 66% of cars were breaking the 30 mph limit. In 2005 this figure had come down to 50% (Department for Transport, 2005). While this represents a considerable shift in law breaking, a significant problem remains. When authorities are faced with such a high proportion of law breaking they are presented with a dilemma. Do they have a mandate for enforcing a law that so many break? The response to this dilemma has been to design enforcement practices that the public will perceive as legitimate. As Tyler (2006) has noted, 'Being legitimate is important to the success of authorities, institutions and institutional arrangements since it is difficult to exert influence over others based solely upon the possession and use of force.' In principle a massive increase in police enforcement either directly or indirectly through technology would produce an increase in compliance but, in practice, the public would have to sanction such an increase in resources and the perceived legitimacy would be a key issue. Future technological solutions that control or limit the opportunity of the car will again be dependent on the perceived legitimacy of such action.

The argument presented here is that public policy on speed control, whether by traditional engineering, traditional policing or by newer technological means, will be dependent on the perceived legitimacy of such action. One current approach to address the perceived legitimacy issue of speed control is to offer speed awareness courses as an alternative to punishment. It has been shown that these courses can increase the perceived legitimacy of speed control by a factor of three (McKenna, 2005). The number of these courses is increasing and the opportunity is there for these courses to be a major health intervention, accessing thousands of drivers each week. A question then arises as to whether these courses should be viewed narrowly, focused entirely on speed, or more generally on high-risk driver behaviour. A related issue is whether we should see these courses in the context of general retraining/re-assessment. It is frequently noted that driving is unusual in that it is one of the few skills that receives no further training or assessment. Of those attending speed awareness course, 94% have received no training since passing their test. Stradling *et al*. (2005) have noted that re-assessment might be based on either a time-based principle (e.g. every five years) or incident-based (traffic offence or accident). Speeding offences could then be seen as the trigger for attendance at a course.

The content of the course would then be dependent on the context in which the course is viewed. If viewed narrowly, then speed would constitute the only focus for the course. The justification for the narrow focus would be that there is a natural justice in focusing directly on the issue that triggered the offence. Whether one viewed the course narrowly or more generally, speed would remain a key factor given its importance in crash and casualties. The issue then is whether there is a rationale for the inclusion of topics other than speed. Clearly if accident involvement is the overriding concern, then other areas such as close following, general driving violations, hazard perception and fatigue would all constitute legitimate areas. The fact that 94% attending these courses have, since passing their test, received no feedback would indicate that there is considerable opportunity to provide drivers with some feedback. This raises a separate question as to whether the current driver system provides opportunities for feedback on factors such as close following, general driving violations, hazard perception and fatigue. At one level it is fairly obvious that the information is available to drivers to work out their relative positions on these factors, since it is possible to observe oneself and others. However, a range of egocentric and self-other biases may render these judgements unhelpful, as is illustrated by the tiny proportion of drivers who consider themselves less skilful than average (McKenna, in press). At a formal level, red light cameras offer the possibility of feedback on at least one type of violation. However, there are minimal opportunities to provide feedback on close following, hazard perception and fatigue. It would appear then that one argument for the inclusion of these other areas is simply that there is no alternative method of providing this feedback that is widely available. If these areas do merit attention, then feedback via speed awareness would merit further attention.

At an empirical level there is an issue as to whether it is the same people who engage in speed who also engage in these other high-risk behaviours. To investigate this issue, two methods were chosen. The first method was to examine the correlations between speed choice and the other risk behaviours. The second method was to examine the extreme ends of the risk behaviours to determine if those who were high versus low in their speed were more or less likely to follow closely etc.

# Method

## Participants

A total of 10,057 drivers attending speed awareness courses participated. Of those attending the course, 5,843 were men and 4,214 were women. Age was determined in large part by participants responding in five-year ranges, for example 26–30. At the young end, an exception was made such that, up to age 20, drivers specified their actual age. The modal age of those attending the courses was 36–40 years of age.

## Procedure

As part of the session, drivers took a computer assessment that provided each driver with an overall Driver Risk Profile which provided tailored feedback depending on the driver's position on each scale. 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. Reliability was assessed by Cronbach's alpha and found to be 0.87 for speed, 0.94 for close following and 0.89 for hazard perception. On finishing the assessment, drivers received a five-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 the participants in the discussion, which was designed to cover both perceived barriers to enforcement and how speed is connected with accident involvement. The latter is illustrated through examining the personal speed choices of the participants.

# Results

In Table 1 the Pearson product-moment correlation is employed to examine the relationship between speed choice and the other high-risk behaviours.

Table 1 **The relationship between speed choice and high-risk behaviours**

| | Close following | Violations | Asleep at the wheel | Hazard Perception |
|---|---|---|---|---|
| Speed | 0.300<br>$n$ = 8,830 | 0.310<br>$n$ = 8,829 | 0.103<br>$n$ = 8,830 | 0.077<br>$n$ = 8,829 |

Given the large sample size, all the correlations are highly significant, even the correlation with hazard perception is highly significant, $p < 0.001$. In terms of conventional levels of effect size, then one would say that none of the relationships was large. The direction of the relationship is as you would anticipate for the standard risk factors. In other words, higher speed choices are associated with greater close following, more violations and more falling asleep at the wheel. The relationship with hazard perception, small though it is, indicates that faster speeds are associated with poorer hazard perception.

The alternative method chosen to investigate the relationship between speed and the other high-risk behaviours was to look at the top and bottom 10% of speeders and consider whether there is an association with the top and bottom 10% of each of the risk behaviours. In examining the relationship with falling asleep at the wheel, the issue was whether those in the top 10% in terms of speed choice were more or less likely to have fallen asleep at the wheel than those in the bottom 10% in terms of speed choice. These relationships were examined by using a logistic regression to determine whether being high or low in speed choices was associated with being high or low in each of the other risk behaviours (Table 2).

Table 2 **The odds of high versus low speed choice being associated with each of the risk behaviours (CI refers to confidence intervals)**

| | Close following | Violate | Asleep | Hazard perception |
|---|---|---|---|---|
| Speed | 37.5<br>CI 21.7 to 64.6 | 29.2<br>CI 16.9 to 50.4 | 2.5<br>CI 1.9 to 3.2 | 2.7<br>CI 1.8 to 4.2 |

We can see then that those who are in the top 10% in terms of speed choice are relative to the bottom 10% in terms of speed choice;

- 38 times more likely to be in the top 10% of close followers;
- 29 times more likely to be in the top 10% of violators;
- 2.5 times more likely to have fallen asleep at the wheel in the last two years; and
- 2.7 times more likely to be in the poorest 10% in terms of hazard perception.

None of these effects are dramatically affected by controlling for age and mileage. Whether one considers that there is much of a relationship between these risk factors will be determined by whether you are interested in the relationship across the distribution. From the correlations it is clear that speed choice is significantly associated with each of the risk behaviours but that the relationship is not large. If you look at the extreme ends of speeding, then those who are at the top end of speeding are more likely to be at the top end of the risk behaviours for each of close following, violations, falling asleep at the wheel and hazard perception.

# Discussion

It is fairly clear that at an empirical level speed choice as measured in the present assessment system is related to the other high-risk behaviours. Across the entire distribution of responses, the relationship between speed and the other risk factors is significant but not large. At the extreme end of the distribution there is an indication that those most inclined to choose fast speeds are more likely to be at the extreme end of close following, driving violations, hazard perception and are more likely to have fallen asleep at the wheel. Depending on your position, perhaps the most unlikely relationship is between speed choice and hazard perception. If you consider Reason *et al*. (1990), they have argued that risk taking violations such as speed are separate from skill-based factors such as hazard perception, and that violations and errors will require different remediation. It is fairly clear that, across the whole distribution, violations as measured by speed choice are different from skills as measured by hazard perception. The interest here is twofold. First, the relationship that does exist is that those who choose faster speeds are poorer at hazard perception. That raises the possibility that part of the problem of high speed choice may be causally related to poorer hazard perception. The second issue concerns remediation. Do violations and skills require different forms of remediation? We have examined this issue recently by training drivers on hazard perception and examining if there is any effect on speed choices as assessed by a video speed test

(McKenna *et al*., 2006). If violations and skill do require different remedial action, then training drivers on hazard perception should have no effect on speed choices. However, as noted, it is possible that at least part of the speeding problem is due to the failure of hazard perception. If that is the case, then training in hazard perception could reduce speed choices at least in the presence of hazards. To examine this issue McKenna *et al*. (2006) trained one group on hazard perception and compared them to a control group who did not receive hazard perception training. Both groups were then presented with speed choices from hazardous and non hazardous scenes, with the prediction that there would be an interaction such that those trained in hazard perception would choose selectively slower speeds for the hazardous scenes. This prediction was confirmed. The very fact that speed choice could be changed by a hazard perception measure might, in itself, be an argument that speed awareness courses might include factors other than only speed. The argument here would be that even if the aim of the speed awareness course was defined narrowly, then other factors might be included.

As noted in the introduction, there are arguments for considering speed awareness courses in a more general context. For a life skill with so much opportunity for negative outcome, it would appear anomalous that having passed a minimum criterion driving test, usually at a young age, no further assessment or feedback is provided. This has remained a longstanding issue. On the issue of feedback it might be thought that on a factor such as speed choice, drivers would need relatively little feedback since they can observe their own speed and the speed of other drivers. However, Walton and Bathurst (1998) found that between 85% and 90% of drivers claimed to drive slower than the average driver. If an assessment and feedback system were to be offered, then something would have to act as a trigger. Time could act as a trigger in the sense that after a set period driver feedback and assessment could be automatically required. Interestingly, Stradling *et al*. (2005) note the results of a survey in which the majority (57%) report that they are in favour of periodic refresher training. The alternative trigger is that it could be incident-based. Such an incident-based scheme is in operation through speed awareness schemes, though the aims of these schemes, in terms its specificity versus generality, is less clear. Implicitly, the title of speed awareness schemes would imply specificity, but it could just as readily be considered an offence-based trigger for general driving risk schemes. The fact that there is some relationship between the risk factors does mean that in identifying those who are at the higher end of speed choice, one is more likely to be targeting those who are at the higher end of other risk behaviours. In addition, it is clear that accidents involve factors other than speed, so including factors such as fatigue, close following and hazard perception can be supported. Indeed, there is an issue as to how these other risk factors might be targeted at all. The detection of fatigue on the road is not readily achievable so, in practice, the identification of fatigue as an issue is most likely to follow the investigation of a serious crash rather than, as one would prefer, to precede it. While it is not readily possible to detect fatigue on the road, it is possible to identify and provide feedback on specific personal risk factors. For this to work, feedback on fatigue would need to be triggered by an event other than the detection of fatigue on the road.

Close following is an interesting issue because it is possible to deliver feedback to drivers by both in-car and roadside measures. In-car devices can measure the gap between the driver's vehicle and the vehicle in front. In addition, the driver can be given online feedback and warnings when close following is taking place. Shinar and Schectman (2002) have shown that these warnings do produce a significant increase in headway. Unfortunately, these devices with feedback systems are not currently fitted to many vehicles so drivers receive little feedback through this measure. An alternative is to provide drivers with feedback through a roadside device that measures the gap between vehicles and signals to the driver that the gap is too small. Again, while this technology is available, it is not employed on a wide scale so drivers receive little feedback on close following through this measure. Another close following measure is to employ markings on the road to provide drivers with feedback. Again this measure is rarely employed so, overall, drivers receive little feedback on close following. The overall result is that, although a two-second gap is recommended, when we measure the gap the mean is just over one second.

Feedback on hazard perception is, in principle, available when one drives and observes other drivers. In theory, drivers could work out their relative hazard perception skills and, if this were the case, we would expect a strong correlation between drivers' ratings of their hazard perception skills and their objectively measured hazard perception skills. The correlation between self-rating of hazard perception and objectively measured hazard perception is $r = 0.055$, $n = 8{,}828$. While the correlation is significant and in the appropriate direction the relationship would hardly be considered strong, it would appear then that drivers have little opportunity to receive realistic feedback on hazard perception.

If it is considered that drivers would benefit from feedback and education on issues such as close following, general driving violations, fatigue and hazard perception, then mechanisms need to be put in place. At present speed awareness schemes offer that prospect. In other words, speed awareness schemes offer the possibility to put on offer an opportunity that has not hitherto been available, namely refresher training/feedback on a wide scale. The advantage of speeding as a trigger is that speed choice is related to crash involvement, it is transparent, readily measured, is related to other risk factors and can be implemented on a wide enough scale to form the basis of a refresher retraining and feedback system. In the context of general rehabilitation, it would clearly make sense to consider all the major risk factors. Given that, at present, for the majority of drivers this is a unique opportunity to experience feedback and education, the aim must be to maximise the safety benefits.

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# 9

# Evidence-based behavioural change for speeding drivers

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## Introduction

Excess speed is a contributory factor in the majority of crashes, and so encouraging motorists to drive at speeds appropriate for the conditions may prevent serious injuries and save lives. In order to achieve this, speed awareness courses have been introduced for drivers detected speeding at just above the enforcement limit, typically 36–39 mph in a 30 mph zone. These courses aim to promote awareness of the negative consequences of driving at higher speeds, such as the increased likelihood of being involved in a crash and the risk of more severe injuries in the event of a crash, and therefore enable drivers to make informed decisions about their driving speed. A substantial body of work has been undertaken to examine the predictors of speed choice, and much of this research has utilised the Theory of Planned Behaviour (Ajzen, 1991). However, less work has been undertaken on the effectiveness of interventions aimed at reducing driving speed.

## Literature review of interventions to change speeding behaviour

A review of the literature of interventions to reduce speeding was conducted. The principles of systematic review were adopted: rigorous and reproducible methods applied to synthesise the available evidence. The methodology for the review, including search strategy and terms, inclusion screening and data extraction is found in Fylan *et al*. (2005). Eligible for inclusion in the review were studies that included speeding as an area for behaviour change. Both primary studies and meta-analyses were eligible for inclusion, but discussion papers or opinion pieces were excluded.

The literature search revealed over 3,500 articles. Inclusion screening, based on the title and abstract, identified 16 studies that were relevant to the review question. Further screening, based on the full article, reduced this to 12. Hand searching, bibliography searches and contact with experts yielded a further two studies, giving a total of 14. Two papers reported the same intervention evaluation, so that the data from 12 different interventions were analysed. The studies were diverse and not sufficiently compatible to conduct a statistical meta-analysis.

Few of the interventions identified were based on a theoretical framework of behavioural change, although the content of the interventions could sometimes be related to one or more theory. The most common intervention type was a video or commercial: six of the studies used this approach. Two of these studies were based on the Theory of Planned Behaviour (TPB). Stead *et al*. (2005) provided support for the TPB to predict speeding intentions, but recall of the advertisements was not related to TPB constructs or intention to speed. Similarly, the videos utilised in the study by Parker *et al*. (1996) did not produce the desired changes in the relevant theoretical construct, although a video based on anticipated regret was most effective in changing the construct. In the Perceived Behavioural Control video there was a change in an unexpected direction, i.e. viewers reported that they would be more likely to speed. While the authors suggest that the low budget available for making the videos might have influenced the results, in another study the cost of anti-speeding adverts was not found to be related to their impact, and the content was more important than the budget (Donovan *et al*., 1999). This study found little difference in the reported intention to speed between viewers of four different adverts of similar content. The least effective advert was judged as being less liked, less clear, and did not include substantial emotion, threat or shock. However, an advert based solely on shock was found to be less effective than one that contains a degree of fear and shows how safe driving can remove this fear (Rossiter and Thornton, 2004).

Several studies indicated that there are likely to be differences in drivers' responses to videos with different levels of shock or fear. For example, drivers who perceive their driving to be important to their self-esteem drive faster following a shock commercial but drivers whose driving is not relevant to their self esteem choose a lower speed (Ben-Ari *et al*., 2000). However, this study was of questionable validity when applied to the drivers who would be attending speed awareness courses. A more robust finding is that females are more responsive to both shock-based and fear-relief based adverts than males (Rossiter and Thornton, 2004).

Most of these video-based studies, with the exception of Stead *et al*. (2005), were based in a research setting in which participants were often asked to rate or describe their responses to the videos. This is a highly unnatural viewing condition, which is likely to overestimate the effect of the video in a real-life situation. However, a similar level of concentration and elaborative processing could be recreated in a speed awareness workshop. Overall, the research reported here suggests that interventions based solely on videos or advertisements are unlikely to change speeding behaviour.

Two interventions were based on reading and rating anti-speeding messages or advertising slogans. One of these (Glendon and Cernecca, 2003) found that messages with an enforcement theme (fines or speed camera) had the highest perceived effectiveness and produced the lowest levels of intention to speed. There was a trend for females to be more responsive to non-enforcement messages, and males were more likely to report intending to speed than females.

Three studies used mixed methods: one of these, based in a school, used a multi-faceted intervention comprising videos, a project and reminders (Ulleberg, 2002). The other two were based in a real-life environment – drivers who had been referred by enforcement agencies (Helander, 1984) or professional drivers in an occupational setting (Gregersen *et al*., 1996) – and compared different intervention approaches, usually driver training, discussion groups and educational material. While these two studies did not address speeding specifically, their naturalistic setting makes them of particular interest. The first of these found that an intervention based on a discussion of techniques to avoid accidents, and an educational pamphlet, was most effective in reducing crash risk. The second again found that discussion groups were most effective in reducing the number of accidents that drivers were involved in. Driver training, which included a practical session, was also effective, although slightly less so than the discussion groups.

We identified one meta-analysis of the driver improvement schemes in the USA (Masten and Peck, 1995). While the studies included did not specifically address speeding, we considered that the interventions included would involve a speeding component. Both the type of intervention and its orientation (e.g. threatening or informative) predicted a significant amount of variance in future crashes and violations. Educational materials alone were not effective, but individual warning letters had a small but significant effect. Group meetings and individual meetings were also effective. Data supplied by the authors indicated that, for interventions delivered in group meetings, education- and information-based approaches were most effective in decreasing future violations.

Two studies (Walton and McKeown, 2001; Ulleberg, 2002) indicated that those drivers who were most likely to speed perceived anti-speeding advertising campaigns to be less relevant or aimed at other people, and not them. Several studies (e.g. Helander, 1984; Rossiter and Thornton, 2004) showed that females are more responsive to changing their behaviour than males. Finally, one study indicated that participants did not find the video materials viewed to be sufficiently forceful or credible (Parker *et al*., 1996). Any materials included in speed awareness courses should therefore be realistic.

# Literature review of interventions to change health-risky behaviour

In order to better inform the content of driver education courses, we also reviewed the wider literature on methods of changing risky health-related behaviours. The review identified a substantial body of work that explores the predictors of health-related behaviour and that describes interventions to change health-risky behaviour, but very little was identified that evaluates the effectiveness of such interventions. However, we identified evidence to suggest that to optimise their effectiveness, speed awareness courses should address the following areas:

- attitudes (beliefs and values) towards speeding, including the benefits of speeding;
- perceptions about the acceptability and ubiquity of speeding (social norms);
- perceptions of the likelihood of being detected or crashing;
- perceptions of the negative consequences of being caught or of crashing;
- the driver's responsibility for their own speed choice;
- perceived barriers to driving at an appropriate speed and drivers' perceptions of their ability to drive at an appropriate speed (self-efficacy);
- the way in which speeding makes drivers feel (anticipated affect); and
- when and where drivers will reduce their speed (implementation intentions).

The evidence suggests that persuasive messages should be paired with strategies such as group discussion that promote elaborative processing, and there should be interactive problem-solving sessions to help individuals identify and adhere to appropriate speeds. Information should be coded, i.e. presented in an easily-recalled format, so as to make it more memorable. Post-course reminders should also be sent to clients some weeks after the course.

# Speed awareness courses

We identified 10 speed awareness courses currently run by Safety Camera Partnerships in the UK. The organisers of each course were contacted, and details of the course content were obtained. A researcher attended the courses and evaluated the extent to which their content draws on the evidence-based methods of behavioural change identified in the review.

## Content of speed awareness courses

Courses could be broadly divided into three types:

- classroom-based presentations and discussions together with a driving demonstration and practice;
- classroom-based presentations and discussions without the practice element; and
- a seminar.

The first two types of course typically limit the number of drivers attending each course so as to facilitate discussion. The third type is conducted with a large number of drivers in a lecture-based format. One course also includes a driving behaviour questionnaire and hazard perception test, which provides drivers with a personalised risk profile. The majority of courses target drivers detected speeding just above the 30 mph enforcement limit, usually 35–39 mph, and some also invited drivers detected in 40, 50 and 60 mph zones. One course also catered for drivers who had been detected travelling at excessive speeds (e.g. 50 mph in a 30 mph zone).

These courses tend to have a common core content, including:

- the reasons people speed;
- the consequences of speeding;
- stopping distances at different speeds;
- the likelihood that pedestrians will die when hit at different speeds;
- the purpose of safety cameras and the criteria used for situating them;
- identifying speed limits;
- hazard perception; and
- selecting an appropriate speed.

Four of the courses contain a two- or three-hour practical session in which two or three drivers practise their driving with an Advanced Driving Instructor. Clients are asked to identify speed limits, hazards and appropriate driving speeds, and may be asked to undertake a commentary drive. Some courses encourage drivers to discuss their choice of speed during the practical session, and the barriers that they face to adhering to the speed limit or to selecting an appropriate speed. Drivers then return to the classroom for a brief discussion of the day and what they have learnt. The content of these courses is mapped onto each of the effective intervention components below.

# Attitudes (beliefs and values) about speeding

Discussions take place to encourage drivers to accept that their driving is speeding, that their reasons for speeding are not justified, and that they represent a risk to other road users. Beliefs about the speeding being safe are challenged by presenting statistics on the likelihood of crashing at higher speeds, and the likelihood that pedestrians hit in a crash will survive. Information on fuel economy is provided to encourage the belief that driving faster is bad for the environment. Beliefs about the consequences of speeding are addressed by noting that they range from nothing to a prison sentence to death. Values are also covered by encouraging discussion of drivers' responsibilities to their families, passengers and other road users. It is noted that drivers who crash do not intend to kill anybody: intention is not relevant. It is discussed that speeding can kill and it is wrong to kill, whereas safe driving is beneficial. Most courses encourage drivers to agree that speeding is risk taking, and speeding is unnecessary, and arriving on time is not sufficiently important so as to justify speeding. It is also important to address attitudes towards the benefits of speeding. Beliefs that speeding in urban environments saves time are challenged by presenting statistics on journey times, by discussing driving experiences, and for those courses that include a practical, by observing traffic.

# Perceptions of the acceptability and ubiquity of speeding/identifying oneself as a speeding driver (social norms)

Statistics are presented on the speed at which drivers speed: while some drivers select a much higher speed (e.g. 50 mph in a 30 mph zone), they are in a minority. The majority of speeders drive at 35–39 mph, and it is these drivers that represent the main problem. It is discussed that speeding by 5–10 mph is still speeding, and represents an increased risk. Pre-course beliefs that other clients would be '17-year-old lads' are discussed on some courses, with the aim of enabling drivers to realise that everybody attending the seminar is a speeding driver and that driving at 35–39 mph in a 30 mph zone is speeding.

# Perceptions of the likelihood of being detected or crashing

It is noted that speed cameras and mobile units are placed throughout the country and will detect speeding drivers. A map of safety camera locations is provided by some courses, although several provide a disproportionate amount of time on this point. It is noted that stopping distance increases with speed, so speeders are more likely to crash: drivers are three-to-five times more likely to crash if they speed. Speeding is the main cause of 30% of all crashes. Statistics are provided on the number of crashes and of killed or seriously injured in the UK, and some courses provide local statistics, and note how many more people are killed or injured on local roads than through crime.

# Perceptions of the negative consequences of being caught or of crashing

The negative consequences to the driver of being detected – such as fines, points, increased insurance costs and loss of licence – are identified, and the correlates of these, such as having less money to spend, restricted mobility, extra transport-related hassles, and possibly loss of friends, are discussed. Some courses encourage drivers to think about what is important to them (e.g. family, job, hobbies) and to acknowledge that speeding can put these at risk. Losing one's job can have severe financial consequences, such as loss of a house and breakdown of relationships. Speeding could therefore affect lots of people, not just the driver. Some courses also consider the affective consequences of being caught speeding, such as anger, frustration and embarrassment. Different courses put varying weight on the grief caused by killing a pedestrian, the driver or passenger. Some show a video in which a bereaved family talks about how their lives have been affected since the crash that killed their loved one. In one course the mother of a young man killed by a speeding driver attends the course and gives an account of the events of that night, and how her life has changed since the crash. Some courses highlight the wider effects, such as the effect of a crash on witnesses, the local community and on people who may have NHS procedures cancelled because resources have been diverted to dealing with crash victims. However, all courses note that the consequences of speeding are tremendously variable, and range from nothing to being killed. This can make clear to drivers that just because they have previously 'got away with it', this does not make them immune to future adverse consequences.

## Drivers' responsibility for their own speed choice

Usually by means of discussions between clients which are fed back to the trainer, external reasons for speeding (e.g. being late, being tailgated, not knowing the speed limit) are revealed as excuses, and drivers acknowledge that they have control of their own speed and it is their own responsibility to choose an appropriate speed. It is emphasised that while the environment, the vehicle and the circumstances have a role to play in crashes, the driver has a degree of control over all of these and they have responsibility for their driving.

## Perceived barriers to driving at an appropriate speed and drivers' perceptions of their ability to drive at an appropriate speed (self-efficacy)

Varying amounts of time are spent on this area across the different courses. Practical tips on driving within the speed limit are given. For example, clients commonly complain that it is difficult to drive larger cars at 30 mph, and so they are advised to use third gear in urban environments. Clients often describe how they were running late, and so they are advised to plan their journey with plenty of time. Most courses address the problem of tailgaters, and that drivers do not have to speed up in responses but should instead ignore tailgaters or slow down and let them pass. Another common excuse is that drivers do not realise the speed at which they are travelling: they are advised to include instruments on scanning, and this is reinforced on courses with a practical element. Perhaps the most common barrier cited by drivers is that they do not know the limit. Most courses inform drivers of the national speed limits, and how to tell the limit for the area in which they are driving. Clients are also given practice in identifying the speed limits of different roads, either in video clips or photographs. Self-efficacy is increased by reducing the barriers to driving at an appropriate speed, and increasing confidence that they can identify the correct speed limit in an area, and react appropriately (i.e. without speeding up) to other road users.

## The way in which speeding makes drivers feel (anticipated affect)

A few courses ask clients to imagine how they would feel if they injured or killed somebody because of their speeding but, in general, this component is not covered in the courses. While the thrill of speeding is addressed in the course with the driver profiling questionnaire, no discussion of this takes place during the course.

## When and where drivers will reduce their speed (implementation intentions)

Some courses encourage drivers to write down what they are taking away from the course, and others reinforce that now that clients know the facts about speeding they must make an informed decision about the speed at which they are willing to travel. However, implementation intentions were not used at any of the courses.

## Interactive sessions, problem solving and personalised feedback

These three approaches are important to achieve behavioural change. Courses made use of a varying level of interaction between clients and the trainer. Some made use of an interactive presentation style and included lots of discussion and an approach in which clients find out through discussions and discovery. Other courses relied on presentations by two or more speakers and did not include any discussions. One course was delivered to a large number of clients, which did not support discussions between clients or presenters. On some courses, clients have a personal work booklet in which they explore their own reasons for speeding and identify changes that they should make to their driving. One course made use of the *Highway Code* booklet for problem solving on road rules and safe driving – this approach encouraged drivers to continue using the *Highway Code* to help them drive more safely after the course. There was also a varying amount of personalised feedback provided for clients. Most courses provided individual feedback to clients on their performance on a hazard perception test. Some courses discuss clients' reasons for speeding, and through this discussion they realise their own reason is an excuse. Courses that contain a practical drive provide clients with constructive comments and written feedback on their driving from an instructor. The course that includes a drive profiling questionnaire provides drivers with a copy of their driving style assessment and hazard perception test results, but these are not discussed with other clients or with the trainers.

# Conclusions

Courses make use of several effective means of behavioural change, such as information to change attitudes towards speeding and to increase threat appraisals. However, most neglect the affective correlates of speeding, such as feelings of thrill and excitement and worry or anxiety, and none makes use of implementation intentions. Despite group discussions and problem-solving exercises being an effective means of achieving behavioural change, there is a large variation in the extent to which these are employed. Drivers' self-efficacy in complying with the speed limit is also addressed to a variable extent.

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10

# The effects of the National Driver Improvement Scheme on re-offending rates

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## Introduction

This paper is a summary of the report *The Effects of the National Drivers Improvement Scheme on Re-offending Rates* (Broughton *et al*., 2005). The report is based on research carried out by the Transport Research Laboratory (TRL) for the Department for Transport (DfT) to assess the effectiveness of the National Driver Improvement Scheme (NDIS) compared with the court prosecution process for minor road traffic offences. Research at the University of Leeds (Conner and Lai, 2005) ran concurrently with this project, assessing driver attitudes and behaviours via self-report questionnaires and driving safety assessments before and after attendance at an NDIS course.

The research analysed drivers who committed careless errors and were deemed to be eligible for and attended an NDIS course between July 1998 and June 1999. A second group of drivers were analysed for comparison with the course attendees. This group committed, and were convicted of, their first careless driving (CD) offence between July 1998 and June 1999.

The research examined convictions for CD, speeding, licence and insurance offences and miscellaneous driving offences (including drink-driving and driving whilst disqualified) in the three-year period after completion of the course or conviction. The results of the analysis were verified using data from later years.

# NDIS

The NDIS was initially launched by Devon and Cornwall Police in 1991; it has since been implemented by the majority of police forces in England and Wales. The scheme offers drivers who have committed minor driving offences the opportunity to retrain at a two-day driver training course instead of receiving a court prosecution.

The offence must comply with the following requirements for an offender to be eligible for the course:

- the driver must hold a full current licence or possess a valid certificate of competence to drive;
- there must be a reasonable chance of prosecution;
- no serious injuries or fatalities were caused by the offence;
- there were no other offences that have to be dealt with by prosecution;
- the driver has not attended an improvement scheme in the last three years; and
- the driver must be prepared to pay the course fee.

The course includes classroom teaching of driving theory and a practical session where an instructor assesses and provides feedback on the offender's driving skills.

# Data sources

Two data sources were utilised in this project: the NDIS database and the Driver Licence File. Both sources are held by the Driver and Vehicle Licensing Agency (DVLA).

The NDIS database holds information on drivers who have committed a minor traffic offence and who may be eligible for an NDIS course. The information available is:

- driver licence number;
- name;
- date of birth; and
- postcode.

In addition, the database holds information about the police force, whether the course was completed or not, and the date of the course.

There were 50,804 current entries available, 16,809 of which had no details about the date of course.

The Driver Licence File comprises records for each licensed driver, including a driver's age, sex, and postcode, and details of any convictions for endorsable offences.

Eighty-three per cent of the records in the NDIS database were matched with records in the Driver Licence File. Those that did not match could have been due to several reasons:

- mistakes in data entry;
- foreign driver licences; and
- not enough information available if the driving licence number was not available in the NDIS database.

Thus there were 41,944 matches of drivers who attended courses between October 1997 and July 2001 and data on their convictions up until June 2002. Owing to the three-month delay in receiving conviction data from the police, records of offences after this time were not complete at the time of analysis. Drivers entered into the NDIS database attending a course between July 1998 and June 2000, and who had not had a previous conviction for a CD offence in the previous two years, were used for analysis. This ensured that drivers could be followed up for two to three years after completion of the course.

# Exposure data

In order to assess the effectiveness of the NDIS course, a control group, made up of people who have not attended an NDIS course, are used to compare re-offending rates. This indicates the number of offences that course attendees may have committed in the future if they had not attended the NDIS course. The control group consists of the 44,690 first-time convicted careless driving (CCD) offenders recorded in the Driver Licence File between July 1998 and June 1999.

# Case and control groups

The case group consists of 16,222 NDIS course attendees – 8,114 from July 1998 to June 1999, and 8,108 from July 1999 to June 2000 – and the control group consists of 44,960 drivers who were prosecuted for their first CD offence in the 12 months beginning July 1998.

Social classification is defined on the ACORN (A Classification Of Residential Neighbourhoods) scale:

- A – Thriving;
- B – Expanding;
- C – Rising;
- D – Settling;

- E – Aspiring;
- F – Striving.

Tables 1 and 2 display details of the age distribution, gender profile and social classification groups for both case and control groups. The average age of drivers from the CCD offenders group at the time of their first conviction (35) is significantly lower than that of course attendees (38) at the time of attending the course.

The percentage of women in the CCD offenders group is significantly lower than that in the course attendees group, suggesting women are more likely to attend NDIS courses if offered than men.

Table 1 **Age and gender profiles for course attendees and CCD offenders**

| | Age distribution | | % of female drivers | |
|---|---|---|---|---|
| **Age group** | **Course attendees** | **CCD offenders** | **Course attendees** | **CCD offenders** |
| <22 | 19% | 22% | 22% | 13% |
| 22–27 | 17% | 19% | 27% | 17% |
| 28–33 | 14% | 16% | 27% | 19% |
| 34–40 | 12% | 14% | 29% | 22% |
| >40 | 37% | 30% | 32% | 22% |
| Total | 100% | 100% | 28% | 19% |

Table 2 **Social classification profiles for course attendees and CCD offenders**

| Classification group | Course attendees | CCD offenders | Population |
|---|---|---|---|
| A + B | 41.3% | 29.7% | 31.0% |
| C | 3.3% | 7.7% | 8.0% |
| D + E | 40.2% | 38.5% | 38.0% |
| F | 15.2% | 24.2% | 23.0% |
| Total | 92%* | 91%* | 100% |

* Percentages are less than 100% due to some postcodes not being matched by the ACORN scale.

Comparing course attendees with the population distribution indicates that proportionately more drivers from the higher social classifications attend courses and fewer from lower social classes. The distribution of CCD offenders is similar to that of the population.

In summary, in comparison to the control group, course attendees tend to be older, from a higher social class and more likely to be female.

# Initial analysis

## Motoring convictions before course/first CD conviction

Table 3 examines the offences committed in the two years leading up to the attendance of an NDIS course and in the two years leading up to a first CD conviction. The table details rates of motoring offence per 100 drivers per year for the two years before course/conviction.

No careless driving offences are recorded in Table 3 as this:

- makes the offenders ineligible for course attendance according to the specification listed in the NDIS section above; or
- means a misclassification in the group who have not yet committed their first CD offence by definition.

Table 3 **Offences and offence rate in previous two years**

| Group | Offences | All motoring offences | CD | Speeding offences | Licence and insurance | Other motoring offences |
|---|---|---|---|---|---|---|
| Course attendees | Number | 1,452 | 0 | 1,098 | 83 | 271 |
| | Rate | 8.9 | 0.0 | 6.8 | 0.5 | 1.7 |
| CCD offenders | Number | 17,137 | 0 | 6,201 | 6,029 | 4,907 |
| | Rate | 19.2 | 0.0 | 6.9 | 6.7 | 5.5 |

It is immediately obvious that overall rates of motoring offences for CCD offenders are much higher, and significantly so, than that of the course attendees. Lower rates are shown for course attendees for licence and insurance offences and ‘other motoring’ offences, including drink-driving and driving whilst disqualified.

## Motoring convictions after course/first CD conviction

From here, the analysis requires three years of post-CD conviction/course attendance to be available for a valuable analysis, so the course attendees group contains offenders who attended the course from July 1998 to June 1999.

Table 4 shows the number of drivers with at least one conviction for a CD offence in the period July 1999 to June 2002 subsequent to attending the course or first CD conviction. Overall, and taking no account of age or gender effect, course attendees are more likely (18%) to be convicted of a CD offence in the three years after attending an NDIS course. This result is not, however, statistically significant and the numbers are small.

Table 4 **Drivers with at least one conviction for a CD offence after course/first CD conviction**

| Group | Number with one conviction | Number of drivers | Percentage with reconvictions | Rate of A relative to B |
|---|---|---|---|---|
| Course attendees | 120 | 8,114 | 1.48% | 118% |
| CCD offenders | 558 | 44,690 | 1.25% | – |

Table 5 details the rates of all motoring offences per 100 drivers per year in the three years post-conviction of a first CD offence or course attendance. The overall rate of all motoring offences for CCD offenders is almost double that of course attendees, although this is mostly due to licence, insurance and 'other' motoring offences. Speeding offences were more common in the course attendees group in the three-year post-period, as were CD offences, although only by a small amount.

In comparing Table 5 with Table 3 it is evident that the overall rate for motoring offences has increased since course attendance for case group and decreased for CCD offenders since conviction. Rates for speeding offences have decreased for both groups. 'Other' motoring offences rates have increased for both groups.

Table 5 **Offences in the three years after course/first CD conviction**

| Group | Offences | All motoring offences | CD | Speeding offences | Licence and insurance | Other motoring offences |
|---|---|---|---|---|---|---|
| Course attendees | Number | 2,279 | 123 | 1,481 | 193 | 482 |
| | Rate | 9.4 | 0.5 | 6.1 | 0.8 | 2.0 |
| CCD offenders | Number | 22,205 | 576 | 5,805 | 7,533 | 8,291 |
| | Rate | 16.6 | 0.4 | 4.3 | 5.6 | 6.2 |

Age and gender, and other influential factors, have not, so far, been accounted for in the initial analysis of reconvictions. The next task within the project was to examine the effect of age, gender, course availability and several other possible influential factors. The interpretations of these disaggregated analyses were that:

- course availability was greater in areas of above average offence rates;
- the difference between speed re-offending rates of course attendees and CCD offenders is greatest among younger drivers; and
- no other factors were seen to affect the offence rates of course attendees relative to CCD offenders – the control group.

In terms of convictions for CD offences post-course, the report has yet to yield any advantages to providing the NDIS course. The paper continues with a technique called Survival Analysis, applied to the data to assess any short-term benefits of attending the course.

# Survival Analysis

Survival Analysis was initially developed for use in medical and biological studies to study the effectiveness of new treatments. The technique assesses the 'survival' of a group of subjects (e.g. people, animals or mechanical parts) by measuring the amount of time between two events. It is almost uniquely capable of handling censored observations, that is data points that have not 'failed' in some sense by the end of the study, come into the study or be 'lost to follow-up' part way through the study.

Here, the two events are attending the NDIS course or time of first CD conviction and conviction for a subsequent CD offence or other motoring offence. Survival is defined as no convictions for a CD or other motoring offence since attending the course or being convicted of the first CD offence.

The data analysed here come from the July 1998 to June 1999 course attendees and first-time CCD offenders from the same period. Smaller groups are analysed later to test for differences between sub-groups, for example drivers with different offending histories.

## Gender

The following figures (Figures 1 and 2) show the proportion of drivers 'surviving' for a certain period, i.e. the proportion of men (Figure 1) and women (Figure 2) who are not convicted of a CD or motoring offence in the period shown.

Figure 1 **Proportion of men convicted of a further motoring offence**

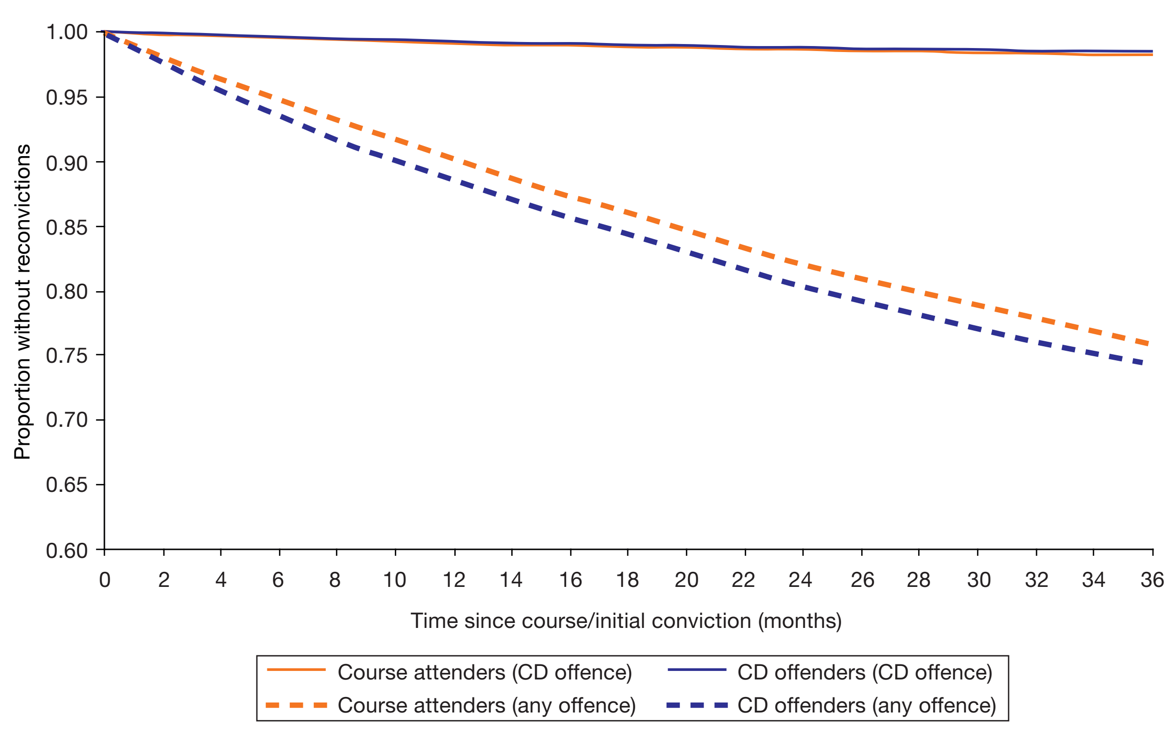
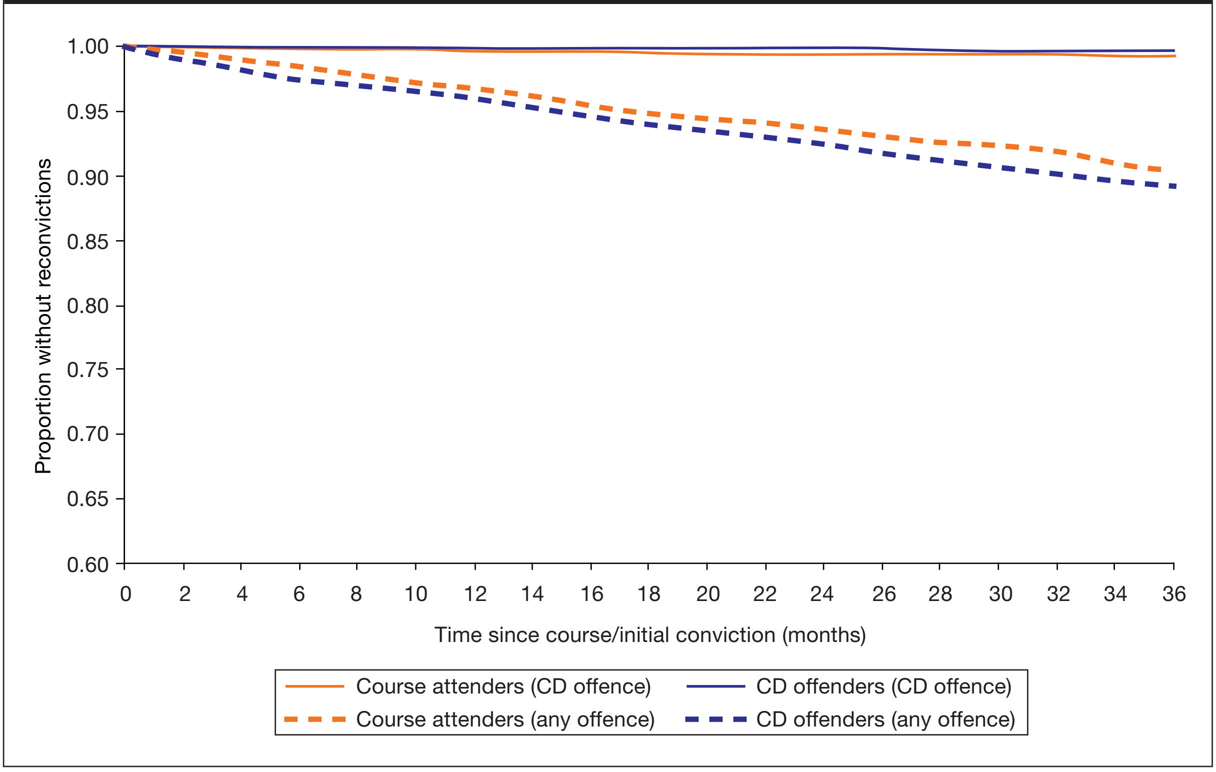


**Figure 2 Proportion of women convicted of a further motoring offence**




Figures 1 and 2 show that 1.7% of male (0.8% female) course attendees and 1.5% of male (0.4% female) CCD offenders were convicted of a further CD offence in the three-year period after course attendance or first CD conviction. A test (Gehan's generalised Wilcoxon test) shows that this difference is not statistically significant and, thus, no effect of the NDIS course on reconviction rates can be identified here.

Differences between rates of any motoring convictions are not statistically significant either; although more CCD offenders (25.5% of men and 10.7% of women) re-offend in the 36 months after conviction than course attendees (24.1% of men and 9.5% of women).

Table 6 sub-divides the re-offending rates into the categories defined in Table 3. Significant differences occur between male course attendees and male CCD offenders. No benefits of attending the course in terms of CD re-offences can be proved, but course attendees are significantly less likely to be convicted for licence and insurance offences, and significantly more likely than CCD offenders to be convicted for speeding offences.

Amongst women, due to small numbers, the differences are not significant but the patterns are the same – course attendees are more likely to be convicted for speeding offences after course attendance than CCD offenders, and women who have been convicted of a first CD offence are more likely to be convicted of licence or insurance offences in the three years after their first CD conviction than women who have attended the NDIS course.

Women constitute just a small percentage of the test population: only 28% of course attendees and 19% of CCD offenders, and this, combined with the fact that women re-offend at less than half the rate of men, leads to small numbers of reconvictions.

This causes small changes in the number of reconvictions to influence the rates and survival curves greatly, and the analysis becomes unstable. Owing to this reason, future analysis will be based solely on male offenders.

The project continued by controlling for certain factors believed to affect rates of convictions for motor offences – age, social classification and previous offending history.

Table 6 **Rates of re-offending for any motoring offences in the three-year period after course/conviction, men and women**

| Gender | Group | CD offences | Speed offences | Licence/ insurance offences | Other motoring offences | All motoring offences |
|---|---|---|---|---|---|---|
| Male | Course attendees (A) | 1.7% | 18.1% | 2.0% | 6.1% | 24.1% |
| | CD offenders (B) | 1.5% | 12.4% | 8.1% | 12.7% | 25.5% |
| | Ratio A:B (X:1) | 1.19 | 1.46 | 0.24 | 0.48 | 0.95 |
| Female | Course attendees (A) | 0.8% | 7.7% | 0.4% | 1.3% | 9.5% |
| | CD offenders (B) | 0.4% | 6.8% | 1.9% | 3.4% | 10.7% |
| | Ratio A:B (X:1) | 2.35 | 1.13 | 0.18 | 0.39 | 0.89 |

# Age

Previous analysis suggested that re-offending reduces at around the age of 30. So, comparisons are made between course attendees and CCD offenders who are aged younger than 30 and those aged 30 or older.

Figure 3 **Re-offending rates for male offenders, by age**

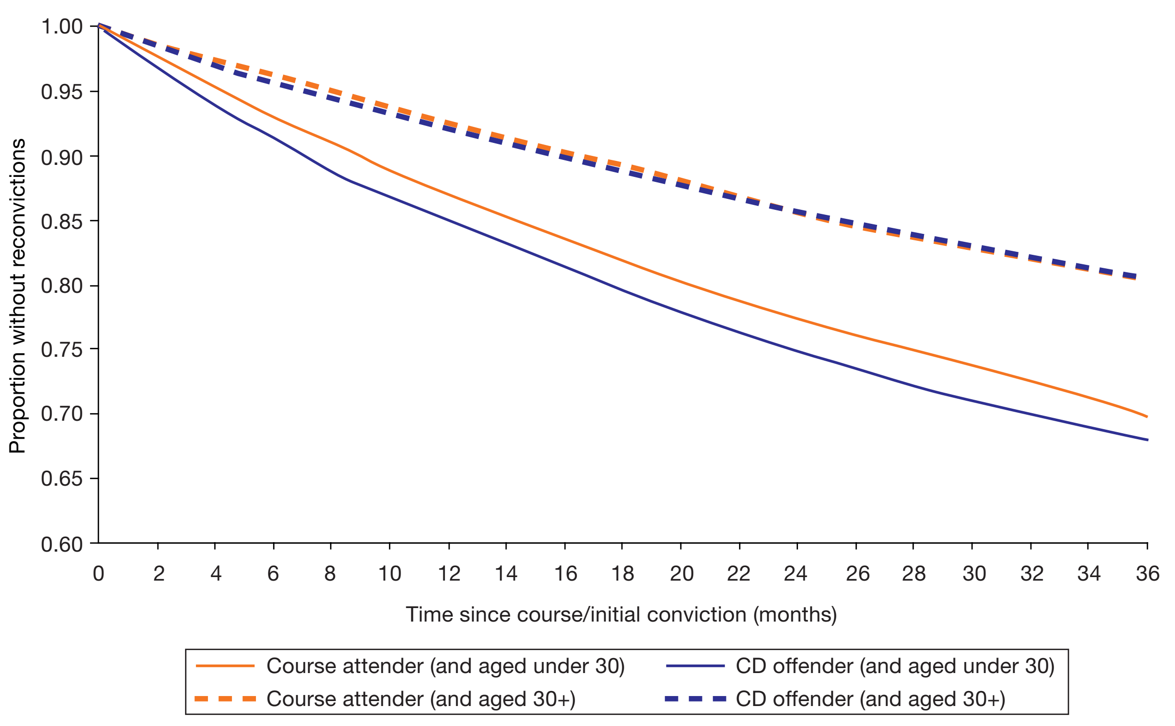


Figure 3 shows a clear difference between the reconviction proportions of the two age groups. Older drivers are less likely to re-offend than those under the age of 30.

Differences between course attendees and CCD offenders are greater at 12 months than 36 months (there is a 12% difference between course attendees and CCD offenders for younger than 30 and a 6% difference for older drivers at 12 months compared with 6% and 1% at the end of the period).

By the end of the three-year period, the effect of the NDIS course is only seen in the younger than 30 years group, although even this difference between course attendees and CCD offenders is not significant.

# Social classification

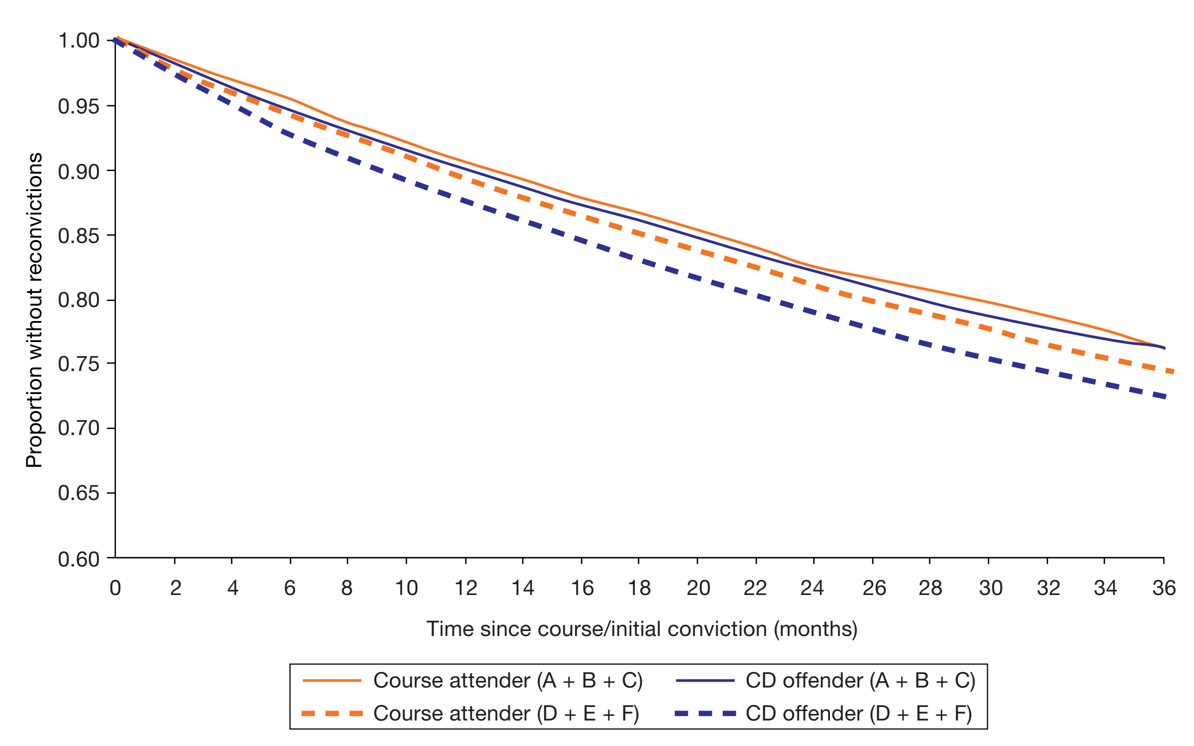
Two sub-groups of course attendees and CCD offenders were compared according to the social classes defined by ACORN and detailed in an earlier section. The sub-groups were drivers who lived in areas classified as classes A, B or C and D, E or F. More detailed splits were not feasible due to the small numbers.

Figure 4 shows the proportion of drivers from each sub-group and case or control group that have not been reconvicted of a motoring offence:

- Relatively more drivers from social classes D, E or F re-offend after their first CD conviction or course attendance than those from classes A, B or C, although this difference is not significant.

- Course attendees from both social sub-groups re-offend less often than CCD offenders, although not significantly so.

Figure 4 **Re-offending rates for male offenders, by ACORN group**



- Similarly to the age group split, by the end of the three years the effect of the NDIS course is concentrated in the drivers living in areas D, E or F.

# Previous offending history

Previous offending history is the fourth factor to be investigated by the Survival Analysis method. An earlier section demonstrated that members of the control group were more likely to have had a previous motoring conviction before their first conviction for a CD offence than those members of the course attendees before they attended a course. Thus, CCD offenders may be more likely to re-offend.

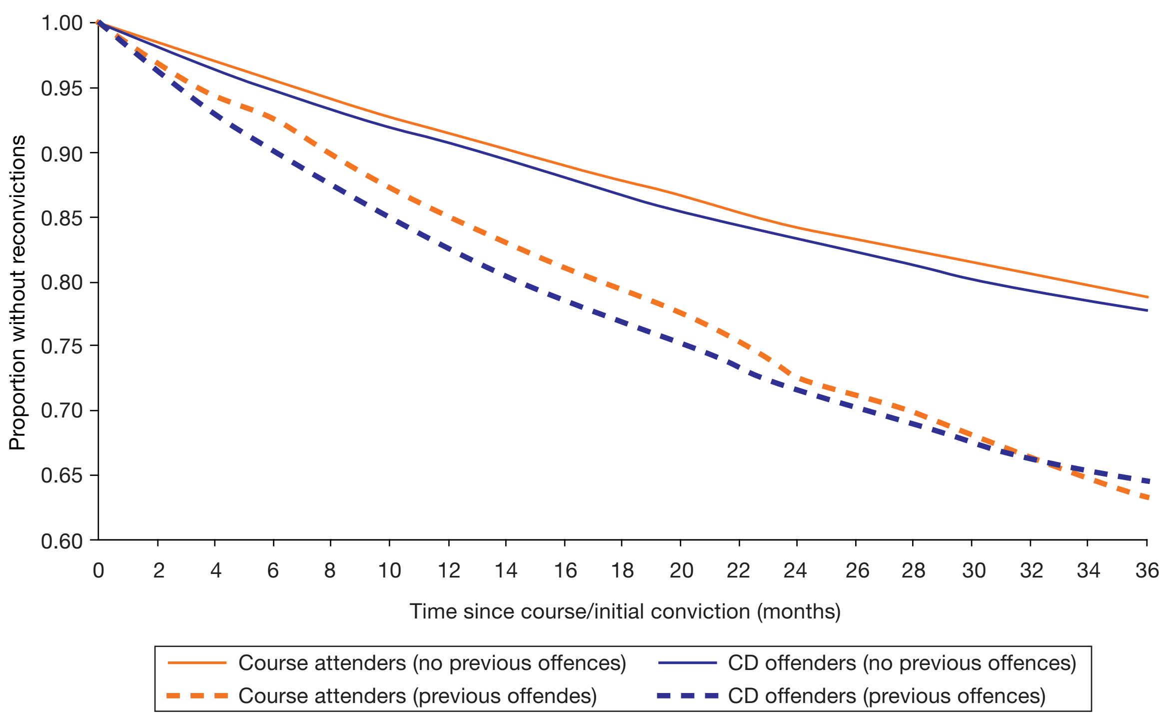
The division into sub-groups here is drivers with no previous recorded motoring offence and those with one or more recorded offence.

A large and significant difference is seen in Figure 5 between the proportions of re-offenders in the two sub-groups. Those with at least one previous motoring offence are more likely to re-offend in the three years after course attendance or conviction for first CD offence than those with no previous recorded motoring offences.

Differences between course attendees and CCD offenders are not significant, although an interesting pattern appears in the sub-group of drivers with at least one previous offence. Initially, course attendees are less likely to be reconvicted of an offence, but this group narrows and, towards the end of the three-year period (in month 32), slightly more course attendees had re-offended.

The analysis of this factor – the existence of a previous conviction, suggests that it may have more effect on reconviction rates than attendance at an NDIS course.

Figure 5 **Re-offending rates for male offenders, by existence of recorded offence**



In general, for the four factors explored above, course attendees from each sub-group were significantly more likely to commit a speeding offence than the respective control sub-group, and significantly less likely to be convicted of licence, insurance or 'other' motoring offences. This is consistent with the general conclusions reached previously.

# Verifying analysis

Towards the end of the project, the full dataset for the subsequent year became available: conviction data was available up to June 2003 meaning that analysis could be carried out up until the next year. These data were used to verify the findings of the main analysis.

The characteristics of course attendees (average age, social classification distribution and re-offending patterns) for this latter period are similar to the drivers attending the NDIS course from July 1998 to June 1999. Re-offence rates and survival curve patterns of course attendees in the second year of data are remarkably comparable to the previous year and, thus, the interpretation is that conclusions reached about the previous year are typical of all course attendees.

# Summary

The report has analysed data from the NDIS database to study the effectiveness of the NDIS courses. Mainly based on course attendees from July 1998 to June 1999, the analysis utilised the outcome measure 'reconvictions in the three-year period after attending the course' and compared these results with drivers who were convicted of their first CD offence in the period July 1998 to June 1999.

The characteristics of course attendees and CCD offenders were not directly comparable. Proportionately more women, higher social classes and older people attended an NDIS course than were in the control group. Fewer course attendees had a previous, recorded motoring offence.

Overall, it was found that course attendees were 18% more likely to commit a subsequent CD re-offence but no significant differences were found for CD or all motoring offences between course attendees and CCD offenders in the three-year period post-course or first CD conviction, respectively. Age and gender are known to affect reconviction rates, so controlling for age and gender was necessary. Repeating the analysis with this modification also found no significant difference between the case and control groups.

Course attendees were more likely to be convicted of speeding offences than CCD offenders and are significantly less likely to be convicted of licence, insurance and 'other' (including drink-driving and driving whilst disqualified) motoring offences.

Survival Analysis was applied to the data to detect short-term effects. The technique uses the length of time between course attendance or first CD conviction and the time of re-offence. Survival in this case is defined by 'no reconviction for a motoring offence in the three-year period after attending a course or first CD conviction'.

No significant differences were found between the survival curves of the two groups. Sub-analysis comparing gender, age groups (younger than 30 and 30+ years), social classification groups (A, B or C and D, E or F) and previous offence history (no offences prior to course/first CD conviction and one or more previous offence) demonstrated that:

- older drivers re-offend less than younger drivers;
- drivers from higher social groups re-offend less often than social groups D, E or F; and
- drivers with previous convictions are more likely to re-offend than those without convictions.

No statistically significant differences were found between course attendees and CCD offenders, however it is suggested that previous offence history may have more of an affect on reconviction rate than attending an NDIS course.

The report concentrates on behaviour changes using the measure of reconvictions after course or first CD conviction. Research carried out at the University of Leeds (Conner and Lai, 2005) investigated attitudinal changes in a more qualitative analysis. Modest improvements in driver attitudes were observed in the course attendees group compared with the control group, however, consistent with the research described above, this was not seen to improve driver behaviour significantly.

The overall conclusion must be that an adaptation to the course to create a link between changed attitudes and subsequent driving behaviour would improve the effect of the course.

# References

Broughton, J., Buckle, G., Buttress, S. and Pearce, L. (2005) *The Effects of the National Drivers Improvement Scheme on Re-offending Rates*. TRL Report No. 649. Wokingham: Transport Research Laboratory.

Conner, M. and Lai, F. (2005) *Evaluation of the Effectiveness of the National Driver Improvement Scheme*. Road Safety Research Report No. 64. London: Department for Transport.

11

# Driver impairment and traffic safety results from IMMORTAL

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## Introduction

The scientific objectives of IMMORTAL (Impaired Motorists, Methods of Roadside Testing and Assessment for Licensing) were:

- to investigate the influence of chronic and acute impairment factors on driving performance and accident risk; and
- to recommend criteria for high-risk categories of impairment; and
- to provide key information to support formulation of European policy on licensing assessment and roadside impairment testing (including drug screening).

Chronic impairment included ageing, mental illness and medical diseases, whereas acute impairment included drugs – illicit as well as medicinal – alone or in combination with alcohol. All reports are available at www.immortal.or.at/deliverables.php.

## Methods

The aims of IMMORTAL covered various aspects in relation to traffic safety:

- accident risk;
- fitness to drive;

- impairment factors; and
- cost-benefit analyses.

The aims were fulfilled by means of various research methods:

- literature reviews;
- questionnaires/interviews;
- prevalence studies;
- case-control studies; and
- experiments.

This paper describes some of the important projects within IMMORTAL regarding the impact of various diseases as well as the use of medicines, illicit drugs and alcohol in relation to traffic safety.

# A meta-analysis

Regarding chronic as well as acute impairment, a meta-analysis of health-related risk factors referring especially to the medical conditions addressed in Annex III of the Council Directive on driving licences (CD 91/439/EEC) was carried out (Vaa, 2003). Sixty-two reports, mainly case-control studies, have been reviewed, giving a total of 298 results that serve as the basis for calculations of the relative risks of being involved in road accidents.

Table 1 shows the results of the meta-analysis and details the relative accident risks associated with a range of health related risk factors (* = statistically significant at the 0.05 level):

Table 1 **The relative risk of being involved in a road accident associated with a range of health-related risk factors and forms of impairment.**

| Health-related risk factor | Relative Risk |
|---|---|
| vision impairment | 1.09* |
| hearing impairment | 1.19* |
| arthritis/locomotor disability | 1.17* |
| cardio-vascular diseases | 1.23* |
| diabetes mellitus | 1.56* |
| neurological diseases | 1.75* |
| mental disorders | 1.72* |
| alcoholism | 2.00* |
| drugs – medicinal and illegal | 1.58* |
| renal disorders | 0.87 |

The weighted average across all main categories is 1.33, which means that a driver with a given medical condition comprised by Annex III would have a 33% higher risk of accident involvement than a driver without that given condition. The relative risks for all main categories are significantly higher than 1.00, except for renal disorders.

# Various experiments

Five experiments are mentioned briefly in this paper:

- treatment with modern antidepressants – on-road experiment;
- Diabetes Mellitus – simulator study;
- ecstasy or amphetamines – on-road experiment;
- ecstasy and alcohol – on-road experiment; and
- cold medicines – simulator study.

## Treatment with modern antidepressants

Actual driving performance and the cognitive performance of 24 patients with a unipolar depressive disorder without antidepressant treatment and 23 patients with unipolar depressive disorder who were treated with an SSRI (selective serotonin reuptake inhibitor) type antidepressant for 6–52 weeks were compared with matched controls (Schmitt *et al*., 2005).

The effects of depression and the treatment effects were assessed using cognitive tests assessing memory, attention and psychomotor speed, and two standardised on-the-road driving tests: the standard deviation of the lateral position (SDLP) and the car following test. The severity of depression was assessed using various depression rating scales, including the Hamilton Depression Rating Scale (HDRS).

The results show that, in accordance with the hypotheses, depression is associated with a significant and quite robust reduction of driving ability, as was measured by the SDLP. Secondly, successful treatment of depression with a SSRI-type antidepressant seems to alleviate not only depressive symptoms but also improve driving ability. However, although the performance of the SSRI-treated group showed better results than the group of unmedicated depressive patients, they still behaved significantly worse than that of the matched healthy controls.

## Diabetes Mellitus

The test battery for the diabetes experiment was built on the base of well-tried methodologies of driver assessment, including a variety of psychological capabilities and personal qualities in relation to safe driver behaviour. The selection of these particular tests was made in consultation with diabetes experts (Rehnova *et al*., 2005).

The simulator test was prepared and developed in close co-operation with diabetes experts and driving instructors, and included basic driving tasks, risky traffic situations, various traffic and climatic conditions, as well as the simulated driving behaviour of other drivers.

Three groups of drivers were involved in this study – 32 diabetic drivers (both in the psychological assessment test and the simulator test). In addition to this, a control group of 49 healthy, sober drivers and 50 alcohol-impaired drivers (0.5 g/l) took part in the simulator test. All participants were volunteers, and diabetic patients were recommended to attend by their doctors.

The results of the psychological assessment and the driver simulator test were processed by the standard statistical method of significant deviations between norms and obtained values, or significant deviations between two independent samples. Meaningful correlations between diabetes parameters (duration of illness, doses of insulin and mode of application) were also evaluated.

The results of both the psychological assessment and the simulator test showed that, although the patients had problems with visual functions and attention, their driving performance turned out to be similar to the control group of healthy drivers. Hence, it is recommended that diabetes patients (Type 1) should be allowed to drive if they keep their diet and regular medicine checks.

However, professional drivers suffering from Diabetes Mellitus Type 1 should be given restrictions due to difficulties in satisfying all work and employer demands.

As for alcohol impairment, all parameters turned out to be critically bad in the simulator test.

# Ecstasy or amphetamines

The effects of MDMA, 75 mg dose (ecstasy), and methylphenidate, 20 mg dose (amphetamines), on actual driving performance, visuospatial attention and memory during intoxication and withdrawal were explored in a placebo-controlled study (Ramaekers *et al*., 2004).

Eighteen recreational ecstasy users (nine males and nine females), aged 21–39 years, participated in a double-blind, placebo-controlled, three-way cross-over study. Drugs and placebo were administered on day 1 of treatment (intoxication phase). Cognitive and driving tests were conducted between 1.5–2.5 hours and 3–5 hours post-drug, respectively. Subjects returned the following day for a repetition of the cognitive and driving tests at the same time as on the day of treatment, i.e. 24 hours later (withdrawal phase).

Actual on-the-road-driving tests consisted of a road tracking test and a car following test. Its main parameters were SDLP, time to speed adaptation (TSA) and brake reaction time (BRT). Visuospatial processing and memory were assessed in a range of cognitive laboratory tests.

The results of the on-road tests indicate that both MDMA and methylphenidate significantly decreased SDLP by about 2 cm relative to the placebo on day 1. SDLP was not affected by treatment or period during withdrawal on day 2. However, MDMA intoxication decreased performance in the car following test, as indicated by a significant rise in the ‘overshoot’ of the subjects’ response to speed decelerations of the leading vehicle.

Cognitive tests furthermore demonstrated that a single dose of 75 mg MDMA impairs performance in spatial and verbal memory tasks. MDMA’s detrimental effect on spatial memory may be of particular relevance to the driver, as it indicates a reduction in situation awareness or spatial orientation while driving under the influence. Collectively, these data indicate that MDMA has a negative effect both on important cognitive functions and on some of the driving tasks, whereas other driving tasks seem to be stimulated.

# The combination of ecstasy and alcohol

Interaction effects of MDMA (ecstasy) and alcohol on actual driving, psychomotor performance and risk-taking behaviour were explored in another experiment (Ramaekers *et al*., 2004).

Eighteen recreational ecstasy-users (nine males and nine females), aged 20–37 years, participated. The treatments consisted of MDMA doses 0 mg, 75 mg and 100 mg, with and without alcohol. Alcohol dosing was designed to achieve a peak blood alcohol concentration (BAC) of about 0.5 g/l during the actual driving tests. Laboratory tests of psychomotor function and risk-taking behaviour were conducted between 1.5–2.25 hours post-MDMA. The actual driving test, i.e. a road-tracking test, and a car following test were conducted between 3–5 hours post-MDMA.

Both doses of MDMA significantly improved performance in the road-tracking test, as indicated by decrements in SDLP and standard deviation of speed. The stimulating effect of MDMA at a dose of 100 mg was more prominent when combined with alcohol, whereas the stimulating effect of MDMA at a dose of 75 mg did not change in magnitude after the alcohol co-administration. MDMA did not affect performance in the car following test, or any other test measuring psychomotor function and risk-taking behaviour. Alcohol alone significantly increased SDLP in the road tracking test, BRT in the car following test and tracking performance in a critical tracking task.

Furthermore, alcohol decreased inhibitory control in a stop signal task, but increased inhibitory control in a test of impulsivity employing a gambling paradigm. Collectively, these data indicate that MDMA is a stimulant drug that may facilitate certain aspects of the driving task, i.e. road tracking, even when combined with a low dose of alcohol. However, performance compensation after combined MDMA/alcohol administration was limited to a single driving parameter and was never sufficient to fully overcome alcohol impairment in all driver-related tasks.

In conclusion, the results showed that driving under the influence of ecstasy, especially in combination with alcohol, must be avoided.

# Cold medicines

The last experiment was designed to assess the effect of a cold virus and cold virus medication on driving performance and cognitive performance related to driving (Ramaekers *et al*., 2004).

Ninety-six participants took part in a single blind 2 × 2 between subjects study. Participants diagnosed with a common cold were compared with and without medication, and with baseline conditions. The medication was typical of many over-the-counter cold remedies used in the UK and contained the following active ingredients: Diphenhydramine hydrochloride 25 mg, Paracetamol 1000 mg, and Pseudoephedrine hydrochloride 45 mg.

Laboratory tests of psychomotor performance related to driving were conducted between 0.25–1 hours post-ingestion of the placebo or medication. The participants' performance was then tested in a driving simulator 1.25–2.5 hours post-ingestion of the placebo or medication.

The results from the cognitive tests were similar to previous findings and showed that volunteers suffering with a cold virus had slower reaction times and impaired visual search abilities. Cold sufferers also reported increased subjective fatigue and depression scores. Medication did not affect performance on the cognitive tasks but medicated volunteers, both healthy persons and patients with colds, reported higher scores of subjective fatigue.

The results from the simulator tasks were somewhat mixed. Generally it seemed that cold sufferers taking medication could perform well in longitudinal control. Indeed, some results suggested that cold sufferers performed better in longitudinal control. Secondary tasks and lateral control, however, were often impaired by medication and sometimes further impaired by taking medication whilst having a cold. It seems that drivers compensate for the effects of medication by modifying their driving style. The extra effort applied to some driving aspects results in decreased performance in other aspects of driving, such as lateral stability. Cold sufferers taking medication also performed poorly on awareness tasks during the simulated run, again suggesting that, although driving ability may appear adequate, there may be less cognitive resources for additional secondary tasks.

In conclusion, the results showed that drivers who took over-the-counter medicine while suffering from a cold might feel capable of driving but, in fact, were less aware and therefore more dangerous than non-medicated cold-sufferers.

# Epidemiological studies

The prevalence and relative risk of drug-driving was explored in IMMORTAL, as well as information about the drug drivers, which was obtained by means of qualitative interviews.

## Studies of the prevalence of alcohol and other drugs in traffic

The prevalence of alcohol and other drugs in the general driving population was examined in three European countries: the Netherlands, Norway and the UK (Scotland) (Assum *et al*., 2005). Although much effort was given to harmonise the studies in the three countries, it was agreed from the start of the project that either urine samples or oral fluid samples should be collected at the roadside. Therefore, due to the existing procedures in the countries involved, urine was collected at the roadside in the Netherlands, whereas oral fluid samples were collected in Norway and the UK.

Irrespective of this and other methodological differences, such as different cut-off values, a rough comparison between the three countries regarding the prevalence of drugs, alone or in combination with other drugs, in the general driving population, by country, is shown in Table 2 (weighted results).

Table 2 **The prevalence of drug-driving in three countries (per cent)**

| **Percentage of samples positive for:** | **NL** | **Norway** | **UK** |
|---|---|---|---|
| Alcohol > 0.2 g/l | 2.1 | 0 | |
| Amphetamines | 0.03 | 0 | 0.66 |
| Benzodiazepines | 2.1 | 0.2 | |
| Cannabis | 4.5 | 0.5 | 3.26 |
| Cocaine | 0.7 | 0 | 1.34 |
| Ecstasy | 0.6 | 0 | 4.61 |
| Opiates (excluding codeines) | 0.06 | 0.2 | 0.08 |
| Codeines | 0.6 | | |
| Tricyclic antidepressants | 0.3 | | |
| Methadone | 0.04 | | |
| **Samples positive for one or more substances** | **9.9** | **1.0** | **10.8** |
| Unweighted number of controls | 3799 | 410 | 1312 |

The prevalence of one or more substances is of the same magnitude, around 10%, in the Netherlands and the UK, whereas it is considerably lower in Norway, only 1%. However, the Norwegian sample is very small and Norway has a long tradition of strict drink-driving rules and enforcement, which may explain the low prevalence of alcohol as well as other drugs among Norwegian drivers.

The prevalence in the UK is slightly higher than the Dutch prevalence, in spite of the fact that the results from the Dutch study include four more substances (alcohol, benzodiazepines, tricyclic antidepressants and methadone) than the results from the UK study.

The estimated prevalence of ecstasy, alone or in combination with other substances, was 4.6% in the UK study. This was high compared with the values obtained in the Netherlands and Norway. The UK value may reflect a sampling variation and/or factors specific to the city of Glasgow, and should not be taken to indicate prevalence in the UK as a whole.

Unlike in Norway and the UK, the use of cannabis is not a criminal offence in the Netherlands. This fact may explain the rather high prevalence of cannabis among the Dutch drivers. However, the urine analysis used in the Dutch study was more sensitive to detect cannabis and benzodiazepines than the oral fluid analysis used in Norway and the UK.

# Case-control studies of the accident risk of alcohol and other drugs

This study explored whether drivers who used one or more of eight defined drug groups had a higher accident risk than drivers not using these drugs; and to, as far as possible, quantify this risk (Assum *et al*., 2005). The relative risk of accident involvement for drug drivers was calculated in the Dutch and Norwegian studies, and the results from the Dutch study are shown in Table 3.

Table 3 **Relative accident risk for drug drivers**

| Substances | | Estimated Odds Ratio | Confidence interval |
|---|---|---|---|
| Negative samples | | 1 | |
| Alcohol alone | BAC 0.5–0.8 g/l | 8.3 | (2.7–25) |
| | BAC 0.8–1.3 g/l | 17.6 | (5.5–56) |
| Drug alone | Benzodiazepines | 3 | (1.3–6.75) |
| | Codeine | 3 | (not significant) |
| | Morphine/heroine | 32.5 | (1.8–592) |
| | Cannabis | 1.45 | (not significant) |
| Combinations | Drug/drug | 24 | (11.5–50) |
| | BAC <0.8 g/l + drugs | 12.9 | (3.8–44) |
| | BAC >0.8 g/l + drugs | 179 | (50–638) |

The Dutch study showed that severe road injuries were especially associated with drug-free BAC levels above 1.3 g/l, with combined alcohol and drug use at BAC levels above 0.8 g/l, and with the combined use of two or more illegal drugs. Together, these three categories were present among only 0.8% of the general driving population, but they accounted for 28% of all serious injuries. No significantly increased injury risk was associated with the use of cannabis, amphetamine, ecstasy, cocaine or tricyclic antidepressants when taken alone.

## Qualitative interviews with impaired accident-involved drivers

A qualitative approach in order to gain more knowledge of accident-involved drivers was used in a study where 333 injured drivers were tested for drugs shortly after the accident (Bernhoft, 2005).

Of 23 drug-positive patients, 15 were found positive for one drug group and eight patients were found positive for two drug groups. Alcohol (>0.5 g/l) was found in nine of the cases, both combined with medicinal drugs and with illicit drugs, as well as with both types of drug. Benzodiazepines and cannabis were the dominating substances.

In 9 of the 23 cases, the concentrations indicated a strong suspicion of impaired driving abilities, and in another six cases it is also assumed that the driving abilities had been impaired. Another 19 patients reported the use of impairing drugs that were not included in the analyses or that were not detected.

Interviews were conducted with both groups of patients. In total, 23 interviews formed the basis for the following groupings of accident-involved drug drivers:

- young, well-functioning men who used illegal drugs either during weekends or in the evening – generally they did not mix drugs with alcohol and did not think that the drugs constituted a traffic safety risk in the same way as alcohol does;
- middle-aged men and women (35–54 years old) who had stopped working because of their alcohol and/or medicine dependency – they did not refrain from mixing their prescribed medicines with alcohol, and they were not aware of the potential road safety risk this might constitute in traffic; and
- drivers aged 55 and above who were still working or who had passed the retirement age and whose drug use was restricted to over-the-counter medicines or prescriptions – they did not combine the medicines with alcohol.

# Conclusions and recommendations

The meta-analysis of health-related risk factors, referring especially to the medical conditions addressed in Annex III of the Council Directive on driving licences, indicated that drivers suffering from various disorders showed an elevated accident risk compared to that of healthy drivers.

This, in combination with the results from the depression and the diabetes experiments, indicates that the increased accident risk of drivers with certain medical conditions should form the basis for a more strict licensing policy within the European Union.

Although, as shown in the experiments with ecstasy, ecstasy plus alcohol and the experiment with cold medicines, driving under the influence of drugs, alone or in combination with alcohol, is very dangerous. Roadside surveys showed that driving under the influence of alcohol is still far more prevalent than driving under the influence of drugs.

Regarding the accident risk when driving while impaired, case-control studies showed that the accident risk while driving under the influence of combinations of drugs (illegal as well as medicinal), or the combination of drugs and alcohol, is extremely high compared with driving while not impaired.

Further research is necessary to describe in greater detail the accident risks associated with concentrations and combinations of drugs. However, for most medicinal drugs, like antidepressants, benzodiazepines, codeine, barbiturates and even morphine, therapeutic levels may be adequate as the legal limits, at least for the time being.

The results of the epidemiological studies indicate that more focus should be given to the information about the risks regarding drugs and alcohol. Furthermore, road safety policy should give priority to the detection, prosecution and rehabilitation of drivers with high alcohol concentrations and drivers having used alcohol/drug or drug/drug combinations.

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# 12

# Methodological experiences of a case-control survey in Glasgow

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## Introduction

The number of drivers driving while under the influence of drugs has increased in recent years. In particular, Tunbridge *et al*. (2001) found a substantial increase in the presence of medicinal or illicit drugs in fatally injured drivers compared with previous studies from the 1980s.

This paper reports on the methodological experiences of a study that formed part of a Europe-wide investigation of the impact that drugs, medications and medical conditions have on road safety. This research programme, known as the IMMORTAL project (Impaired Motorists, Methods of Roadside Testing and Assessment for Licensing) investigated the accident risk associated with different types of driver impairment and examined the implication for licensing and roadside impairment testing (including drug screening).

A common methodological approach was attempted in the three participating European countries: the Netherlands, Norway and the UK. The UK contribution to the study, which was funded jointly by the European Commission and the Department for Transport, was carried out in Glasgow, Scotland.

## Study objective

The objective of the study was to examine whether drivers using one or more of eight defined drug groups have a higher crash risk than drivers not using these drugs, and, as far as possible, to quantify this risk.

In order to do this, samples of oral fluid or urine from both crash-involved drivers and the general driving population would be collected and checked for metabolites of substances consumed. The hypothesis was that, if the presence of any of the drugs being considered in the study impaired driving, this would increase accident risk. The prevalence of drug(s) usage in the injured sample was expected to be higher than in the roadside control sample. It was planned to calculate an odds ratio to estimate the relative risk of driving while impaired by each drug of interest.

The drugs included in the screening were ones which might affect driving. This included prescription, non-prescription/illicit drugs and alcohol. Specifically, the eight drug groups of interest were:

- benzodiazepines;
- codeine;
- other opiates;
- amphetamines;
- ecstasy;
- cannabis;
- cocaine; and
- alcohol.

# Study design

It was intended to adopt a common methodology of a case/control study across the three countries and to compare the prevalence of the above substances among injured drivers (a hospital sample) with the prevalence in drivers in general (a roadside sample). For each substance or combinations of substances, the relative risk to the driving task could then be estimated using statistical models to control for such confounding effects as the age and gender of drivers, which are associated with accident risk. The data would be collected over a period of one year. As will be seen, it was necessary to revise this methodology in light of difficulties encountered in obtaining ethical approval for the study in the UK.

For the roadside control sample in the UK, it was decided to collect oral fluid (i.e. saliva samples) from non-crash involved drivers. The samples were collected at six sites within the central Glasgow area with a historically high injury accident rate. These were principally the main radial trunk routes serving Glasgow city centre, and were situated within the catchment area of the hospital providing the case samples.

In partner countries, the case samples were collected from both fatally and non-fatally injured drivers. This was also the original intention in the UK. Oral fluid samples would be taken from consenting crash-injured drivers. However, although considerable efforts were made to obtain ethical approval to collect hospital samples from injured drivers, this proved not to be possible. The main argument from the ethics committee was that drivers who had been involved in a crash may not be in a sufficient mental or physical condition to give informed consent to a body fluid sample being taken; the procedure would therefore be ethically unacceptable.

Therefore, as the case samples in the UK study could not be provided by hospitals, an alternative method of collecting data on cases was attempted. This included obtaining data on drug and substance use from fatally injured drivers in the defined catchment area, through post-mortem records. Data from a 3–4 year period were collected in order to increase the sample size for comparison. However, the relatively low number of fatalities in the Glasgow area greatly reduced the sample size, and meant that it was impossible to obtain good estimates of risk ratios.

Despite this difficulty, TRL was asked to go ahead with the study in Scotland, mainly on the basis that it would provide estimates of drug prevalence in Glasgow drivers, and provide some information of drug use in fatally injured drivers in the catchment area.

# Roadside survey

The roadside survey was conducted between July 2003 and June 2004. Roadside control samples were collected from non-accident involved drivers. Working closely with Strathclyde Police, survey points were set up in a coned-off area at the survey sites. Two officers were present at all times: one police officer to stop traffic and the second to make the initial contact with drivers. Teams of up to three interviewers collected the oral fluid samples.

In order to be compatible with the methodology of the other IMMORTAL partners, sampling was divided into four six-hour periods. Sites were grouped into northern and southern areas, and a day was spent surveying each group. The schedule was balanced so that sites were surveyed on various days of the week, and during the various time periods.

Ensuring that all time periods were covered presented some challenges to the research team, as police shift patterns meant that it was impossible to cover the period of 04:00–07:00 on any day other than Tuesdays or Wednesdays. Bad weather also caused the cancellation of some sessions during the winter, and alternative sessions had to be scheduled.

For a scientifically valid sample, the drivers of cars and vans were stopped at random and were not stopped on the basis of any preconception of impairment. The procedure adopted was that, after a test was completed and the vehicle had cleared the site, the officer in charge would stop the next approaching vehicle. This meant that drivers were not queuing up to be interviewed and that interviewers did not have to wait for, for example, the twelfth vehicle to come along to be selected.

Drivers were told that the purpose of the research was to ascertain the level of drug usage (including alcohol) in the general driving population. The anonymity of the driver was emphasised. If informed consent was obtained from the driver for participation in the study, the police officer would pass the driver over directly to the interviewer for collection of oral fluid.

If the driver declined to co-operate, the police officer would request a reason for non-co-operation and the driver would then be allowed to proceed without hindrance. The reason for refusal, together with an age estimate and gender of the driver who declined, would be passed to the interviewer and a complete record of the ages and genders of all drivers was made.

The driver was asked to provide a specimen of oral fluid via the ‘Omnisal’ testing system. In addition, an individual test record was completed of the driver’s age and gender, together with the time, date and location at which the sample was obtained.

Once the sample was collected, the driver was given a questionnaire asking for details of alcohol consumption, driving habits and any use of drugs or medicines. This questionnaire was used in all three partner countries. The driver was also given an explanatory letter outlining the purpose of the evaluation and thanking them for their participation.

There was a high level of compliance with the roadside survey, and only 12 drivers refused to take part. Of the 1,312 samples taken, 868 males and 425 females contributed. In 19 cases the gender was not recorded.

643 self-report questionnaires were returned, i.e. nearly 50%. Twenty-five respondents admitted that they used cannabis or other illegal drugs. Three respondents had used cannabis, heroin or codeine less than four hours before giving the oral fluid sample.

## Substances detected in the roadside sample

The Department of Forensic Toxicology at Glasgow University analysed the oral fluid samples from the roadside survey. This consisted of initial screening followed by a full confirmatory GC/MS (gas chromatography/mass spectrometry analysis of all positive samples.

It had been intended to establish the prevalence of drugs at concentrations that may be considered impairing. However, impairment thresholds for drugs in oral fluid have not been established, and therefore cut-off levels proposed by the Substance Abuse and Mental Health Services Administration (SAMHSA) were used. Substances detected above these cut-offs indicate recent drug use, but not necessarily at levels that could be considered impairing. Twelve per cent of the sample (158 cases) showed one of the drugs at or above SAMHSA cut-offs and 236 cases (18%) were detected with drugs at any level, as shown in Table 1.

**Table 1 Number of instances where substances were detected at or above proposed SAMHSA cut-off levels**

| Drug of interest | Detected at any level above analytical cut-off | Detected at or above proposed SAMHSA levels |
|---|---|---|
| Codeine | 31 *(13.1%)* | 18 *(11.4%)* |
| Opiates excluding codeine | 6 *(2.5%)* | 3 *(1.9%)* |
| Amphetamines | 12 *(5.1%)* | 11 *(6.9%)* |
| Ecstasy | 57 *(24.1%)* | 51 *(32.3%)* |
| Cannabis | 52 *(22.0%)* | 52 *(32.9%)* |
| Cocaine | 25 *(10.6%)* | 23 *(14.6%)* |
| Benzodiazepines | 23 *(9.7%)* | n/a – |
| Alcohol | 30 *(12.7%)* | n/a – |
| Total | 236 *(100%)* | 158 *(100%)* |

The prevalence of drug use was estimated from the results of the roadside oral fluid test, using weighting factors derived from the traffic flow in order to obtain an estimate of the driving population of Glasgow.

Only results for the prevalence of substances at or above the confirmatory test cut-off concentrations for oral fluid proposed by SAMHSA are reported in Table 2.

**Table 1 Estimates of the prevalence of substances at or above the confirmatory test cut-off concentrations for oral fluid proposed by SAMHSA**

| | Estimated prevalence where drug is used alone | Estimated prevalence where drug is used in combination with other drugs* | Estimated prevalence where drug is used on its own or in some combination | | |
|---|---|---|---|---|---|
| | | | | 95% confidence interval† | |
| Substance | | | Estimate | Lower | Upper |
| Cannabis | 3.14% | 0.12% | 3.26% | 2.38% | 4.29% |
| Amphetamine | 0.49% | 0.17% | 0.66% | 0.31% | 1.20% |
| Ecstasy and similar | 4.10% | 0.51% | 4.61% | 3.57% | 5.84% |
| Cocaine | 0.98% | 0.36% | 1.34% | 0.81% | 2.06% |
| Opiates excluding codeine | 0.02% | 0.06% | 0.08% | 0.02% | 0.42% |
| Codeine | 1.34% | 0.27% | 1.61% | 1.06% | 2.43% |
| Any drug from above list | 10.07% | 0.73% | 10.80% | 9.20% | 12.55% |

* This has been computed by taking the difference between the drug used alone and the drug used alone or in combination.

† The confidence intervals have been derived under the assumption of an underlying Binomial distribution.

The prevalence varied from 4.1% for ecstasy or similar to 0.02% for opiates (not including codeine). Ecstasy and cannabis (3.14%) were, by far, the drugs with the highest prevalence.

## Data from fatalities

In order to calculate risk ratios, data from the analysis of bodily fluid samples of fatally injured drivers were compared with data from the roadside sample.

However, although 36 fatal cases were found, only 22 of these cases had post-mortem data available and so provided some indication of drug or alcohol use.

The drug data from those available post-mortem cases was not generally based on oral fluids. This complicated any analysis since there are no established equivalent levels to allow direct comparison between blood or urine analyses and oral fluid levels. Hence, it was not possible to estimate the increased risk to driving on the basis of drugs present as planned.

# Conclusions

A roadside survey of drivers in central Glasgow was successfully completed, from which estimates of drug use were made. The survey involved a considerable organisation and scheduling of teams of police and research staff in order to obtain oral fluid samples from drivers. Over a period of one year more than 1,300 drivers were stopped and agreed to help in the survey by giving an oral fluid sample and completing a questionnaire on drugs and driving.

The original intention was to match the roadside survey with a survey of drivers involved in traffic accidents and to calculate odds ratios for a range of different potentially impairing substances while controlling for potentially confounding influences, such as age and gender. In practice, due to ethical constraints, it was not possible to follow the intended design. Instead, this element of the case-control study was restricted to a sample of fatally injured drivers for whom post-mortem records were available. Data on any drug found were extracted from these records.

It was clear that the small size of the resultant case sample would mean that, at best, only imprecise estimates of risk could be calculated, making it unlikely that any useful estimates could be derived from the study on the effect of drugs on driving risk. An added complication was that the post-mortem reports did not contain sufficient data on concentrations of substances to enable a comparison with the results of the roadside survey.

The main outcome from this study was an estimate of the prevalence of different substances at or above the SAMHSA levels in Glasgow drivers, which showed that ecstasy and cannabis were, by far, the drugs with the highest prevalence.

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# Modelling the collision risk of London's motorcyclists

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## Abstract

Motorcycle riders are over-represented in London's road collisions and casualties. They make up around 20% of casualties yet account for less than 5% of passenger kilometres travelled. Furthermore, progress towards the casualty reduction targets for motorcycle riders lags far behind that for other road users.

Standard police-reported data provide counts of collisions and casualties but tell us little about the relative risks of different modes. Nor do the data tell us which characteristics of riders might help explain how many collisions they are involved in.

This study uses self-reported information from motorcycle riders, including information about collision involvement, which is comparable to, but independent of, the standard data.

A generalised linear model is used to establish what features of riders, their bikes and their journeys best explain the variability in their collision involvement. Exposure is controlled for using annual mileage.

Based on the model, the riders who are at an elevated risk of collision are:

- those who have less experience;
- cite enjoyment of riding as their motive for choosing motorcycles to travel;
- attend race-day events;
- use their machine to commute;

- are single and not living with their parents; and
- ride fashionable scooters.

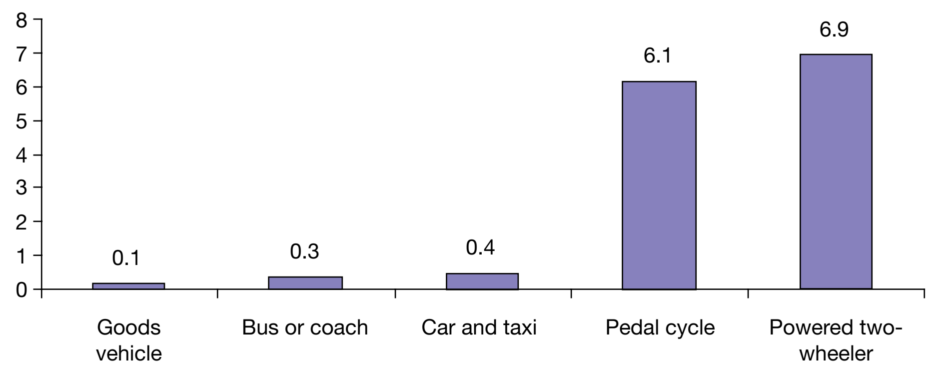
Based on these findings, a number of recommendations are put forward which aim to raise awareness amongst riders with these characteristics to their elevated risk.

# Introduction

## Relative risk

In London, motorcyclists (also called powered two-wheeler riders) are at much greater risk per passenger kilometre travelled than any other motorised mode, see Figure 1 (TfL, 2005a, 2004b).

Figure 1 **Casualties per million passenger kilometre by mode, London 2004**




Much government-sponsored work has been done to establish the reasons for the higher risk of this group (see, for example, Sexton *et al*. (2004), Clarke *et al*. (2004) and Broughton (2003)) and some of the reasons behind this are well understood. Motorcycles are single-track vehicles – making them both more unstable and more difficult to see in profile – have high power to weight ratios and are capable of more rapid acceleration and braking than other modes of transport. Furthermore, relative to other modes, arguably higher risk groups of people ride motorcycles: around 90% of riders are male, and many are young and many are thrill seeking (Mannering and Grodsky,1995).

## Targets and progress

The Mayor of London has set a target to reduce the overall number of people killed and seriously injured (KSI) on London's roads by 2010 by 40% compared with the baseline average of 1994–98. This target is disaggregated to apply to road users in each of the following modes:

- 40% reduction in pedestrian KSI casualties;

- 40% reduction in pedal cycle KSI casualties; and
- 40% reduction in motorcycle KSI casualties.

These targets are enshrined in *London's Road Safety Plan*, published in 2001 (TfL, 2001).

# Progress

Progress towards most of the Mayor of London's road safety targets has been good, see Table 1.

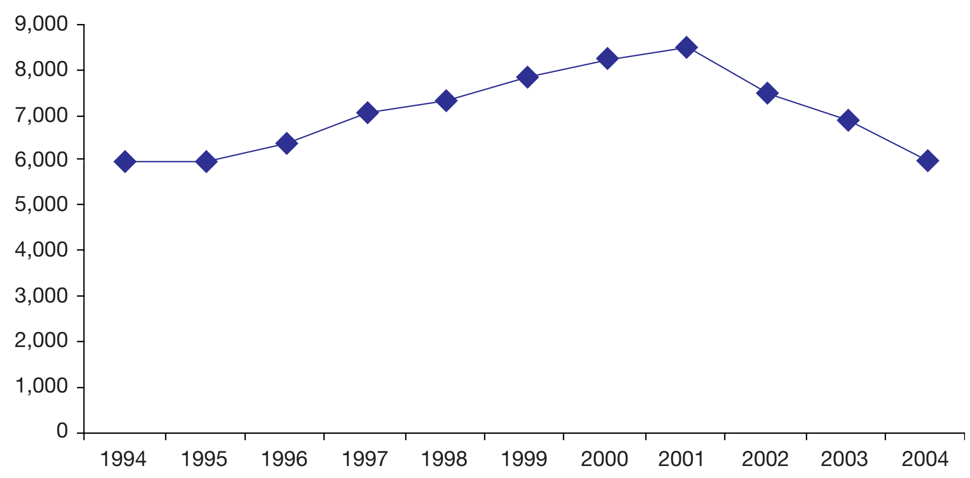
Table 1 **Summary of progress towards casualty reduction targets, London 2004**

| Category | Target change by 2010 (%) | Casualties 1994–98 average | Casualties 2003 | Casualties 2004 | % change by 2004 compared with 2003 | % change by 2004 compared with 1994–98 average |
|---|---|---|---|---|---|---|
| ***KSI casualties*** | | | | | | |
| Total | –40% | 6,684.4 | 5,164 | 4,169 | –19% | –38% |
| Pedestrians | –40% | 2,136.6 | 1,499 | 1,334 | –11% | –38% |
| Pedal cyclists | –40% | 566.8 | 440 | 340 | –23% | –40% |
| Powered two-wheelers | –40% | 932.8 | 1,152 | 895 | –22% | –4% |
| Children | –50% | 935.4 | 543 | 487 | –10% | –48% |
| ***Slight casualties*** | | | | | | |
| Total | –10% | 38,996.8 | 33,266 | 30,386 | –9% | –22% |

Source: TfL, 2005b.

However, up to and including 2001, powered two-wheeler casualties increased in number from the 1994–98 average baseline figure of 932.8 KSI casualties. Since 2001 the number of powered two-wheeler casualties has been falling, see Figure 2.

Figure 2 **Motorcycle casualties in London, all severities, 1994–2004**



In the 1990s the number of powered two-wheeler casualties largely fluctuated in line with the change in registered vehicles (TfL, 2004b). However, in recent years, the number of casualties has started to decline, despite the number of vehicles registered in London remaining fairly constant.

## Data sources

There are two main data sources drawn on in this study. The main source is data from a telephone questionnaire (the User Survey), identifying and interviewing those who ride motorcycles in London. STATS19 data are also used.

Many have argued that STATS19 data are a poor research tool (for example, Labatt and Langham, 2005). Furthermore, not all injurious collisions are reported to the police and reporting rates vary by mode, severity and location (Ward *et al*., 2002). For example, reporting rates in London (at c. 70%) are thought to be higher than those in Gloucester (c. 50–60%).

In this study, self-reported accidents and annual distance travelled are used to understand what factors underpin risk amongst London's motorcycle riders using a log-linear model of the factors affecting risk. The dataset contains information about riders at the level of the individual and models accident involvement at the level of the individual.

The User Survey is a database of information from 504 telephone interviews with motorcycle riders who had ridden in London in the 12 months ending September 2004. The data were collected by FDS International for Transport for London (TfL) and forms the main dataset analysed here. The information used from it is described in more detail in the analysis section.

Harrison and Christie (2005) suggest that motorcyclists are likely to produce less biased reporting of collision involvement than other modes because their collisions are likely to be more severe and, hence, more memorable and reportable. For this reason, comparison of the self-reported collisions and the STATS19 data might be expected to be more reliable for motorcycles than for other modes.

# Analysis

## The problem

The aim of the study is to establish which of the various characteristics about which the User Survey provided information have an influence on the number of collisions that riders are involved in, in order to identify what that influence is and to recommend measures to control or mitigate against it.

The data being modelled are count data: the number of collisions over the previous three years. Collisions are relatively rare events, so three years of data were used (rather than the single-year timescale of the exposure data, distance travelled) with the hope of improving the granularity of the findings. The distribution of collision counts is assumed to be, at least approximately, poisson distributed. The collision count data need to be explained in relation to the exposure to risk of the riders. In this case the exposure to risk is measured using categorical data of the annual distance riders travel on their motorcycles. Although categorical, there were 20 categories in the information relating to distance travelled, providing adequate granularity.

The standard way of reporting collisions is proportionate to distance, so using a log-linear model lends itself well to this modelling. Using a log-linear model means that the factors are expected to affect the number of collisions proportionately, by a percentage amount above or below the baseline.

The baseline corresponds to riders who have all the features of the base level of every factor. The coefficient of the intercept of the baseline gives the collision risk for these individuals. The relative risk of individuals with characteristics that are not in the baseline level of a particular factor can be easily calculated. It is given by the product of the exponentiated baseline coefficient and the exponentiated factor level coefficient. When cases are being grouped into factor levels, using larger numbers of cases in the baseline group increases the precision (reduces the standard error) of the estimate of the baseline coefficient, so giving a better estimate of individual collision risk.

One of the difficulties with this dataset was the large number of explanatory variables: a strategy was needed for picking which were most appropriate. A useful variable would be one that explained the variability of the number of collisions well and lent itself easily to practical recommendations.

Firstly, the variables were assigned to groups with similar characteristics: those described earlier. Then, within each of these groups, variables were added to a null model (the offset model described below). This used log of annual distance travelled as an offset term. Consideration was given to the size of the estimate of the coefficient of these explanatory variables (the larger the better), along with the significance of their effect, when deciding which to take forward into a final model. Having investigated the variables individually, within each of the groups, those that were significant with the largest coefficients were then considered together and some interactions between them were also considered. This showed whether each variable was useful in explaining deviance in the presence of the others, or whether correlations between terms or particular interactions were of interest.

Most of the variables considered were factor variables, but a few were continuous. Where variables were continuous, attempts were made to create factor variables out of these by defining a number of levels within the continuous range. The successful grouping of levels within the factor variables would make them more easily applicable to recommendations. For example, motorcycle engine size was a continuous variable in cubic centimetres. Various choices of factor levels were tested to see if the variability in self-reported collisions explained by engine size could be meaningfully captured in, say, three levels: bikes below 51cc, bikes between 51 and 250 cc and those above 250 cc. This is described in more detail in the section below relating to the variables in the category of details about the bike. The aim of this was to make any recommendations easier to establish and communicate.

Where explanatory factors, which were significant, had a large number of levels within a factor, an attempt was made to capture the deviation explained in a smaller number of useful factors. Examples are given of this in the following explanation of the analysis.

Each group of explanatory variables contained some factors that usefully explained collisions. These were all brought together in the final model. However, in the presence of variables from the other groups, some that had been significant, when used only with variables within their group, were no longer significant. For this reason, some were removed from the final model.

# The null model

Initially, the number of self-reported collisions over the last three years (from the date of the survey) was modelled using a generalised linear model in S-Plus V6.1. This regressed the log of the annual distance travelled on the number of self-reported collisions over the previous three years. Missing data were excluded. Table 2 shows a sample of the output from this model.

Table 2 **Coefficients, their standard errors and t-values**

| | Value | Std Error | t-value |
|---|---|---|---|
| Intercept | –3.333 | 0.502 | –6.645 |
| Log distance | 0.336 | 0.060 | 5.619 |

In this model, log distance is used as the only explanatory variable to model the count of collisions in the last three years. In Table 2, the coefficient is given as 0.336 and the t-value shows that log distance is significant as a predictor of collisions. This means that the following model for the expected number of collisions ($\mu$) over three years holds:

$$\log(\mu) = \varepsilon + 0.336 \times \log(\text{distance})$$

Or, approximately:

$$\mu \approx k \times \sqrt[3]{(\text{distance})}$$

This shows that the count of collisions in the last three years is approximately proportional to the cube root of the annual distance travelled. This suggests that log distance might usefully be used as an offset term in the model. An offset term is one that is taken to be a known constant that is easily used in the procedure to estimate the model's coefficients (Dobson, 2002). Using log distance as the offset term means that the interpretation of the coefficients of the explanatory variables is made simpler. For example, the coefficient of a binary explanatory variable (or two-level factor) can simply be exponentiated to give the rate ratio for presence versus absence of the feature:

$$\text{Rate ratio} = \frac{\text{Expected collisions given factor present}}{\text{Expected baseline collisions (given factor absent)}} = e^{\text{coefficient}}$$

This shows the relative proportion of collisions over the baseline – how many more or fewer – a rider with the particular feature present might expect over a three-year period. The count of collisions is proportional to distance rather than, as was seen in the model without the offset term (see Table 2), the cube root of distance. Exponentiating the coefficients gives the proportion of collisions, relative to the baseline case, that the model predicts for the given level of a factor.

Using the log of distance as an offset term on the model means that the expected number of collisions is:

$$\mu = k \times \text{distance}$$

The null model, then, uses log distance as an offset term. The remainder of this section describes the analysis and selection of each of the explanatory variables by group as they are added to the null model. The resulting model is given and explained in the following section.

# The bike

Having established the predictive use of distance ridden, other variables about the motorcycle itself were introduced to the null model. Key factors included:

- the make of the bike (initially a 14-level factor: Honda, Piaggio, etc.);
- the engine size (initially a continuous variable in ccs); and
- the type of bike (initially a four-level factor – scooter, moped, motorcycle, etc.).

t-values for several of the makes of bike suggested that the make could help explain the number of collisions. Those who rode BMWs were less likely, and those who rode Lambrettas much more likely to have been in a collision or collisions. Using this information, the 14-level factor relating to bike make was recast into the following three factors:

- baseline – those riding all bikes except BMWs and Lambrettas (475 cases);
- level 1 – those riding Lambrettas (eight cases); and
- level 2 – those riding BMWs (25 cases).

This was used in the model and proved significant in predicting collisions, with those riding Lambrettas expected to have around 2.4 times more collisions and those riding BMWs around half as many collisions as riders of other bikes. As described earlier, these ratios are calculated as the exponent of the model estimated coefficient.

Langley *et al*. (2000), and others, have shown links between engine size and collision risk. Size was initially put into the null model as a continuous variable and then a number of different groupings of engine size were tried to create a factor variable for engine size. For example, the six-level factor shown in Table 3 was tested.

Table 3 **Example of factor levels tried for engine size**

| Engine size groups | Cases | Significant at the 5% level | Collisions relative to baseline |
|---|---|---|---|
| 0–100 cc | 63 | Y | n/a (baseline) |
| 101–250 cc | 113 | Y | 1.61 |
| 251–500 cc | 52 | N | 1.62 |
| 501–750 cc | 156 | N | 0.96 |
| 751–1,000 cc | 76 | N | 0.71 |
| >1,000 cc | 40 | Y | 0.36 |
| No data | 4 | n/a | n/a |

This showed that riders of bikes with engine sizes between 101 and 500 cc appeared to have had more collisions than riders of bikes with smaller engines. Also, riders of large bikes (with engines greater than 750 cc) had the fewest collisions of all. However, not all of these results were significant, so other factorisations of the continuous variable engine size were tried.

None produced highly significant results for all levels of the factor. However, all factorisations seemed to show broadly similar results. Riders of mid-sized bikes were at greater collision risk than those of the smallest bikes and riders of the smallest bikes were, in turn, at greater collision risk than the riders of the largest bikes. This is, in itself, a useful finding. The factorisation that might most usefully be included in the final model is given in Table 4.

Table 4 **Factorisation for consideration in final model**

| Engine size groups | Cases | Significant at the 5% level | Collisions relative to baseline |
|---|---|---|---|
| 0–250 cc | 176 | Y | n/a (baseline) |
| 251–500 cc | 52 | N | 1.08 |
| >500 cc | 272 | Y | 0.81 |
| n/a | 4 | – | – |

Also, information on the body shape, or type, of the motorcycle was added to the null model as a factor. It had the following levels:

- baseline – motorcycle (over 50 cc), 385 cases;
- level 1 – scooter (over 50 cc), 61 cases;
- level 2 – moped 50 cc or under, 'astride the frame' style, 32 cases; and
- level 3 – scooter (50 cc or under), 25 cases.

Those riding machines in the scooter (50 cc or under) category were at higher collision risk, being expected to have around a fifth more collisions, although this was only marginally significant at the 5% level. The type of bike was recategorised into those using this type of higher risk bike (level 1) and all others (the baseline).

With this refined factorisation, the higher risk of those riders of scooters with an engine size of less than or equal to 50 cc is captured in the model with the loss of one degree of freedom.

It can be seen that information about the bike that riders use is helpful in predicting their collision risk. Details about the type, make and engine size can all explain some variability within the data. All three of these variables can usefully help explain the collision risk of London's motorcyclists.

# The rider

In addition to details about the bike, information about the rider was considered, again building on the null offset model using log of the annual distance travelled as the offset term to predict collisions in the last three years assuming a poisson distribution. The key ones were:

- age and age started riding;
- sex;
- whether they had ridden continuously or taken a break;
- experience (in years of riding as well as experience measured as a function of distance ridden annually); and
- sociodemographic measures – marital status, work status, class, salary, ethnicity.

Age was added to the null model in a number of ways, as a continuous variable, as a factor with various numbers of levels and as a two-level factor variable identifying whether riders were above or below a certain age.

Treated as a continuous variable, age was significant at the 5% level. An increase in rider age decreased collision risk, indicated by the negative coefficient (see Table 5).

Table 5 **Baseline model with age and sex as explanatory variables**

| | Value | Std Error | t-value |
|---|---|---|---|
| (Intercept) | –8.193 | 0.272 | –30.150 |
| Age | –0.017 | 0.006 | –2.689 |
| Sex | 0.165 | 0.097 | 1.694 |

Table 5 suggests that, for every year older riders are, the number of collisions they experience will reduce. This particular model suggests a decrease in collisions of around 2% (e-0.017) per year increase in rider age. This model also shows that sex, considered in the presence of age, is not significant at the 5% level.

As a factor, age suggested that riders in certain age groups were at significantly more risk than others, as shown in Tables 6 and 7.

**Table 6 Age as a five-level factor**

| Age group | Cases | Significant at the 5% level | Collisions relative to baseline |
|---|---|---|---|
| ⩽20 | | 13 | N 1.98 |
| 21–30 | 40 | Y | 1.80 |
| 31–40 | 169 | N | 1.17 |
| 41–50 | 159 | N | 1.12 |
| >50 | 116 | Y | n/a (baseline) |
| n/a | 7 | n/a | n/a |

When five levels were used, riders above 50 years old (used as the baseline) were at lower risk than all other groups. Riders less than 21 years old were at around twice the risk of collision, and riders aged between 20 and 30 were at 80% more collision risk than those aged over 50.

**Table 7 Age as an eight-level factor**

| Age group | Cases | Significant at the 5% level | Collisions relative to baseline |
|---|---|---|---|
| ⩽20 | 13 | N | 1.98 |
| 21–25 | 16 | N | 1.26 |
| 26–30 | 24 | Y | 2.16 |
| 31–35 | 76 | N | 1.47 |
| 36–40 | 93 | N | 0.99 |
| 41–45 | 86 | N | 1.25 |
| 46–50 | 73 | N | 0.98 |
| >50 | 116 | Y | n/a (baseline) |
| n/a | 7 | n/a | n/a |

Table 7 shows a factor with more levels, used to try and add more granularity to the impact of rider age on collision risk.

More deviance was explained with age as a factor than as a continuous variable when eight levels were used. Here, all riders below 35 appear to be at greater risk than those above 50. The highest risk age group using this factorisation is those aged 26 to 30, who have more than twice the collision risk of over 50-year-olds. However, few of the levels of either of these factorisations show results significant at the 5% level.

Besides age, experience (i.e. the number of years riders have been riding) was also known from the questionnaire. This yielded a significant result when treated as a continuous variable and so attempts were made to factorise it in a useful way. A number of factorisations with more than two levels were tried, but none yielded useful or significant results. However, a binary factor, whereby riders were allocated to one level if they had less than or equal to a certain number of years experience and the other level if they had more, did yield significant results. The results, at various cut-off points, are shown in Table 8.

**Table 8 Choosing a binary variable to act as cut-off for riding experience**

| Years riding | Cases with less than or equal to years riding | Collisions relative to baseline | Significant at the 5% level |
|---|---|---|---|
| 1 | 20 | 1.29 | N |
| 2 | 46 | 1.29 | Y |
| 3 | 67 | 1.35 | Y |
| 4 | 91 | 1.39 | Y |
| 5 | 101 | 1.34 | Y |
| 6 | 108 | 1.22 | Y |
| 7 | 118 | 1.24 | Y |
| 8 | 125 | 1.24 | Y |
| 9 | 132 | 1.20 | Y |
| 10 | 141 | 1.23 | Y |
| 15 | 181 | 1.31 | Y |
| 20 | 220 | 1.18 | Y |
| 25 | 294 | 1.26 | Y |
| 30 | 365 | 1.17 | N |
| 35 | 411 | 1.44 | Y |

For each cut-off level, the baseline is taken to be all other cases. For example, where years riding is four, the baseline is all those riders with more than four years'riding experience. This means that the model predicts that those with four or fewer years'riding experience will have 1.32 times the number of collisions of the riders with more than four years'experience.

All of the coefficients are positive, which suggests that riders who continue to build-up experience continue to reap the benefits in terms of fewer collisions. For example, as a group, the riders who have less than or equal to 10 years of experience on a motorcycle can expect to have 23% more collisions on average than those who have more than 10 years'riding experience.

The relatively high significance of the less than or equal to four years category (with a t-value of 4.6) and the relatively large number of collisions relative to baseline predicted, at 1.39, suggest that this might be a good cut-off to use.

Riding experience, as a characteristic of the rider, can be thought of in terms of years riding and age. Experience gained in terms of distance travelled may also hold useful information about rider collision risk. Estimated, categorical, annual mileage of the respondents is known and has been used as the offset term to account for exposure. The same data are used here to give an indication of experience.

The distance ridden was considered as a factor in the null model in similar ways to those described above for age and engine capacity. Factorisations with different numbers of levels were tried, as was the idea of a binary variable determining whether riders had above or below a certain level of experience measured by the annual distance they travelled.

An eight-level factor of the annual distance data is given in Table 9.

**Table 9 Annual distance travelled as an eight-level factor**

| Distance groups (miles) | Cases per group | Significant at the 5% level | Collisions relative to baseline |
|---|---|---|---|
| 0–1,000 | 85 | Y | n/a (baseline) |
| 1,001–2,000 | 69 | Y | 0.27 |
| 2,001–3,500 | 59 | Y | 0.25 |
| 3,501–5,000 | 107 | Y | 0.18 |
| 5,001–6,500 | 65 | Y | 0.14 |
| 6,501–8,000 | 42 | Y | 0.16 |
| 8,001–15,000 | 38 | Y | 0.11 |
| <15,000 | 22 | Y | 0.06 |
| n/a | 17 | – | – |

**Table 10 Annual distance travelled as a four-level factor**

| Distance groups (miles) | Cases per group | Significant at the 5% level | Collisions relative to baseline |
|---|---|---|---|
| 0–2,000 | 154 | Y | 4.15 |
| 2,001–4,000 | 166 | Y | 1.80 |
| 4,001–6,000 | 65 | N | 1.23 |
| >6,000 | 102 | Y | n/a (baseline) |
| n/a | 17 | – | – |

Other factorisations were tried, including a four-level factor, also concentrating on the lower experience end in terms of distance travelled, see Table 10.

The fact that all of the levels for the eight-factor model showed significant results and the greater granularity given by the larger number of levels means that this is the most useful to be taken forward to the final model.

As an alternative to factorising distances to model rider experience, models using a binary cut-off variable were examined (as described above for years of riding experience, see Table 8). The output for this is given in Table 11.

If this type of binary factorisation were to be used, splitting the riders into those who ride less than 1,000 miles and those who ride more (as the baseline) appears a sensible cut-off. A large and highly significant coefficient suggest that those who ride less than 1,000 miles per year might expect between two and three times more collisions (which is equal to e0.963, calculated as described at the start of this section). When these different ways of modelling experience (using annual distance ridden as a proxy) as a predictor of collision risk are used, more deviance is explained with the eight-level factor than with this binary cut-off variable.

Other results show that the older a rider is when they start, the more collisions they have reported in the previous three years. Whether they have ridden continuously did not seem to be an important factor in collision prediction.

Some socio-demographic variables appeared to be useful in predicting collisions. For example, divorced riders, and riders who were single and not living with parents,

Table 11 **Choosing a binary variable to act as an annual mileage cut-off**

| Annual mileage | Cases with less than or equal to annual mileage | Collisions relative to baseline | Significant at the 5% level |
|---|---|---|---|
| 1,000 | 102 | 2.62 | Y |
| 2,000 | 171 | 1.81 | Y |
| 3,000 | 230 | 1.64 | Y |
| 4,000 | 337 | 1.46 | Y |
| 5,000 | 337 | 1.46 | Y |
| 6,000 | 402 | 1.38 | Y |
| 7,000 | 402 | 1.38 | Y |
| 8,000 | 444 | 1.50 | Y |
| 9,000 | 444 | 1.50 | Y |
| 10,000 | 444 | 1.50 | Y |
| 15,000 | 482 | 1.74 | Y |
| 20,000 | 489 | 1.78 | Y |
| 25,000 | 492 | 2.04 | Y |

were more likely to be involved in collisions. Marital status was re-factorised, from five to two levels, into those who were single and not living with their parents, and others (baseline). This yielded a significant result, such that single people not living with parents could expect to have around 40% more collisions.

Other socio-demographic variables were of little use in predicting collisions. Social Class had some bearing in that ABs and C2s had reported fewer collisions. However, only the result for C2s was significant.

Initial investigation of work status appeared to show that those who were unemployed or had refused to answer the work status question were more likely to be involved in collisions than those in full-time employment, although not significantly. Further re-categorisation of the information on work status yielded no significant and robust results.

The relationship between household income and collisions was investigated also. The significance of earning above or below certain levels was modelled, but yielded no significant and persistently robust results.

Riders were also asked about the media channels they used (radio stations, TV, magazines, etc.), what motorcycle events, shows and meets they attended, and what specialist motorcycling press they read. Events mainly described outdoor track racing-style events, whereas shows mainly described indoor conference-style shows with stands. Occasions where groups of riders get together for self-organised group rides on public roads are called meets.

Both events and shows proved useful in predicting collisions; meets did not. Those who had attended at least one show in the last year reported fewer collisions, whereas those who had attended at least one event had more.

In summary, the information about the rider which can be usefully considered are:

- binary details of their marital status (single not living with parents or not) and their experience as measured by the number of years they have been a rider (less than, or equal to, or more than four years);
- experience as measured by an eight-level factorisation of distance riders travel annually; and
- attendance at shows and events related to motorcycling.

Although early data exploration indicated that sex might be of use in predicting collision involvement, it was not. This may be a genuine result, or may indicate collision under-reporting by males.

Issues relating to correlation between variables are discussed with the fit of the model in the 'Results'section.

# Journeys and usage

This category of information overlaps somewhat with the information about the rider, and covers how the bike itself is used, including:

- uses made of the bike in London (commute, delivery, leisure, etc.);
- reasons for riding a motorcycle in London (e.g. speed, convenience, cost, safety, reliability, etc.);
- pattern of usage (e.g. whether a year round rider, number of months per year ridden, etc.);
- proportion of the journey that is a commute and the number of days per week the rider rides in London; and
- whether riders rode in the Congestion Charging Zone (CCZ).

The uses made of a motorcycle in London appeared to be relevant in predicting the number of collisions reported. Those who used their bikes for delivery or job-only purposes (i.e. riding as part of work but not delivering parcels) had been involved in more collisions. This was used as a two-level factor where those who used their bikes only for delivery or job-only purposes (not commuting) were in one level, and the baseline comprised all other riders. The significantly higher numbers of collision reported by the delivery group remained under this factorisation.

Besides the usage patterns, the motivations of riders could also prove useful in predicting collisions. For example, whether riders use motorcycles for speed, cost or reliability. Many riders expressed multiple reasons for riding. Some, however, expressed single reasons. Their motivations for riding were initially categorised in the following levels:

- speed only;
- convenience only;
- cost only;
- congestion only;
- enjoyment only;
- reliability only;
- safety only;
- parking only;
- more than one of these reasons; and
- none of these reasons/unknown.

Only two levels of this factor gave significant results: those whose reason for riding was only for enjoyment appeared to have had significantly more collisions and those who rode for multiple reasons, significantly fewer. However, this latter result was less significant and had a much smaller coefficient, hence was of less predictive use. Given this, two groups were chosen to reduce the number of levels in this factor to two. One level was those who rode only for enjoyment and the baseline level contained all others. This yielded the significant result that those riding only for enjoyment had reported more collisions in the preceding three years.

Other bike usage information included:

- the number of days per week the rider used the bike in London;
- whether or not the rider ever rode in the CCZ;
- the proportion of the distance they used the bike to commute; and
- the proportion of the distance covered in each of the four seasons.

Of these, the most useful measures appeared to be the first two.

The days per week that a rider rode in London appeared to be important. Using this as a factor, with those using their bikes fewer than seven days a week in the baseline and those using the bikes seven days a week in another group, yielded significant results, showing the latter group to have reported more collisions over the preceding three years.

Some questions relating to the CCZ were also asked. For example, how the CCZ had influenced riding behaviour and whether respondents thought it had improved safety and parking. The main areas of interest with respect to modelling collision involvement were to do with riders'usage of motorcycles in the CCZ and how implementation of the zone had affected this.

Riders who used their motorcycles in the CCZ appeared to have reported 18% fewer collisions. This was a significant result. Furthermore, those who avoided the CCZ, or used it less since charging came into effect, reported having had around 40% more collisions over the previous three years. This could reflect a reduced collision risk associated with lower speeds in central London (using the CCZ as a proxy) and higher speeds in outer London areas, with their correspondingly higher collision risk.

The variable of the proportion of distance travelled which was a commute appeared to yield significant results. Riders were grouped into those for whom commuting constituted less than 75% of distance ridden (baseline) and those for whom it was more. This yielded a significant result, showing that the latter group had had around a quarter more collisions in the previous three years.

Respondents were also asked to estimate the proportion of distance travelled in each of the four seasons. The proportion of mileage in winter seemed to offer the best predictive power. However, when considered in conjunction with other variables, it proved not to be significant.

Several pieces of information about the journeys and usage patterns of riders appear to be of use in predicting collisions. Aspects of their riding behaviour relating to CCZ usage, commuting and their motivation for riding all appeared to be useful collision predictors in the presence of other variables, and are considered in the final model.

# Rider attitude

Various questions covered the attitudes and opinions of the riders towards their self-confidence and self-perception of skill. Also covered were their attitudes towards some of the more dangerous riding activities and manoeuvres, such as speeding and filtering. Also, specific questions were asked about what kept motorcyclists safe when riding in London: would riders be okay if they were careful, skilful or rode defensively? Were pedestrians and other drivers, or the riders themselves, mainly responsible for the accidents in which motorcycles were also involved?

Some of these were measured on a four-point scale of agreement with statements, and others were measured with more granularity. Scales such as these lend themselves well to use as factor variables.

Rider confidence scores (originally measured from plus to minus five, and rebased here) ranged from 1 (very confident) to 11 (very cautious), shown in Figure 3.

Whilst confidence scores in the middle of the scale (4 and 7) were associated with riders who had reported more collisions (a significant result), extremes of confidence (both high and low levels of confidence, >9 and <2) appeared to be associated with riders having experienced fewer collisions. However, these results were not significant in the presence of other variables.

Riders were also asked about their own skill levels, shown in Figure 4. Those who thought that they were less skilful than average did indeed have more collisions, whereas those who thought they were about average in terms of skill, had fewer

Figure 3 **Rider confidence scores (rebased)**

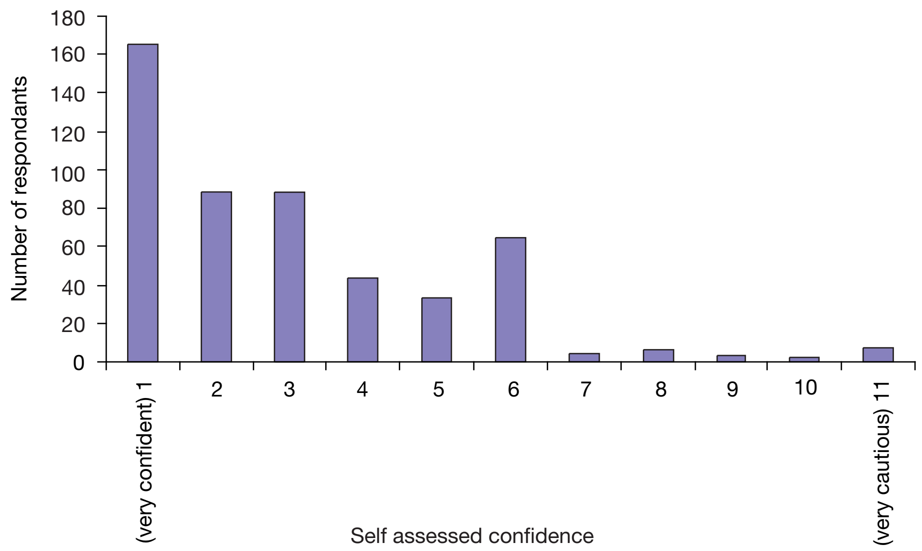
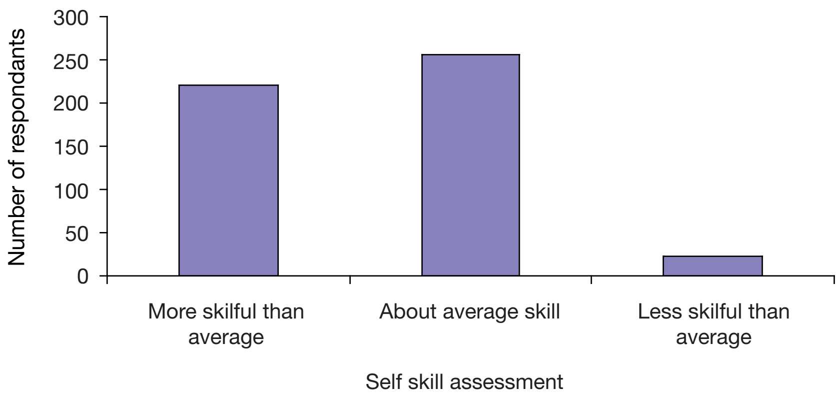



Figure 4 **Riders self-skill perception**




collisions. Both results were statistically significant. Whether skill assessment predicts collisions or vice versa, however, is uncertain.

Figure 3 and 4 show that riders in this survey consider themselves to have higher levels of skill than average and are much more confident riders than average. This may be due to biased sampling but is more likely to be because of inaccurate self-perception amongst all riders and drivers, not just those in this survey.

Other factors had some significant results. Riders were asked to respond using a five-point scale of strongly agree to strongly disagree (creating a factor with five levels) to statements including the following:

- 'Riders have a responsibility to ride defensively';
- 'In stationary traffic it is the responsibility of pedestrians to ensure that there are no motorcycles filtering before crossing the road'; and

- ‘Most accidents involving motorcycles, scooters or mopeds are not caused by the riders themselves’.

Often one level of a factor was significant, for example riders who neither agreed nor disagreed with the first of the above statements had reported fewer collisions over the previous three years. Most of the results that were significant were only just so, at the 5% level, and had relatively small coefficients. For this reason, from all of the aspects of rider attitude, self-skill assessment is the only factor which was taken forward for consideration in the final model.

## Safety equipment

Riders were asked what pieces of safety equipment they used and how frequently they used them. A four-point scale of never, sometimes, usually, and always was used. Also, they were asked what type of helmet they owned and how much they had paid for it, as well as the use of their headlights. Any or all of these measures may give an indication of the importance riders give towards safety considerations and may be useful in modelling collision involvement.

The number of items of safety equipment used at least sometimes, whether as a factor or an integer, does not predict collisions.

The wearing of open face helmets did provide some ability to predict collision involvement, in that all those who said that they always wore an open-faced helmet (71 cases) had fewer collisions. They reported 35% fewer collisions than other riders, a significant result. Scooter riders are more likely to wear open face helmets. This may be because their motorcycles travel at slower speeds, or perhaps for fashion or other reasons.

# Results

## The model

A number of useful and statistically significant predictors of collision risk were identified. Some proved less useful, having smaller coefficients, when put into a model with all other factors, from all groups. For this reason the final model includes only those with the largest coefficients (therefore the biggest relative impact on collision numbers), the highest significance, in terms of t-test fits and $\chi^2$ tests of deviance explained, and that are useful when considering recommendations.

The final model chosen, with the descriptions of the variables and estimates of the impact on collision numbers in decreasing order of relative risk, is shown in Table 12.

The $\chi^2$ significance of the deviance explained by each of the variables, added sequentially, is given in Table 13.

Table 12 **The variables, estimates of coefficients, Standard Errors and t-values of final model**

| Variable description | Variable name | Collisions relative to baseline |
|---|---|---|
| Baseline collisions | (Intercept) | 1.00 |
| Enjoyment is main reason for riding | Reason.ride.enjoy | 2.09 |
| Lambrettas | Make.21 | 1.61 |
| Ride only as delivery or part of job | London.uses.3 | 1.59 |
| Consider themselves less skilful than average | Self.skill.assessment1 | 1.52 |
| Been to >0 'events'in last year | biker.mad.events.2 | 1.42 |
| Use CCZ less/not at all since charging started | CCZ.2 | 1.39 |
| <4 years riding experience | ltet.four | 1.33 |
| Single people not living with parents | Marital.3 | 1.32 |
| Ride in London 7 days a week | days.7 | 1.27 |
| >75% riding is commute | prop.comm.2 | 1.26 |
| Ride 6,501–8,000 miles per year | dist.35 | 0.93 |
| Ride 8,001–15,000 miles per year | dist.36 | 0.88 |
| Ride >15,000 miles per year | dist.37 | 0.85 |
| Ride 2,001–3,500 miles per year | dist.32 | 0.83 |
| Ride 3,501–5,000 miles per year | dist.33 | 0.83 |
| Consider themselves about average skill | Self.skill.assessment2 | 0.82 |
| Ride in the CCZ currently | Ride.in.CCZ | 0.82 |
| Ride 5,001–6,500 miles per year | dist.34 | 0.8 |
| Been to >0 'shows'in last year | Shows.2 | 0.74 |
| BMWs | Make.22 | 0.65 |
| Always wear an open-face helmet | open.face.is.1 | 0.59 |
| Ride 1,000–2,000 miles per year | dist.31 | 0.52 |

Table 13 **Deviance of final model**

| | Df | Deviance | Resid. Df | Resid. Deviance | Pr(Chi) |
|---|---|---|---|---|---|
| NULL | 473 | 727.0 | | | |
| dist.3 | 7 | 91.7 | 466 | 635.3 | 0.0000 |
| Marital.3 | 1 | 28.0 | 465 | 607.3 | 0.0000 |
| prop.comm.2 | 1 | 16.4 | 464 | 590.8 | 0.0001 |
| shows.2 | 1 | 9.0 | 463 | 581.8 | 0.0027 |
| Make.2 | 2 | 16.6 | 461 | 565.2 | 0.0002 |
| open.face.is.1 | 1 | 18.8 | 460 | 546.4 | 0.0000 |
| Ltet.four | 1 | 11.2 | 459 | 535.2 | 0.0008 |
| Self.skill.assessment | 2 | 14.3 | 457 | 520.9 | 0.0008 |
| reason.ride.enjoy | 1 | 9.6 | 456 | 511.3 | 0.0019 |
| days.7 | 1 | 10.8 | 455 | 500.4 | 0.0010 |
| biker.mad.events.2 | 1 | 9.7 | 454 | 490.7 | 0.0018 |
| london.uses.3 | 1 | 8.4 | 453 | 482.3 | 0.0037 |
| Ride.in.CCZ | 1 | 5.8 | 452 | 476.5 | 0.0161 |
| CCZ.2 | 1 | 5.4 | 451 | 471.1 | 0.0197 |

This shows that all variables provide a significant reduction in the deviance and so are of value in predicting collisions. Around 35% of the deviance is explained by these variables and factors.

# Explanation

The interpretation of the model is simpler because an offset term of the log of the distance has been used alongside a series of factors. The baseline of the model refers to riders in the first level of all factors, i.e. riders who:

- ride fewer than 1,000 miles per year;
- are not single and living with their parents;
- spend less than 75% of the distance they travel commuting;
- have been to no shows or events over the past year;
- do not ride a BMW or Lambretta;
- do not always wear an open-face helmet;
- consider themselves more skilful than average;
- do not ride mainly for enjoyment;
- do not ride in London seven days of the week;
- do not ride only as a delivery rider or as part of their job; and
- do not currently use the CCZ, but nor do they use it less since charging started in February 2003.

Binary factors which the model showed to confer greater risk on riders were:

- enjoyment is their main reason for riding;
- they ride only as delivery or part of their job;
- they have been to at least one event in the last year;
- they use CCZ less or not at all since charging started;
- they have less than four years'riding experience;
- they are single people, not living with parents;
- 75% of their riding is commuting;
- they do not currently ride in the CCZ;

- they have not been to any shows in the last year; and
- they do not always wear an open-face helmet.

The opposites of these binary factors suggest lower risk. Where factors had more than one level, riders with the following characteristics were at lower risk than the baseline:

- they ride more than 1,000 miles per year;
- they ride BMWs; and
- they consider themselves about average skill.

And riders with the following characteristics were at higher risk:

- they ride Lambrettas; and
- they consider themselves less skilful than average.

It appears that single riders with low levels of experience who live at home and regularly enjoy using their Lambrettas (which is perhaps a proxy for the fashionable end of the scooter market) to commute are at higher risk. The distinction between BMWs and Lambrettas is perhaps giving an indication of the characteristics of those who buy these two very different machines. BMWs are expensive and more likely to be bought by older riders. They are larger and perhaps more difficult to weave and filter with (both potentially dangerous manoeuvres) in the London traffic environment. Lambrettas are smaller, cheaper machines which are favoured by younger riders, partly as a fashion accessory, for commuting and riding smaller distances.

Those who currently ride in the CCZ may be at lower risk for a number of reasons. The CCZ may be indicative of lower central London traffic speeds. It has been shown (Taylor *et al*., 2000) that lower speeds are associated with fewer collisions. Alternatively, those who ride in the CCZ, or central London, may have gained more experiences of dealing with congested, heavy traffic conditions and may, through this, be able to perform more dangerous manoeuvres (such as filtering) with relatively lower risk levels than others.

Those who rode as part of their job were at a higher risk. This is slightly surprising, as one might have thought that these riders would travel larger distances and have some experience benefit from this. However, they do not get to decide when or where they ride, so may spend more time out in wet and dark conditions, when collision risk is expected to be higher. Also, some respondents were police riders. These individuals may be involved in high-speed riding, which is more dangerous.

In all cases, those who rode more than 1,000 miles per year were at lower risk than those who rode less. Many levels of this factor are at similarly low relative risk to the baseline: all those riding more than 2,000 miles per year have 10–20% fewer collisions. The safety benefit was increased a little for riders who rode between one and two thousand miles per year, who appeared to have the least collisions of all the experience groups. This may reflect the complex interplay between the increased danger through more exposure (riding longer distances) and the increased experience, hence reduced danger, gained from riding further.

Riders who thought themselves less skilful than average were also at higher collision risk. This may be a misleading result as it is unclear whether this is a cause of collision involvement or an effect: do they believe themselves to be less skilful because they have been involved in more collisions or vice versa?

Riders who were single (and also perhaps riders who were divorced) had higher collision risk. This may be a function of those in this group being younger (although this did not come out as a significant factor). Alternatively, those with no dependents may ride with less care and take more risks as their personal circumstances make them less risk averse.

Those who said they rode mainly because they enjoy it were at twice the risk of those who cited other motivations. This may be identifying a pleasure-seeking characteristic of certain riders who enjoy the thrill of the speed and comparative danger of riding a motorcycle. It is difficult to market safety to this group.

The distinction between shows and events in predicting collisions is interesting. Those who attend shows appear at lower risk, whereas those who attend events are at higher risk. Shows are mainly indoor activities with stands at places like Exel or Alexandra Palace conference centres – effectively marketing opportunities for the retailers of motorcycle goods and services. In contrast, events tended to be track days and racing and touring meets. It could be argued that these glamorise speed, power and risk-taking among motorcyclists and, as such, may be promoting riskier behaviour on the public highway amongst those who attend these events.

Surprisingly sex, engine size and bike type did not make it into the final model. That these factors did not prove important in predicting collisions is not supported by other research (e.g. Sexton *et al*., 2004). This may indicate a 'London effect' in motorcycling, which has been found by other research (Jamson and Chorlton, 2004), whereby other factors outweigh the importance of these three. For example, London traffic is often at or close to saturation, which may negate the effects of larger engine sizes, with their concomitant higher speeds. Also, travel in London is motivated, arguably more than other places, by transport need than as a leisure activity, thereby potentially negating, to some extent, sex effects.

Correlations between variables in the final model were, for the most part, acceptably small. An example of variables with stronger correlations included a negative correlation of -0.40 between shows and events, suggesting that those who attend shows do not attend events. This might suggest two distinct groups of riders for targeting. The positive correlations between those who consider themselves less skilful than average and most of the levels of the distance-as-experience factor suggest that, as riders gain experience, they become more aware of their own weaknesses.

# Conclusions and recommendations

Motorcycle riders in London are the road-user group with the highest risk of collision involvement in terms of vehicle or passenger kilometres travelled. There are many reasons for this, including those relating to the bike, the rider and the ways that motorcycles are used.

Collision and casualty data collected by the police are used to measure progress towards road safety casualty reduction targets for all modes, including, in London but not the UK as a whole, a specific reduction of 40% in motorcyclists killed or seriously injured.

Much is already being done to improve the safety of London's roads for motorcyclists through engineering, education and enforcement methods. However, if casualty reduction targets for motorcycles are to be reached, effective allocation of road safety resources is essential. It is harder to decrease the number of casualties from some modes than others, and motorcyclists are a particularly hard group to reach effectively. STATS19 data alone cannot easily identify high-risk groups within the motorcycling community as it contains only scant information about the characteristics of the riders involved in collisions and the journeys they are making, and does not account for exposure to risk.

This modelling exercise has identified a number of groups within the motorcycling community in London whose involvement in collisions is high. It also reveals the relative importance of these characteristics and so can lead to the development of recommendations that may help mitigate against the problems of certain groups and allow resources to be more effectively targeted towards them, to reduce their collision risk.

The results of the modelling lead to a number of recommendations regarding road safety policy for London that might benefit motorcyclists should they be adopted. These include the following:

1. More resources should be allocated to activities of attending motorcycle events.

2. Road safety practitioners should work with retailers of motorcycles to give new riders more information about the potential dangers of riding.

3. Some future safety campaigns should focus on the following specific groups and bring to their attention the dangers of riding:

   (a) the group of people who ride because they enjoy riding;

   (b) riders of scooters who mostly commute short distances on their machines; and

   (c) single people not living with their parents.

4. The higher risk of those who ride as part of their job should be addressed through contact with their employers. Dispatch and delivery companies should be encouraged to improve their staff training, or stronger enforcement of their health and safety responsibilities should be considered.

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# 14

# The implication of the flow state for powered two-wheeler training

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## Abstract

According to the Department for Transport, 'Motorcyclists are at a much greater risk of death or serious injury than other road users. The relative risk of a motorcycle rider being killed or seriously injured per kilometre travelled was almost 50 times higher in 2003 than for car drivers' (DfT, 2004). This research explores the reasons why people ride, with the aim of finding methods to reduce that risk.

One of the findings is that the major goal of riding is enjoyment, which can be further enhanced by the 'flow state' (Csikszentmihalyi, 1990). When a person is in a flow state their attention is fully focused on the task at hand. To enter into a flow state, this task must be carried out in an automatic manner, with no interference from the brain's explicit memory. Therefore, these skills must be well practised. With experience, the motorbike is ridden in an automatic manner with very little or no conscious thought. This control is developed when learning to ride, and to a greater extent, by post-test experience.

Whilst being taught to ride, the pupil will be thinking about his actions, hence using explicit memory, but with experience the riding task control is passed to the more efficient, automatic areas, the implicit memory. Therefore a different brain area is used when a skill is being taught than when this skill is used during unsupervised riding. This paper discusses this dichotomy and its repercussions for post-test rider behaviour.

# Introduction

This paper reflects part of ongoing research examining the motivations of powered two-wheeler (PTW) users by discussing the implication of Csikszentmihalyi's flow state on PTW user training requirements. First, the paper briefly reviews aspects of the theory of flow (Csikszentmihalyi, 1990) before examining the connection between flow and the riding of a PTW found by this research.

To be able to appreciate what affect the undertaking of an activity while in a state of flow has upon the training requirements, an understanding of flow at the neurocognitive level is needed. This paper reviews some of these neurocognitive mechanisms and, by using examples from sports coaching, relates these to training and, specifically, how the flow state impacts on PTW training.

# The Flow State

Csikszentmihalyi, in his theory of flow, describes the state as being 'the holistic sensation that people feel when they act in total involvement' (Csikszentmihalyi and Csikszentmihalyi, 1988). When a person is in a flow state their full concentration is on the task at hand, in this case the riding of a PTW, and this concentration is so intense that there is no attention left over for anything irrelevant or to worry about problems. This trait of flow may be seen with bikers who often describe freedom as a major reason for riding (Broughton, 2005). How though can a person obtain this highly enjoyable state of flow?

Within the theory of flow, Csikszentmihalyi and Csikszentmihalyi (1988) describe four conditions based on an interaction between a person's skills and the challenge that they are using these skills to face (Figure 1). When a person has a low skill level, and is faced with a low challenge, then an apathetic attitude results but with a high skill and the same low challenge there is a shift from apathy to boredom. When the challenge is high, and outstrips the skill level, then a state of anxiety exists that the PTW user will often feel as being at risk (Broughton and Stradling, 2005). However, when a rider matches his level of skill to the challenge presented by the road, then the flow state can be entered into.

Figure 1 **The four states within Csikszentmihalyi's theory of flow**

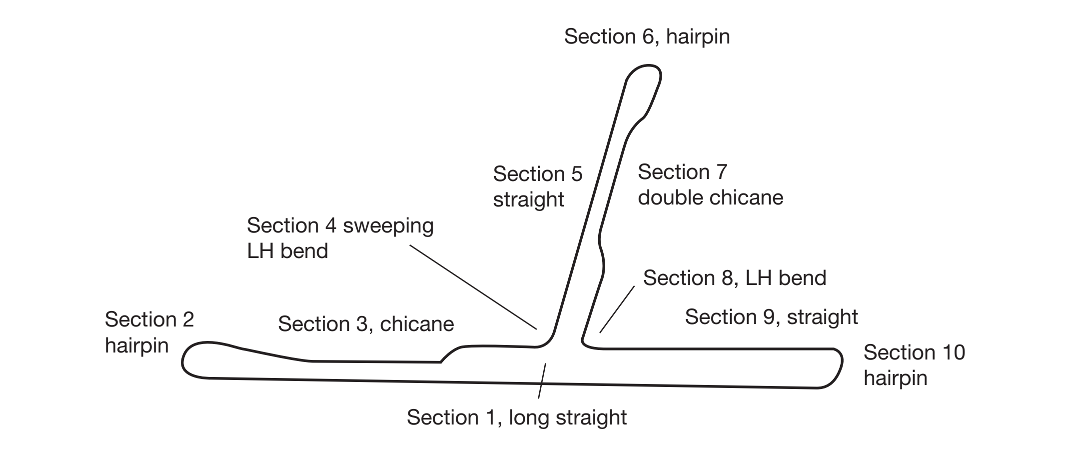
| | | Skill level | |
|---|---|---|---|
| | | Skill level | High |
| Challenge | Low | Apathy | Boredom |
| | High | Anxiety | Flow |

When a person enters a state of flow their concentration is purely on the task in hand because this concentration is so intense the task becomes almost automatic and effortless, and, as the task is executed, without strain or effort, it is performed to the best of the person's ability.

# The flow state and PTW users

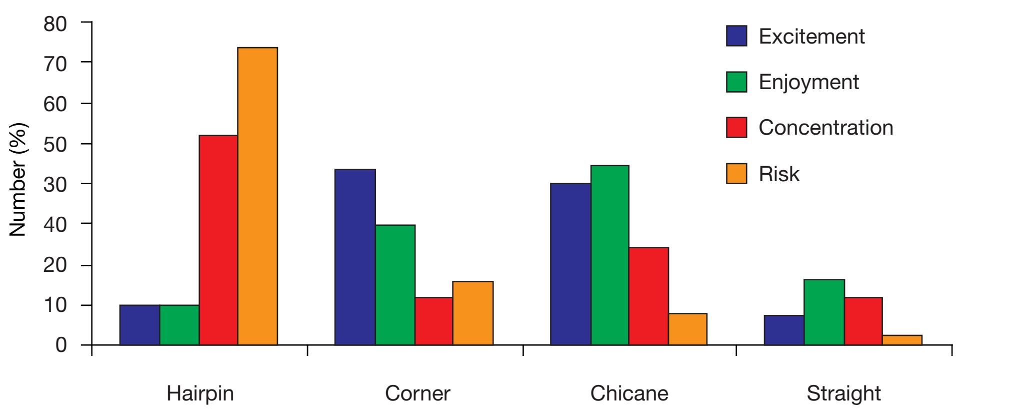
The relationship between challenge and the enjoyable flow state for PTW users was explored further by interviewing riders who had just ridden on a track during a public riding session (Broughton, 2005). The track used for this was situated at Edzell in Scotland (Figure 2) and was selected for this trial partly due to the ease with which various 'challenge' features could be identified.

Figure 2 **Edzell track**




Data were collected by asking riders who had ridden on the track that day to nominate the sections of the track that they felt was most enjoyable, the most exciting, where they felt most at risk and where they used most concentration. Figure 3 shows the results with the data combined for the four track features (hairpins, chicanes, bends and straights).

Figure 3 **Results from the Edzell track**



On the hairpin section of the track, risk and concentration had a high rating, with enjoyment and excitement being low. Hairpins are an area of heavy braking, a skill that is not much practised by bikers due to its inherent dangers, therefore for most riders this would be an area where challenge outstrips skill and therefore anxiety results, which is felt as risk.

The corners and chicanes are an area of some excitement and high enjoyment. Corners are an area where bikers can match their skills to the challenge provided, using speed as a modifier of the challenge level. Hence, skill and challenge are high and matched, therefore a flow type of enjoyment is felt. In contrast, the straights provide a low challenge, and coupled with the higher levels of skill that the rider possesses, results in boredom. This can be seen with straights being rated low for all four measured attributes.

The importance of challenge is exemplified in a quote from a biker taking part in a focus group – here the biker is talking about when he rides his PTW on the public roads:

> 'Some bits you go because you know you can go and test yourself and the bike, without necessarily going too fast, but it's challenging.'

As stated earlier, one of the features of flow is the effortless way that tasks can be performed, almost in an automatic manner, and this too is shown in another quote from the same focus group with a biker discussing riding on public roads:

> 'And everything becomes sort of semi-automatic and it's going well and that can make you forget about the speed limit because you are just enjoying it so much.'

The data collected at Edzell and through focus groups suggest that PTW users are having a flow type experience, and thus the challenge of the road is providing feelings of enjoyment, but does this mean all enjoyment comes from flow or near flow experiences? This, in part, can be answered through the results of an experiment designed to examine the connection between risk and enjoyment. In this experiment, a set of scenarios were presented in the form of pictures to PTW users and they were asked to rate each of the scenarios for a number of attributes, including risk, enjoyment, how fast they would ride, bends and the opportunity to overtake. The data were entered into an SPSS (Statistical Package for the Social Sciences) database and a factor analysis was carried out. Two factors were found for enjoyment (Table 1). One of these factors is not related to skills or challenge, but rather to speed and the adrenaline rush that can be achieved by just riding fast. The second factor is challenge/skill-based and this factor had bendy roads, a high level of challenge and a good road surface as its components.

Table 1 **Enjoyment factors**

| Factor 1 (speed/rush) | Factor 2 (bends/challenge) |
|---|---|
| Visibility | Bends |
| Overtaking | Challenge |
| Speed | Surface |
| Temptation | |

These two enjoyments can be compared to the difference between bungee jumping and rock climbing. Both of these activities can be enjoyable to people, yet enjoyment is found in completely different ways. Bungee jumping does not require much skill in throwing yourself off a high place with only a piece of elastic to act as your safety net, yet this is very enjoyable for those who are seeking an adrenaline buzz. Rock climbing on the other hand is a sport where a climber pits his/her skill against the challenge presented by the rock face. Enjoyment is found in that skill/challenge match.

People who ride PTWs may find enjoyment from the challenge presented by bends or from the adrenaline rush of just riding fast. This article discusses the flow type experience and how this has an impact on PTW training needs, but before these needs can be addressed a better understanding of what is happening in the brain during the flow state is required.

# The flow state and procedural memory

Memory can be split into two systems, explicit and implicit. The explicit memory system is the one that a person is aware of and is tied to conscious memory. The contents of our explicit memory can be expressed by verbal communication and allows for behaviour to be flexible by permitting the testing of conflicting hypotheses by reasoning. The implicit and, in particular, the procedural memory contain information to perform certain tasks – it is skill or experienced-based memory and, as such, it is not accessible to conscious awareness and therefore its contents can not be verbalised but only conveyed through the performance of tasks. The procedural memory is not versatile and does not allow for the testing of hypotheses by reasoning, rather it allows for the automatic running of schemas, with the schema being run dependent on the information at hand, mainly provided by the senses. The explicit memory is slow and versatile, while procedural memory is fast but not flexible.

Arne Dietrich (2004) relates flow to the states of the implicit and explicit memory, stating:

> 'A necessary prerequisite to the experience of flow is a state of transient hypofrontality that enables the temporary suppression of the analytical and meta-conscious capacities of the explicit system.'

Hence, when the flow state is entered into, the explicit memory is turned off and the person is being controlled totally by the implicit or procedural memory. For this to happen, the task being performed must have been installed into procedural memory through being highly practised. As this task is being performed with no interference from the explicit system, the control is very efficient, but inflexible. Within the field of sports psychology, this state is often referred to as 'being in the zone'. As athletes are trained in sport to carry out tasks in an automatic way, and ideally be able to perform them while 'being in the zone', examples from this area could be applied to aid in the design of PTW training.

# Flow and training

An example from sport can be used to illustrate how the procedural memory operates. In cricket, a batsman has a fraction of a second from when the ball leaves the bowler's hand to when it reaches him. During this time he has to decide where the ball is going to bounce, the direction or line of the ball, what would be the best shot to play, take into account where the fielders are positioned, move into position to play the selected shot, allow for any movements that the ball may make and, finally, he must hit the ball. As it can be seen, the hitting of a cricket ball is a complex task and to attempt to do this consciously by using explicit memory would be too slow, therefore this task has to be carried out using procedural memory. How, though, does a batsman learn to do this?

First, the whole task cannot be learnt at the same time. It is too complex. Rather, it has to be broken down into small sub-tasks that the explicit memory can handle. Then this new, or improved, skill-part can be learnt in the explicit memory while the rest of the task is being run in procedural memory. How then would a batsman learn a new sub-task? The learning starts with the coach giving instructions using his explicit system to the batsman, then the batsman's explicit system forms a mental representation of the task, which is then executed by the explicit system. A lot of effort is needed for this new task to be performed and it takes a long time to run due to the capacity limit of the explicit system. This limit also restricts the number of control movements that can be performed and, therefore, the action may not be smooth. Also, during this time the brain's attentional network is fully engaged, making it impossible to attend to anything else. With practise of the new task, a shift in neural control occurs and the task gradually becomes controlled by the implicit memory as the implicit system builds its own mental representation of the task. Once a skill or part-skill becomes automatic, it can be built upon with further skills until a complete task is possible from procedural memory. How though, does this apply to motorcycling?

A PTW rider will use his acquired skills to meet the challenge presented to him by the road, most likely by bends. Therefore, when the biker enters a flow, or near flow state, the rider will be riding almost completely on procedural memory and, hence, automatically. These automatic tasks have to be learnt by the implicit system by being practised, so how can it be known if these tasks have been practised and learnt so that they can be performed safely? Asking a rider how a task is performed will not get at how that task is really performed, as it is not possible to verbalise the content of the implicit memory. Rather, as shown by Berry and Broadbent (1984), all that will be verbalised is what was said to them while they were being trained. The only way to know if the skills in procedural memory are safe skills is through observation.

For PTW trainers there are two challenges: to train those with no procedural knowledge of riding, that is new riders, and to retrain those who already have implicit skills, that is experienced riders.

The only way that tasks can be proceduralised is by practice within the environment where flow riding occurs, that is on national speed limit 'A-roads' that have sets of bends – these are also the roads where a significant amount of killed and serious injury (KSI) accidents occur (Scottish Executive, 2004). Therefore, it is logical that riding should be practised on these roads. Also, when riding on these roads, it is important that quick and accurate feedback is given to ensure that incorrect skills are not practised and moved into procedural memory. Currently, it is possible to obtain a licence to ride without being tested on these ‘flow roads’ and therefore some riders are graduating to large and powerful machines without being given the opportunity to correct unsafe riding methods that have been proceduralised. More training would be required, over a longer time, to train riders correctly before they build incorrect procedural memory.

Such training would help to improve safety for new riders, however, more experienced riders will have had time for bad habits to be formed in procedural memory. Therefore, they would be required to unpack these while ensuring that the safe tasks are kept. The procedural memory of old skills and tasks will not forgotten, so there will always be the risk of the rider reverting back to old ways or that the old skills may interfere during retraining, causing a dip in safety performance. During the practise of these skills, a trainer would need to be present so that fast and accurate feedback can be provided along similar lines to new riders.

# Conclusion

PTW users are very likely to be engaged in expressive riding (Broughton, 2005) and, as such, their goal would be to gain enjoyment from riding. This enjoyment can be found in two ways: based on the adrenaline rush from riding fast and from using their skill set to match the challenge of the road, that is to ride well around sets of bends. The use of skills to meet a challenge can allow a rider to enter into a flow state (Broughton and Stradling, 2005) while riding and, when in this state, their actions will performed automatically, being controlled by procedural memory. These actions must be first encoded into procedural memory by being well practised, and these skills must be practised correctly otherwise the automated actions that are carried out may be unsafe or dangerous.

As it is not possible to prevent a rider from entering the flow state, training methods are needed to proceduralise safe riding skills and to correct unsafe ones. To place safe riding skills into procedural memory would normally take longer than to acquire enough skills to obtain a licence to ride by passing the current DSA (Driving Standards Agency) practical riding test. Even after passing a more intricate test, with time the skills that have been correctly learnt may become corrupted through incorrect practise and, therefore, some form of retraining may be needed at regular intervals (Broughton, 2005; Broughton and Stradling, 2005; Goldenbeld *et al*., 2004). The only way that the re-education of riders can happen is by having a trainer present to assess riding skills and to provide fast feedback.

This flow phenomenon may also apply to other types of road use, such as car driving, and therefore will have the same training implications. Once a person has a full driving licence in any category, they are at liberty to practise their skills and to place bad habits within procedural memory without any check by the DSA, unless they are identified for breaking the law and sent for further training, such as a speed awareness course or driver improvement scheme. This means that a person who passes a driving test at 18 has 52 years of practising with little, or no, feedback. Any scheme that attempts to address the issue of teaching implicit skills would be more time consuming and cost intensive than the current system and, therefore, likely to be politically unpalatable. However, it does raise questions regarding the rights and time constraints of holding a driving licence.

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# 15

# Communicating work-related road safety messages

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## Introduction

Over the last few years, work-related road safety has emerged as a focal point for decision makers in the field of transport. Research indicates that individuals who drive for business purposes drive better cars and are at an increased risk of accident relative to the general population. According to Downs *et al*. (1999), 53% of newly registered vehicles are company-owned cars and are, on average, larger and more powerful than privately-owned vehicles. In 1998, Lynn and Lockwood found that a company car or van driver was 49% more likely to be involved in a damage-only accident, even after controlling for demographic variables and exposure. The authors found evidence that higher accident liability was a result of habitually bad driving styles in company drivers, which also translated into non-work-related driving. A more recent study by Broughton *et al*. (2003), which included self-reported injury accidents, reported a 53% higher accident-involvement liability for those company drivers who drove more than 80% of their overall annual mileage at work. This study also suggested that company drivers more frequently reported potentially risky behaviours, such as eating and drinking whilst driving, using a mobile phone, driving long hours or driving under time pressure. Against the background of their findings, Broughton *et al*. (2003) came to the conclusion that isolated measures, for example the introduction of driver training, do not sufficiently deal with the problem of work-related road risk. Rather, they suggested that companies needed to change the conditions under which their employees drive, to reduce time pressure and fatigue, and to strongly discourage attention-demanding in-car tasks like mobile phone conversations.

But does work-related driving only include sales representatives driving more than 20,000 miles per year in a company car? Definitions of work-related road safety vary between authors. Lynn and Lockwood (1998), for example, include ‘drivers of company-owned or company financed cars who drive regularly for business purposes’, whereas Chapman *et al*. (2001) also include employees using their own vehicle for work purposes. It is, however, agreed that ‘there is no such thing as a typical fleet driver' and that 'company fleets vary enormously in both size and function, ranging from cars used by directors of a small business to the several thousands of vehicles in the fleets of major companies' (Downs *et al*., 1999). For the purpose of our project, we included any journey within the context of work, be it in a privately-owned, company-owned or leased vehicle as work-related road transport. This implies that even a quick trip to the post office in an employee's privately-owned car to post a company letter during office hours is counted as work-related transport.

Work-related road accidents are a problem with considerable economic impact; approximately a third of serious and fatal injuries on UK roads involve someone driving for work at the time (HSE, 2003). This equals approximately 900 road accident deaths per year, many more hours of staff sickness absence, vehicle down time or vehicle replacement, lost production and less tangible costs such as the loss of reputation and contracts. In 1995, Health and Safety Executive (HSE) economists estimated the costs of work-related road accidents to the employer to be in the region of £2.7 billion per year (HSE, 2001).

The scale of the problem led the DfT to commission the Transport Research Laboratory (TRL) with the development and evaluation of an information resource on work-related road safety that would help managers of companies with vehicle fleets to manage the risk of injury and death to their drivers by providing them with concise and relevant information and guidance. Through the Health and Safety at Work Act 1974, employers have a 'duty of care' for the safety of their employees at work regardless of the type or size of the business. However, employers frequently fail to notice that this duty of care also applies to their employees' business-related driving, or they are uncertain what systems they can reasonably be expected to put into place to comply with their duty of care requirements. The following paper describes the development process of the Work-Related Road Safety (WRRS) information resource that was informed by the findings from qualitative research carried out with managers and drivers of UK-based businesses.

# The Work-Related Road Safety project

## Project scope

The scope of the project, commissioned by the DfT in August 2005, is to develop and evaluate an information resource for those with responsibility for staff driving at work. At the time of writing, Phase I has been completed, and work on Phase II has begun.

In line with Broughton *et al*.'s (2003) recommendation that companies need to set the frame for the safety of company drivers, the guidance is explicitly targeted at managers with the power to implement change and not at drivers.[1]

1 However, as the resource aims at initiating the implementation of work-related road management systems and, thus, a change of the overall company culture, improved driver behaviour and reduced casualty numbers would be expected to result from it too.

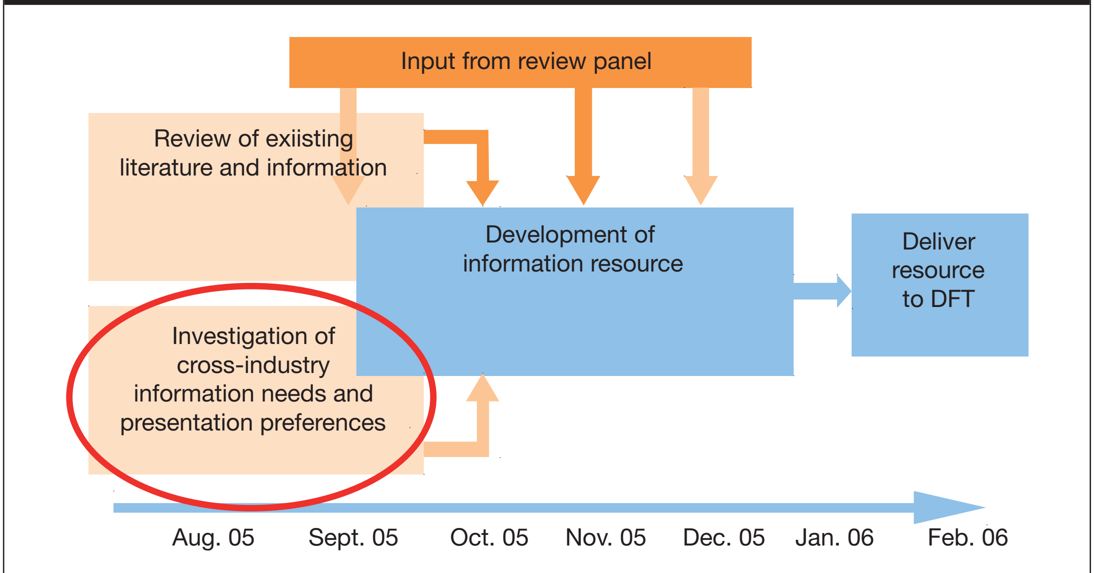
The project is divided into two distinct phases:

- Phase I includes the development of the resource in a user-friendly format on the basis of existing information; and

- Phase II aims to evaluate the resource in terms of implementation or improvement of (existing) work-related road safety management systems.

Figure 1 provides a breakdown of Phase I tasks along a timeline and illustrates the two sources of information that have fed into the development of the information resource: (a) the review of existing literature and guidance, and (b) the investigation

Figure 1 **Overview on Project Phase I**




of cross-industry information needs and presentation preferences. In the following sections, findings from the latter are presented.

# Information needs and presentation preferences

## Sample

To inform the development of the information resource in terms of required contents and preferred format, qualitative research was carried out with managers and drivers. This included two one-hour focus groups each with four drivers who regularly or occasionally drove cars, vans or trucks for work and eight in-depths interviews with managers who carried responsibility for employees driving at work. Participants were recruited through advertisements in road-safety and transport newsletters, opportunity sampling and snowballing techniques, as well as utilising existing contacts with companies who had participated in other TRL projects. Corroborating evidence was gathered through in-depth interviews on WRRS conducted within a project for the AA Motoring Trust with professional and occasional van drivers ($n = 12$) and (transport or health and safety) managers of companies with van fleets ($n = 10$).

The business sectors covered in the overall sample included:

- courier services;
- logistics companies;
- energy providers;
- laundry and cleaning services;
- supermarkets;
- construction and manufacturing businesses;
- print media; and
- vehicle recovery.

Company size ranged from micro-businesses (one-man businesses) to very large companies (many thousands of employees).

## Qualitative research with drivers

Interviews and focus groups with drivers concentrated on their awareness and knowledge of WRRS-management procedures, their perceived challenges of driving whilst at work, and on their adherence to safe driving rules. This part of the study aimed to identify current practice with regard to the management of WRRS in companies, and at investigating whether existing procedures actually filtered down to the drivers.

We found that drivers were, on the whole, unsure about the existence of safety policy that covered driving at work or the completion of risk assessments in relation to the journey, the driver or the vehicle. We asked specifically about the existence of driving licence checks, policies on alcohol, fatigue or mobile phone use, provision of information on WRRS and safety messages given out by management. All drivers reported driving licence checks at the start of their employment. However, the frequency of consequent licence checks varied greatly between companies and ranged from ‘no further checks’ to ‘six monthly checks’. The provision of driver training was equally variable between businesses; some drivers reported not having received any driving-related training at all, whereas others underwent annual driving assessments and extensive familiarisation and training. The incidence of potentially dangerous behaviours was high in the driver group. This included speeding, eating and drinking or reading maps whilst driving, mobile phone use and driving when tired or ill. Drivers often played down the danger of such behaviours or reported that they only carried out these activities when they felt safe doing them (e.g. only use mobile phone when on quiet, straight roads). Employees in high-pressure environments, for example courier drivers, frequently perceived a dominance of profit over safety and reported covert encouragement of unsafe driving by management ('The customer is waiting. As fast as you like'). Perceived challenges in driving at work typically included:

- driving in unfamiliar environments;
- driving under time pressure;
- driving long hours;
- driving in busy traffic;
- poorly maintained work vehicles; and
- adjusting to unfamiliar vehicles.

In summary, the drivers' statements illustrated a limited awareness of the WRRS management activities conducted by their companies and a high incidence of potentially dangerous driving behaviour. This implies that:

- WRRS management procedures either did not exist; or
- if WRRS procedures existed, they failed to permeate the whole organisation, possibly because the chosen pathways of communication were inadequate or alternatively because the drivers accurately perceived that safety was not a priority in the organisation.

## Qualitative research with managers

The interviews with managers served to:

- investigate the current status quo with regard to managing WRRS; and
- to identify what guidance on WRRS management should include and how it should be presented to fulfil managers' requirements.

As with the drivers, managers were asked initially about the WRRS management systems that their organisation had in place. This covered the existence of a safety policy that included driving at work, the completion of risk assessments on the driver, the vehicle and the journey, accident data recording facilities, driver monitoring, driver incentives and driver education measures and challenges in managing work-related road risk. The second part of the interview then dealt with the information sources that managers utilised to obtain information relevant to their business, their format preferences for the provision of guidance on WRRS and their preferences for the content of guidance on WRRS.

Most managers agreed that WRRS was an important issue, however, many of them reported not having sufficient resources or knowledge to manage this risk properly. The latter was a particular concern to small and medium enterprises (SMEs) without a dedicated health and safety manager, where the managing director filled various other roles at the same time and was extremely over-utilised. The existence of a safety policy that extended to driving at work varied between companies and was less frequent in those organisations who had some at-work driving of staff as a by-product of their business (e.g. construction). Managers of SMEs (e.g. with 10 employees) were often unaware that they were required to have a written safety policy at all or believed that managing WRRS was ‘common sense’. Completion of driving-related risk assessments was in place in some of the organisations, frequently for the driver and the vehicle, and almost never for the journey. Accident recording (including damage only accidents) was, particularly in SMEs, very poor and the real costs of accidents were never considered in cost calculations. Some managers voiced the concern that introducing systems that would monitor employees’ driving performance would get little support from unions or employees themselves, as driving is often regarded as a private activity and not perceived as being a work requirement. This concern was even greater for privately-owned cars driven for work purposes. Some managers felt that extending the WRRS management to privately-owned vehicles would require such sophisticated logistics that it would not allow the organisation to attend to their actual business activities.

The greatest challenges in managing WRRS were perceived as instilling a safety culture throughout the organisation. This included:

- convincing employees driving at work that driver assessment, training or monitoring would not be measures directed against them; and

- persuading senior management of the benefits of investing resources in the management of WRRS.

Demonstrating reductions of accident costs through the introduction of WRRS systems was, because of the frequently poor accident recording systems, perceived as being difficult. SME managers frequently regarded the introduction of WRRS management measures as complex, costly and distracting from core business activities. They felt that further legal requirements could threaten their profitability and, thus, their livelihood.

Almost all managers reported that they have access to a computer at work and the majority could use the internet. Information sources utilised to keep up to date with legislation relevant to their business predominantly included publications from trade associations or government websites (such as the DfT and HSE). Managers, especially those filling several roles in SMEs, preferred to be provided with information relevant to their business rather than to search for it themselves. They did, however, explain that information provided had to be addressed to them personally, with its relevance and applicability to the business immediately visible to attract their attention and to avoid it being discarded. Seminars and toolboxes were very popular with the interviewees, however, to convey large amounts of information and to allow repeated access at convenient times. A CD was rated to as the most time-saving and successful format, provided that it was user-friendly and easy to navigate. A web-based approach did not fulfil the requirement of being provided with information instead of actively searching for it, but was otherwise considered helpful, if finding the relevant information on the website was easy to do. It was emphasised that, in order to be read, guidance needed to be written in straightforward and simple language, it needed to be concise and to the point, and had to be tailored to the specific needs of the business.

Managers were asked to indicate (on a three-point scale: unnecessary – helpful – very helpful) the usefulness of potential content components of guidance on WRRS management. Some components were rated almost unanimously as helpful, whereas for others, opinions on the helpfulness varied:

- business case – very helpful;
- case studies – helpful;
- overview on legislation – helpful;
- advice on risk assessments – very helpful;
- assessment tool for WRRS – unnecessary to very helpful; and
- useful links/useful contacts – unnecessary to very helpful.

# The WRRS CD-Rom

The information obtained from the qualitative research was used to specify the content, structure and format of the information resource, And to provide concise and relevant guidance on WRRS management:

- in an easy to use and appealing format;
- for a broad range of industry sectors and company sizes; and
- covering different vehicle fleets, including cars, vans and trucks.

It was decided to develop a WRRS CD-Rom that could be personally addressed to, and sent out to, the decision makers of organisations with at-work transport. The CD was produced by TRL in co-operation with Indzine, a graphic design company.

The structure of the CD resembles a website with menu options horizontally arranged at the top and navigation buttons on the left side of the page. The CD automatically starts up when inserted into the CD drive. A voice-over is provided in addition to the visually presented information. However, this is not essential for understanding the information and can also be turned off by the user. A central homepage provides information on how to navigate through the CD. To simplify navigation, only a few information hierarchy levels were introduced to allow the users to return to the main menu within two clicks of the mouse at all times. All information presented on the CD is also available to the user as a Word document – this allows managers to copy relevant sections, for example for inclusion in staff presentations or memos.

As the interviews with managers had identified the business case as a potential driving factor for senior management to implement WRRS management systems, particular care was taken to provide evidence on company savings through the introduction of WRRS management systems. Even though an overview of the relevant legislation around the employer's duty of care requirements was included on the CD, it was decided to put the financial benefits ('Managing WRRS makes good business sense') rather than the potential losses ('Non-compliance with our duty of care requirements might lead to prosecution') in the foreground. As Figure 2 illustrates, the financial advantages of managing WRRS are demonstrated in three sections of the CD – in the opening animation, in the business case and in the case studies.

The opening animation, approximately two minutes long, is directed at the senior management level, the audience that the CD will be sent to initially. It demonstrates that WRRS management is relevant to every business with at-work transport and specifies how it can save companies money. In the business case section, more detailed information on potential savings and estimations of true accident costs are provided. The case study section presents six small, medium and large companies who introduced WRRS management measures and, as a consequence, reduced accident rates and saved their business money. A further 20 very brief case studies (presented in the style of newspaper headlines) illustrate negative outcomes if WRRS management systems are absent.

Figure 2 **Overview of WRRS CD contents**


More reasons why work-related road risk should be managed are provided in the sections 'Statistics', which provides figures on the frequency of accidents at work, and 'Legislation', which gives a simply-worded overview on employers' legal responsibilities with regards to WRRS.

The bulk of the guidance is in the section 'How to manage WRRS'. It illustrates how policy statement, risk reduction measures, rules and procedures, data recording, audit, communication and review form a basic system for managing WRRS. 'Rules and procedures', which is a sub-section of 'How to manage WRRS', is a library of detailed guidance on how to manage the risks for drivers, vehicles and journeys. Depending on the characteristics of their companies, managers can read up on how to deal with privately-owned vehicles, fatigue and many other topics.

Three examples of checklists (pre-employment checklist, vehicle checklist and incident recording form) are provided under 'Model forms'. The model forms can be downloaded as Word documents and then modified by the user depending on their specific requirements. The contact details of transport-related organisations that were referred to in the guidance can be found in the 'Useful links' section. A feedback questionnaire was included in the CD to gather comments and suggestions from users and to enable an initial evaluation of the developed resource. To allow online completion of this feedback questionnaire, a supporting website for the WRRS was designed.

# Discussion

At the time writing, the development of the CD has been completed and work on Phase II, the evaluation of the resource, has started. Kirkpatrick (1994) suggests evaluating interventions at four different levels, including:

1. Reactions (is the recipient of the intervention satisfied with it?);

2. Learning (has the recipient acquired new skills or knowledge though the intervention?);

3. Transfer (does the recipient implement his new knowledge in his work environment?) ; and

4. Results (does the intervention lead to tangible improvements on a business output level?).

Following these recommendations, the evaluation of the WRRS CD starts by piloting the resource with a sample of 30 companies to ensure that the functioning of the CD is correct, and to measure user satisfaction (Reactions).

To determine if the WRRS resource actually (a) succeeds at raising awareness for work-related road risk (Learning), if it (b) conveys the necessary knowledge to managers to implement or improve (existing) WRRS management systems (Transfer) and if it (c) instils a change in the business culture that leads to improvements in driving behaviour and business practices and thus to a reduced number of casualties (Results), a 12-month evaluation of the WRRS CD will be carried out. This will include a pre and post comparison with a sample of 60 organisations from the private and public sector that represent small, medium and large organisations. Vehicle fleets will include cars, vans and trucks, as well as a mixture of them. The evaluation will employ qualitative and quantitative research techniques and will measure variables that are judged to be an expression of the concept 'safety culture' on different hierarchy levels of the participating organisations.

Even though the qualitative research showed that businesses prefer to be provided with relevant information instead of having to search for it (especially SMEs), because of the large number of businesses in the UK, the future will see the WRRS resource as a web-based tool. This will also allow the updating of information regularly. Plans are currently underway to include the WRRS CD content on the DfT's Think! campaign website.

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# 16

# Factors influencing the behaviour of people who drive at work

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## Abstract

Work-related road accidents account for around 25–33% of all road fatalities in Britain and in the region of 250 serious injuries per week. Previous studies show that those who drive for work have a higher accident risk than the general driving population, even when their greater exposure is factored out.

Quantitative and qualitative data were collected from Strathclyde drivers who drive as part of their work. The data show that drivers who have points on their licence or who have recently received a speeding ticket are more likely to have been involved in a road traffic accident and these accidents are more likely to have occurred during work time. This confirms the theory that cameras spot and illustrates the importance of educating those who drive as part of their work, in particular, to slow down. This paper also examines why occupational drivers are vulnerable on the roads by giving an insight into their attitudes and motives surrounding the driving task.

A greater understanding of the beliefs and behaviours of drivers who are at risk of being involved in a third of road traffic accidents should serve to inform more effective road safety policies. With the possible advent of a graduated penalty system, attitudes to the current points and fine system will be of interest in those who drive for work as the security of their livelihood is most likely to be impacted by such changes.

# Introduction

Work-related road accidents account for around 25–33% of all road fatalities in Britain and in the region of 250 serious injuries per week (Health and Safety Executive, 2003). These alarming statistics are echoed worldwide, with road traffic accidents accounting for 39% of work-related fatalities in Australia (Harrison *et al*., 1993), 27% in the USA (Miller, 1995; Miller and Galbraith, 1995) and professional drivers having the highest injury incidence of employed people in Sweden (Bylund *et al*., 1997).

A number of studies show that those who drive for work have a higher accident risk than the general driving population even when their greater exposure is factored out (Lynn and Lockwood, 1998; Dimmer and Parker, 1999; Chapman *et al*., 2000; Kweon and Kockelman, 2003). This elevated risk has been attributed to the **extra motives** (Naatanen and Summala, 1976) of these individuals, motives outside the driving task, such as time pressures, stress of work, fatigue and the use of mobile phones (Salminen and Lahdeniemi, 2002

Research also shows a positive link between involvement in road traffic accidents and detection for speeding offences (Rajalin, 1994; Cooper, 1997; Stradling *et al*., 2000, 2003). Stradling *et al*. (2000) found that those who drove some of the time as part of their work drove faster, breached the rules of the road more often and scored lower on a self-report safety scale than those who did not drive for work.

Employers undoubtedly have a responsibility to their driving work force. Following the Government's Road Safety Strategy, *Tomorrow's Roads: Safer for Everyone* (DETR, 2000), an independent Work-related Road Safety Task Group was established in collaboration with the Health and Safety Commission (Work-related Road Safety Task Group, 2001a, 2001b). The group recently published *Driving at Work - managing work-related road safety* (Health and Safety Executive 2003)giving guidance for employers on managing risk on the road. In a recent report, the House of Commons Transport Select Committee supported greater enforcement of this guidance as well as better reporting of work-related road incidents.

This paper reports data collected from occupational drivers in the Strathclyde area, with the aim of gaining insight into these extra motives. Driving for work is compared to driving outside work in terms of collisions, convictions and driving behaviour. In addition, qualitative sections of the questionnaire cover drivers' attitudes to the increasing use of safety cameras in their 'place of work' – the road – and to the current enforcement system and how this, in turn, influences their speed choices.

This paper concludes that a greater understanding of the behaviour and attitude of drivers who are at risk of being involved in a third of road traffic accidents should serve to inform more effective road safety policies.

# Method and results

## Sample

Companies and organisations within Strathclyde were approached to take part in a survey in which their employees who drove either frequently or infrequently as part of work were asked to complete a questionnaire.

The questionnaire comprised a number of straight answer, free text and multiple choice (rating) questions. The respondents were not required to put their name to their answers.

## Demographics

201 questionnaires were completed. Fifty-eight per cent were from the private sector. These came from a variety of companies such as construction companies, football clubs, food and drink manufacturers, and pharmaceutical companies. Thirty-seven per cent were from the public sector, namely the council and health authority. Four per cent of the questionnaires came from the voluntary sector and 1% from the self-employed.

The average age of respondents was 42 years (range: 18–63), and comprised 82% males and 18% females. A number of professions were represented, ranging from drivers, sales people and road workers, through health professionals and engineers, to managers and directors.

Participants had held a driving licence for, on average, 21 years, with the majority driving between 0–9,999 miles for work and 3,000–5,999 miles outside work annually.

Forty-six per cent of the sample drove a company car for work, 23% their private car, 21% heavy goods vehicles (HGVs), and 10% were van drivers. Table 1 gives the particular vehicular combinations of at work and outside work driving in the sample.

Table 1 **Total per cent of sample driving each vehicle combination in and out of work**

| **In work** | **HGV** | **Van** | **Company car** | **Private car** | **Total** |
|---|---|---|---|---|---|
| Outside work | | | | | |
| HGV | – | – | – | – | – |
| Van | – | <1 | – | – | 0.5% |
| Company car | – | – | 34 | – | 34% |
| Private car | 21 | 9 | 12 | 23 | 65% |
| Motorbike | – | – | <1 | – | 0.5% |
| Total | 21% | 10% | 46% | 23% | |

Table 2 shows that, while for each vehicle type the modal value of frequency of at-work driving is five days per week, there is substantial variation both below and above this value within each vehicle type.

Table 2 **Number of days per week each vehicle type is driven for work**

| Days per week | <1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| HGV | – | 3 | | 5 | 15 | 38 | 33 | 8 |
| Van | – | 5 | 5 | | 11 | 53 | 21 | 5 |
| Company car | – | 17 | 20 | 21 | 9 | 29 | 2 | 2 |
| Private car | 7 | 11 | 17 | 15 | 13 | 28 | 9 | – |
| Total | 2% | 12% | 14% | 14% | 11% | 33% | 12% | 3% |

# Likes and dislikes of driving for work

When asked what they liked and disliked about driving as part of work, responses were divided between those that enjoyed driving and those that liked nothing about the experience. A common theme among the former was the perceived freedom that driving gives, both in terms of independence from the constraints of public transport and as ‘an escape from the office’. Others saw it as a welcome addition to their working time: ‘I enjoy driving to add a diversity to my work. It also allows me to think about problems and work in a beneficial way’ (male, aged 40). Rather alarmingly, many people echoed the practice of driving as a time when they could concentrate on thinking about work: ‘[It] gives me time to think about work issues without distractions’ (Male, aged 54).

However, for some, this additional work time can cause stress: ‘[I] don’t mind driving when it is in the course of normal working hours, however, generally, when driving, this is tagged onto the beginning or end of [the] working day, this is lengthening working time with no financial reward or recognition’ (female, aged 30). These pressures undoubtedly have an impact on safety: ‘[I dislike] being in a rush because of work and conscious that as a result I am not driving as safely as I could’ (male, aged 40).

Bad weather, road conditions and traffic hold-ups were also cited as common dislikes of driving as part of work.

# Driving for work versus driving outside of work

Respondents were asked to indicate on a five-point scale how much they agreed or disagreed with a number of statements regarding the difference between driving for work and driving outside of work:

- when asked whether they drive faster when at work, participants were split, with a majority of 62% stating they did not. However, 56% admitted to driving faster during work time if they had been held up, compared with 45% reacting this way if they had been held up on a personal journey;

- 80% of participants did not agree that they drove less carefully when at work and 67% did not agree that they took less care when driving a vehicle they did not own;
- 61% agreed that they were often under time pressures when driving for work compared with 25% who felt these pressures outside work;
- 35% found driving for work stressful, whilst only 15% reported driving outside work stressful; and
- overall, 76% of drivers felt their driving style was the same during work time as outside work. An interesting insight is that only 21% did not agree that their driving was better than those who only drive short distances or infrequently.

# Penalty points and crash history

Respondents were asked to provide information regarding their driving licences and recent road traffic accident involvement:

- 24% had been flashed by a speed camera and 16% received a ticket in the past three years whilst driving during work time, with only 14% receiving a ticket whilst driving outside work;
- 15% of the HGV drivers, 15% of the private car drivers, 22% of the transit/large van drivers and 32% of the company car drivers had been flashed by a speed camera while driving at work in the previous three years;
- 7% of the HGV drivers, 9% of the private car drivers, 17% of the transit/large van drivers and 24% of the company car drivers had received a speeding ticket for driving while at work in the previous three years;
- 67% of respondents had no penalty points on their licence at the time of asking, but overall only 47% had never received any points;
- 21% currently have three points, with 23% receiving three points in total over the life of their licence;
- 9% currently have six points, with 12% having received six in total;
- 17% had received over six points in total, with one respondent claiming 36 points in total so far!
- 40% of the sample had been involved in one or more accidents in the past three years, 58% of these accidents occurred whilst driving for work.

Table 3 shows that, while 23% of those who had never received any penalty points in their driving history had been involved in an accident in the previous three years, accident involvement was elevated to 54% for those that had received three or more points in their driving career (Fisher's exact test $p = 0.000$).

Table 3 **Proportion of drivers who have ever received penalty points who have been involved in a road traffic accident as a driver in the previous three years**

| Total number of points | Accident free | One or more accidents |
|---|---|---|
| 0 | 77% | 23% |
| 3 or more | 46% | 54% |

Table 4 **Proportion of drivers that have and have not received a speeding ticket while driving for work who have been accident involved in the previous three years while driving for work**

| Number of speeding tickets | Accident free while driving as part of work | One or more accidents while driving as part of work |
|---|---|---|
| 0 | 80% | 20% |
| 1 or more | 38% | 63% |

Table 5 **Proportion of drivers that have and have not received a speeding ticket while driving outside work who have been accident involved in the previous three years while driving outside work**

| Number of speeding tickets | Accident free while driving outside work | One or more accidents while driving outside work |
|---|---|---|
| 0 | 83% | 17% |
| 1 or more | 48% | 52% |

Table 4 shows that the likelihood of accident involvement at work increases from 20% for those who have not received a speeding ticket while driving for work in the past three years to 63% for those that have (Fisher's exact test $p = 0.000$).

Table 5 shows the same pattern as previously for driving outside work, with more of the recent detected speeders also having a recent collision history (Fisher's exact test $p = 0.000$).

# Attitudes to speed enforcement

The participants were asked to respond to questions regarding their attitude to speed cameras:

- 91% of drivers drove on roads with safety cameras every day or most days, but only 30% felt the spread of safety cameras had made driving for work safer;
- 40% felt that driving for work had become more stressful since the spread of speed cameras and 37% felt it had added to the stress of driving outside of work;
- a majority (57%) of drivers admitted to slowing down when driving on roads with safety cameras but then speeding up for the rest of the journey, 30% said

that they always stick to the speed limit and 9% slow down for the whole journey;

- on unfamiliar roads with safety camera signage, 36% only slow down when they see a camera, 27% slow down for the whole stretch where the signs are, 8% slow down for the whole journey, 28% are always obeying the limit and 1% do not slow down at all; and

- when asked if they could choose between receiving just penalty points or just a fine if caught speeding, 87% opted for the fine, with the most common reason given as 'I can afford a fine but I can not afford to lose my licence.'

## Corporate responsibility

A number of questions were posed to ascertain the attitude of employers towards their drivers and their safety practices that are in place:

- the majority (62%) of respondents stated that their employers were understanding if journeys took them longer than expected, although 55% agreed that their employer would expect the same amount of work to be done despite such delays; and

- 65% of respondents had received no guidelines on the number of hours they should be on the road when driving for work, with 73% receiving no training with regard to road safety.

## Conclusions

People who drive as part of work are more at risk of being involved in a road traffic accident than those who do not, and this is partly due to extra motives, such as time pressure, stress and thinking about work. Such motives are less pronounced in these individuals when driving in their own time.

It is alarming to find that many respondents view the complex physical and mental task of driving as a time when they can think without distractions. It is likely that this escape from a stressful office environment impacts on their driving. Studies show that work-related stress is related to involvement in accidents for all drivers (Cartwright *et al*., 1996). Those that are on the road during working hours are therefore not only affected by the stress of driving itself but by the work they leave behind and/or take with them. Interestingly, the new Mercedes 'A' Class is being marketed as 'A Space to Think', depicting the car as a safe and peaceful haven from the hustle and bustle of the office and city life. Panou *et al*. (2005) characterise the driving task as involving (at least) eight levels of strategic and tactical tasks:

- strategic levels – activity choice, mode and departure time choice, discern route alternatives and travel time;

- navigation tasks – find and follow chosen or changed route, identify and use landmarks and other cues;

- road tasks – choose and keep correct position on road;
- traffic tasks – maintain mobility ('making progress') while avoiding collisions;
- rule tasks – obey rules, regulations, signs and signals;
- handling tasks – use in-car controls correctly and appropriately;
- secondary tasks – use in-car equipment, such as cruise control, climate control, radio and mobile telephone, without distracting from performance on primary tasks; and
- speed task – maintain a speed appropriate to the conditions.

It would be of interest to examine the extent to which these tasks vary between at-work and out-of-work driving, and the extent to which these driving tasks are interfered with by the additional demands and stresses of at-work driving.

Compared with their driving style outside work, subjects claimed not to drive any faster or less carefully when driving for work, but were under greater time pressures and found driving more stressful. Sixty-one per cent agreed that they were often under time pressures when driving for work, compared with 25% who felt these pressures outside work. This is consistent with a study by Adams-Guppy and Guppy (1995), who cited time pressures as the most likely influence for over half of company car drivers in Britain exceeding motorway speed limits by at least 10 mph.

twenty-four per cent of the sample had been flashed by a speed camera and 16% had received a ticket in the past three years whilst driving for work and 14% had received a ticket whilst driving during leisure time. Those that had received tickets were more likely to have been accident involved in the past three years. This is consistent with research by Stradling *et al*. (2002), which showed that both males and females who had reported recent collision involvement were statistically more likely to be detected speeders. In this sample, the effect was more pronounced in those that had been caught speeding whilst at work. In other words, those who speed at work are more likely to be accident involved than other drivers. It is therefore especially important to slow these drivers down.

We know that 'cameras spot crash magnets' (Stradling and Campbell, 2002) and it would appear from this study that, in particular, 'cameras spot working crash magnets'. However, with 40% of subjects feeling that the spread of speed cameras had made driving for work more stressful, and 57% only slowing down for cameras and speeding up for the rest of the journey, this message is not getting through to the population of drivers who need it most. Not surprisingly, subjects would rather not be penalised by their licence being endorsed with penalty points with the prospect of an accumulation leading to loss of licence and livelihood, but it is questionable whether this prospect is enough to slow drivers down. With the possible advent of a graduated penalty system, attitudes to the current points and fine system is important in assessing the deterrent effect of such a system.

It is clear from the fact that 73% of respondents had not received any training with regard to road safety that work-related road safety is not considered a high priority by all companies and organisations. In 2004, the Department for Transport recommended a major change in management strategy regarding work-related driving accidents, alongside the implementation of ‘accident monitoring’ to ascertain the true extent of the problem and convert insurance claims data into risk management information. Where this is essential for improving safety on our roads, the individuals who are doing the driving also need to take responsibility for their actions and those of their colleagues, i.e. maintain a safe work ethic: ‘Work habits accepted by one’s co-workers and the need to vary actions are extra motives in work life’ (Hakkinen, 1978, quoted in Salminen, 2002). Education concerning road safety therefore needs to be directed both at a corporate and individual level, and, probably most importantly of all, the attitudes of those who use our roads the most need to be challenged.

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# 17

# The HASTE test regime for the safety assessment of in-vehicle information systems

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## Introduction

There has been a dramatic take-off in the last couple of years in the sales of in-vehicle information systems (IVIS). Last year sales across Europe of navigation systems, almost entirely after-market fitment, totalled six million units (*The Guardian*, 17 November 2005). The major safety question, both for the consumer and for the authorities, is how can we know which systems are safer in actual use. The authorities wish to ensure that traffic safety is not impaired by the usage of IVIS, while consumers would no doubt prefer to buy systems that are easy to use and do not compromise their safety. However, there is no such consumer advice currently available – at least none based on properly validated metrics – and therefore the authorities have no reason to believe that systems that are safer to use are more attractive to consumers than more unsafe systems.

Addressing this lack of an objective, performance-based, safety-related test procedure for IVIS was the aim of the HASTE (Human-Machine Interface and the Safety of Traffic in Europe) European project, which began in January 2002 and ended in March 2005. The intention of HASTE was to create a new test regime for the assessment of IVIS, which:

- **was technology-independent**, i.e. did not depend on a particular technology being employed in a system design (for example by specifying minimum screen size or contrast or minimum volume of audio messages);

- **had safety-related criteria**, i.e. used criteria in evaluating a system that were related to the safe operation of the vehicle;

- **was cost-effective**, i.e. did not require huge resources or effort;

- **was appropriate for any system design**, i.e. could assess any kind of information from traffic messages over the radio to a navigation system, and could even potentially cover the impact on driving of mobile phone use; and

- **was validated through real-world testing**, i.e. could be shown to be diagnostic and effective when applied to the evaluation of real systems.

The development of this test regime needed to begin from first principles, i.e. with an assessment of the influence of both the visual and cognitive task load on driving performance and safety. This would show which indicators of driving performance and safety were most diagnostic and allow surplus test conditions and situations to be eliminated. The prototype test regime thereby developed could then be applied to the testing of some real IVIS systems (or tasks on those systems). This second stage would permit further refinement of the test regime and thus the proposal of a draft test regime to such interested parties as governmental authorities, standards bodies, and system and vehicle manufactures.

An earlier paper in this conference series (Carsten, 2004) summarised the results of the HASTE experiments in which visual and cognitive distraction were manipulated in order to ascertain their affect on driving performance and hence safety. These experiments produced a candidate set of indicators and also identified that a rural road environment in a driving simulator provided the cleanest and most powerful test environment, although it was also established that drives in an instrumented car on real roads provide useful complementary information. This paper summarises the subsequent work of the project in which that initial simulator test protocol was applied to the evaluation of a number of real IVIS systems in order to:

- prove that the protocol was workable; and

- further refine the protocol and propose a draft test regime.

A detailed account of this work is to be found in Johansson *et al*. (2005).

# Is there a need for a new test regime?

Driver distraction is a major cause of accidents (see, for example, Stutts *et al*., 2001) and the introduction of new mobile devices and in-vehicle information systems into road vehicles has the potential to exacerbate the problem of distraction by creating new sources of interference with the driving task (see, for example, Burns *et al*, 2002; Kircher *et al*., 2004; Klauer *et al*., 2006). Hence the concern among safety experts and policy-makers over the impact of mobile phone use on traffic safety. Arising from this concern and focused particularly on concerns about IVIS, such as satellite navigation systems, there have been a number of initiatives in Europe, North America and Japan. In Europe there was the European Statement of Principles on HMI (human-machine interface), issued in 1999 (European Commission DGXIII, 1999), in North America there was the AAM (Alliance of Automotive Manufacturers) Statement of Principles issued in draft in 2000 and revised in 2002

(AAM, 2002), and the Japan Automobile Manufacturers Association (JAMA) produced its initial set of guidelines in 2000, which were revised in 2003 (JAMA, 2004).

In spite of this activity, when the HASTE project began in 2002 the international state of the art in terms of methodologies for assessing the safety implications of HMI was highly problematic. There were various pieces of advice on issues to consider in product development, with the most notable being the original version of the European Statement of Principles, and there were various proposed tests and quasi-standards, which generally lacked proper validation and which also, typically, were not designed to evaluate usage and performance **while driving**.

Thus the available advice, tools and metrics did not permit, in any straightforward way, judgements to be made about the safe use of a particular IVIS during driving. There were, as a result, no criteria which could be used by a manufacturer, a system supplier, consumer organisations or the public authorities to determine whether a particular system meets a minimum threshold of safety in actual use, or, for that matter, to rate or rank different products in terms of their safety while in use.

Since the start of HASTE in January 2002, there have been a number of developments in parallel with the HASTE project. In the US, the CAMP (Crash Avoidance Metrics Partnership) Driver Workload Metrics Project brings together Ford, General Motors, Nissan and Toyota to develop performance metrics and test procedures for both visual and cognitive aspects of driver workload from telematics systems. The intention is that, in the future, vehicle Original Equipment Manufacturers (OEMs) will be able to use these workload evaluation procedures to assess what in-vehicle tasks might be accessible to a driver while the vehicle is in motion. The work was supposed to be reported by the end of 2004, but, to date, no public reports have been issued.

In terms of statements of principles, the European Statement of Principles of 1999 was used as a model elsewhere. The formal version of the North American Statement of Principles (AAM, 2002) included detailed specifications of how to test compliance with particular principles. The Japanese guidelines for in-vehicle display systems (JAMA, 2004) include stipulations on display positioning and the amount of detail to be shown in map displays, and recommend a static occlusion test for assessing visual demand.[1]

A new draft of the European Statement of Principles has recently been issued (European Commission DG Information Society, 2005). The new version is considerably lengthier than the original version and has considerably more explanation and elaboration. However, this document acknowledges that, for many principles, no pass/fail criteria are provided. At the beginning of the document, a number of overall 'design goals' are proposed, of which the first is: 'The system supports the driver and does not give rise to potentially hazardous behaviour by the driver or other road users' (p. 7). These design goals are high-level objectives which

1 In the occlusion method, users are assessed in their interaction with a system while wearing a set of goggles equipped with shutters. The JAMA Guidelines specify that the shutter pattern shall be 1.5 seconds open and 1.0 second closed. The number of 1.5 second chunks used for viewing a display provides a means of assessing visual demand. In the JAMA procedure, this is done statically, i.e. not while driving. The latest version stipulates that, when using the occlusion method statically, the total shutter open time shall not exceed 7.5 seconds, i.e. five openings.

are supported by the more specific principles and, as such, are not intended to be directly verifiable. Therefore, no procedures for assessing compliance with the design goals are provided. It is also stated that ‘the principles are not a substitute for regulations and standards and these should always be taken note of and used’ (p. 4).

A very useful assessment of the utility of the statement of principles as an assessment tool has recently been provided by a project carried out on behalf of Transport Canada (Morton and Angel, 2005). This project asked a group of experts to provide critical reviews of the AAM principles. In addition, the AAM principles were used to guide an expert assessment of four different navigation systems as installed in their vehicles by OEMs. This was intended to indicate whether the application of the principles could produce a reliable evaluation. Compliance, as assessed by the inspectors, is provided in the report, principle by principle. The report concludes:

> In the assessment of the AAM guidelines, principles appeared to be valid but often insufficiently detailed and too vague in the accompanying elaborations. This led to poor reliability of results between inspectors. A focus group of inspectors came to the consensus that the guidelines were valid but elaborations needed further work … On the whole, the AAM guidelines were found to be valid. With revisions, the AAM guidelines may be sufficient to ensure safe operation of telematic systems, but insufficient in current form due to inadequate scientific support, incompleteness, and poor reliability of results. (p. i)

Thus, the new version of the European Statement of Principles can provide advice and even act as a kind of checklist for the designer, but it is not intended to serve as a test procedure. Also, there is serious reason to doubt that any such statement of principles can ever serve as a robust methodology for a test regime.

# Applying the initial HASTE protocol on real systems

The objective of the work applying the initial HASTE protocol to the evaluation of real in-vehicle information systems was to prove the viability of the approach (show that it was efficient and could distinguish between safer and less safe systems) and to further refine the protocol. Four actual systems were selected to be evaluated. They were as follows:

System A: an integrated navigation system featuring a 6.5 inch TFT colour display with guidance provided in the form of symbols, a map display and voice output. The system is similar to many others supplied as original equipment in new vehicles.

System B: a PDA (personal digital assistant) combined with a global positioning system (GPS). The unit features a colour touchscreen with data entry via a stylus or through hardware keys. The presentation of visual output is with icons and text, as well as by voice instructions.

System C: a Finnish traffic information system intended for use via a mobile phone. Messages were displayed as text on a black-and-white touchscreen together with an auditory reminder. On notification of message arrival, the user could agree to read the full text by pressing a button on the touchscreen (this required using a scroll function on the screen). The user was also able to select previous messages via menus, but messages were presented to users only in message number order.

System D: a PDA with an integrated GPS. The PDA features a 51 mm by 81 mm display with operation via a stylus. Navigation information is provided by symbols, map display and voice. Information on the current journey (distance to destination, current speed, average speed, etc.) is provided.

For each system, a number of tasks were pre-selected for the evaluation. It should be noted that the evaluation was always carried out at the task level and no attempt at this stage was made to aggregate across the tasks to produce an overall system score. This was because the tasks required to use the system varied from one system to another, depending on system functionality.

The evaluations were carried out in a variety of test environments:

- a field study in an instrumented vehicle on a motorway;
- a simulator with a rural two-lane road featuring straights and S-shaped curves; and
- a laboratory (low-grade simulator) with the same road layout.

The distribution of systems across partners and test environments is shown in Table 1. A total of 12 experiments were conducted across seven test sites (the Leeds simulator and laboratory comparison was performed as one study). Leeds studied one system across all three environments, in order to be able to compare the power and reliability of those three environments.

Table 1 **Distribution of test environments and systems**

| System | Field (motorway) | Simulator (rural) | Laboratory (rural) |
|---|---|---|---|
| System A | Volvo, VTT | VTI, Transport Canada | – |
| System B | Volvo, Leeds* | VTI, Leeds, TNO | Leeds |
| System C | VTT | – | Minho |
| System D | – | Transport Canada | – |

*In the field experiment by Leeds the participants also drove along a rural road.

Baseline (non-system) driving was included within each experimental drive. There were three baseline sections: one at the beginning of the route, one in the middle and one at the end. The tasks were split: half of them occurred between the initial and middle baseline sections, and half between the middle and end baseline sections. However, at VTT, the baseline driving was done on a separate drive to enable use of the Wiener Fahrprobe expert protocol (Risser, 1985).

The Peripheral Detection Task (PDT) was included as an extra condition in the Volvo and VTI experiments – Transport Canada used the PDT task, but not as an extra condition. The PDT data collected were hit rate, reaction time, miss rate and cheat rate (i.e. responses faster than the hit threshold). The PDT task was viewed as a replacement for the critical events in the initial HASTE experiments. Subject numbers were in the range 15 to 20.

For each system an expert a-priori ranking of the tasks was carried out. This ranking was based on the number of modalities, number of button presses and manual difficulty level. Table 2 shows the various tasks assessed for System B. The a-priori ranking for these tasks was 1, 2, 3, 7, 9, 4, 8, 5, 6.

Table 2 **Tasks for System B**

| Task | Description | Modality | Approx. completion time (seconds) |
|---|---|---|---|
| 1 | Check visual information: distance and suggested action | Visual | 11.6 |
| 2 | Read list of directions | Visual | 23.4 |
| 3 | Close the navigation program and re-open | Visual–manual | 11.1 |
| 4 | Change settings from large to small and back to large keys | Visual–manual | 21.2 |
| 5 | Set destination by choosing a pre-set destination | Visual–manual | 18.9 |
| 6 | Destination entry – city, street, no. | Visual–manual | 47.6 |
| 7 | Zoom in to 10 m, out to 10 km and back to 100 m | Visual–manual | 32.5 |
| 8 | Change settings: route options | Visual–manual | 24.3 |
| 9 | Create a waypoint by pointing to a road on map with stylus | Visual–manual | 16.5 |

The dependent measures were the most promising measures from the previous set of studies and, as already mentioned, the PDT.

# Results

The experimental results are discussed in detail in the report. Here only a few example results will be provided. Figure 1 shows the results for standard deviation of lateral position (SDLP) when using System B in the Leeds simulator and laboratory (combined data). A sliding window of 15 seconds was used in order to reduce the effect of task length (SDLP goes up with time). Interestingly, the laboratory condition produced higher values of SDLP than the simulator condition.

Figure 2 shows the mean reaction times to the PDT when assessing System D in the Transport Canada simulator experiment. Here Tasks 1 and 2 were purely visual, Task 3 was auditory and the other tasks were visual–manual. In terms of task, drivers responded significantly more quickly during baseline driving than when they were

Figure 1 **SDLP using 15 second sliding window**

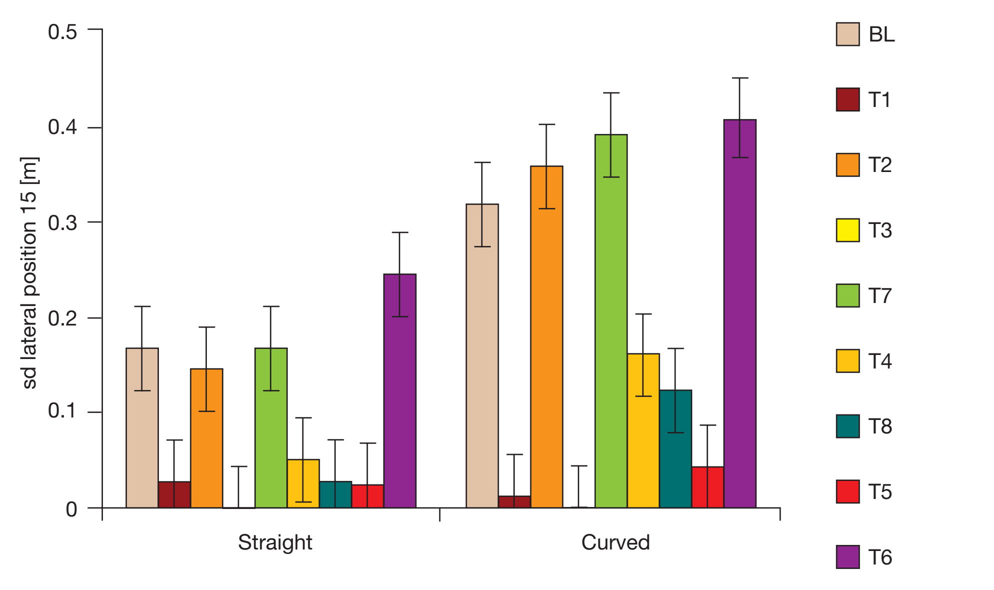
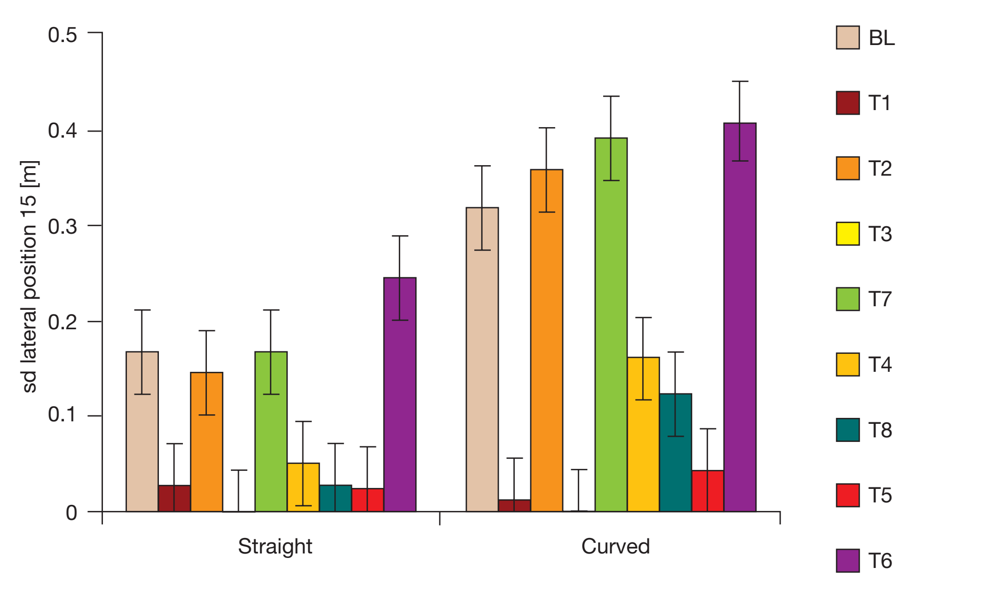



Figure 2 **PDT reaction time for tasks on System D**




occupied with an in-vehicle task, by about 300 ms. The data followed a step-like pattern: the fastest reaction times were observed in baseline driving, there was a mid-range of reaction times during tasks that relied on auditory (Task 3) or relatively easy visual processing (Tasks 1 and 2), and the slowest reaction times were found for the much more demanding visual–manual tasks. In addition, there was a global phenomenon of quicker response when driving on curves, perhaps because drivers felt under time pressure to return their attention to the road (driving on curves did not affect the PDT hit rate).

# Meta-analysis

A meta-analysis of the results of all studies was performed. This had a number of objectives. There was a need to identify the common patterns in the results across the 12 experiments and to identify the most powerful parameters for revealing those patterns. There was also a need to compare the results from the evaluations of real systems with those from the earlier group of experiments, looking at the impact of visual and cognitive distraction. If there was general consistency that the indicators identified as the most powerful in the first set of experiments were also effective in the second set of experiments, then this would provide broad confirmation that the prototype test regime was robust.

This section mainly focuses on the mandatory measures, i.e. the measures used by all partners. The PDT measures, as well as the measures reflecting eye movements (per cent road centre (PRC)), were also compared across sites, since they appeared to be promising on the basis of earlier results. However, since the equipment for these measures was not available to all partners, they were not tested in all experiments, and conclusions on PDT and PRC should therefore be treated with some care.

A three-stage procedure was adopted. A parameter had to pass each stage to be eligible for the next one. First there was a check of significance level with the criterion for the mandatory (included in all the studies) measures, being that they should be significant to at least the $p = 0.10$ level. A further criterion applied was that a parameter should have been measured in at least four out of the twelve experiments. There were 11 parameters that met both these criteria.

The second stage of the analysis involved considering the consistency of the effects. This was based on the reasoning that all task level effects for a given IVIS should be in the same direction, compared to baseline. This test ensures that a behavioural parameter cannot be considered a good indicator of IVIS task difficulty if it varies in direction over conditions. An overall consistency score for each parameter (% consistent) was obtained by noting how often a parameter was consistent in this sense over the total set of experiments.

The last stage looked in more detail into how strong were the effects associated with the parameters and whether these effects varied (were discriminating) across the tasks. Effect sizes (Cohen's *d*) were computed for the set of 11 parameters, which involved calculating the standardised difference score for an IVIS task relative to baseline. This was done separately for each experiment. The performance of the retained parameters could then be described in terms of their average effect size across tasks and the range of effect sizes between tasks. The concluding calculation consisted of calculating the sum of a parameter's average effect size and its range, and multiplying the sum by its consistency value.

# Outline test regime

From the results of the meta-analysis it is possible to derive the outline of a prototype test regime for assessing the impact of IVIS on driving. This test regime has a number of 'ingredients':

- Driving in at least a medium-level driving simulator with a relatively small number of subjects (15 subjects are indicated as sufficient). The field studies did not provide any crucial extra information in these sets of experiment beyond what was observed from the simulator studies, and the laboratory studies produced less consistent data on steering behaviour.

- A rural two-lane road driving situation and a duration of approximately one hour.

- A small number of dependent variables (indicators) is sufficient. At the moment, a set of five indicators is recommended.

The candidate indicators are:

- subjective rating (the self-rated quality of driving performance);

- mean speed;

- proportion of high-frequency steering activity; and

- minimum time headway.

One additional indicator should also be included, namely reaction time to the PDT. Although this was only collected in six of the studies, it nevertheless showed good discriminative power. Yet another indicator, per cent road centre (i.e. the amount of eye movement that is focused straight ahead), was only collected in three studies and thus did not have the possibility of meeting the criteria of the meta-analysis. But given earlier results in HASTE, where it proved a powerful indicator of the gaze concentration caused by cognitive load, it remains a candidate.

It is perhaps slightly disappointing that one of the indicators is a subjective rating scale rather than an objective performance scale. There was a also a slight problem with this rating scale in that it appeared to be less sensitive to non-visual (cognitive tasks). Further work should look at the feasibility of eliminating this indicator.

# Further steps needed

The test regime is, as yet, only a prototype. There are a number of issues that need to be investigated before it can be promulgated as a recommended tool which could be used, for example, to provide information to consumers on the relative safety of different systems.

Issues that require further investigation or definition are as follows:

1. Scoring and weighting issues. Thus far, the analysis of IVIS systems has been at the task level. A protocol is needed to aggregate scores across tasks to provide a final weighted score at the system level.

2. Test re-test reliability. Owing to time and financial limitations, only a select number of IVIS systems have been evaluated. Clearly, it is important to ascertain if the HASTE protocol can be applied to any in IVIS, independent of its technology and design. It is necessary to ascertain whether the test regime produces repeatable and reliable results when it is used on the same system time and time again. This needs to be checked both within laboratory (where measurement error might be an issue even when using the same group of drivers) and between laboratories. The results here would help in defining, for example, how the test group of drivers should be selected and precisely what is the minimum specification of a 'qualifying' simulator. This work would therefore involve undertaking repeated measurements of the HASTE protocol on a much wider range of available IVIS, across a range of laboratories.

3. Applying the HASTE protocol to the older driver. Results from the initial HASTE assessment demonstrated that older drivers are inclined to suffer from severe motion sickness when attempting to complete a visual IVIS task while driving on the simulator. Therefore, for older drivers, studying the interaction between visual in-vehicle systems and driving is best achieved in the field. Some preliminary observations on this area were made in the HASTE project by VTT. However, due to vehicular limitations, most of these data were based on experimenter observations. A more detailed investigation that includes the same kind of parameters as collected in the simulator studies (in particular, speed, headway, steering behaviour, PRC and PDT reaction time) is therefore warranted. Such work on the older driver would ascertain whether the scoring system used by the HASTE protocol for the 'average driver' is applicable to the older driver. One important issue would be whether older drivers should be recommended not to use systems that were acceptable (though not ideal) for younger drivers. Alternatively, there might be a separate scoring system for rating a system for older drivers.

# Conclusions

The HASTE project achieved its overall objectives of outlining a cost-effective and valid test regime with safety-related criteria. Once fully developed, the test regime will be able to provide feedback to system developers on whether their designs are adequate and should help consumers to choose equipment that will not endanger them. There are, of course, substantial benefits to be obtained from the use of IVIS, but those benefits should not be at the expense of risk from poor design.

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# 18

# Young drivers: the road to safety

OECD
Organisation for Economic Co-operation and Development
Paris

The following text synthesises the key findings of the report entitled *Young Drivers: The Road to Safety*, (OECD, 2006) which was developed under the aegis of the **Organisation for Economic Co-operation and Development (OECD) and the European Conference of Ministers of Transport (ECMT) Joint Transport Research Centre**.[1]

## Introduction

Globally, 16–24-year-old drivers are greatly over-represented in crash and fatality statistics. They pose a greater risk than other drivers to themselves, their passengers and other road users. This problem imposes great social and economic costs on individuals, families and societies.

The recent research work of the Organisation for Economic Co-operation and Development (OECD) and European Conference of Ministers of Transport (ECMT) Joint Transport Research Centre focused on the high levels of risk associated with young, novice drivers of passenger vehicles,[2] including fundamental causes and concrete options for action. **Young** drivers are defined in that project as those below the age of 25, keeping in mind that the minimum licensing age varies from country to country. However, it should be noted that many of the proposed countermeasures would be relevant for all novice drivers.

The ECMT Ministers have established the target of a 50% reduction in traffic-related deaths in the period 2000–12. Similar commitments have been made within the European Union and by many national governments. A 2003 United Nations

1 This report is the product of over two years of efforts by a working group that comprised road safety experts from throughout the OECD and ECMT member countries. The working group Chair, Divera Twisk of the Netherlands Institute for Road Safety Research (SWOV), presented these findings to the Behavioural Studies Seminar in Bath on 5 April 2006. The present text is based on the Executive Summary of the working group's final report, and is the property of the OECD. For more information regarding this project, please see the ECMT website: http://www.cemt.org/.

2 Two-wheeled motorised vehicles (i.e. motorcycles, scooters, etc.) are not covered in this work.

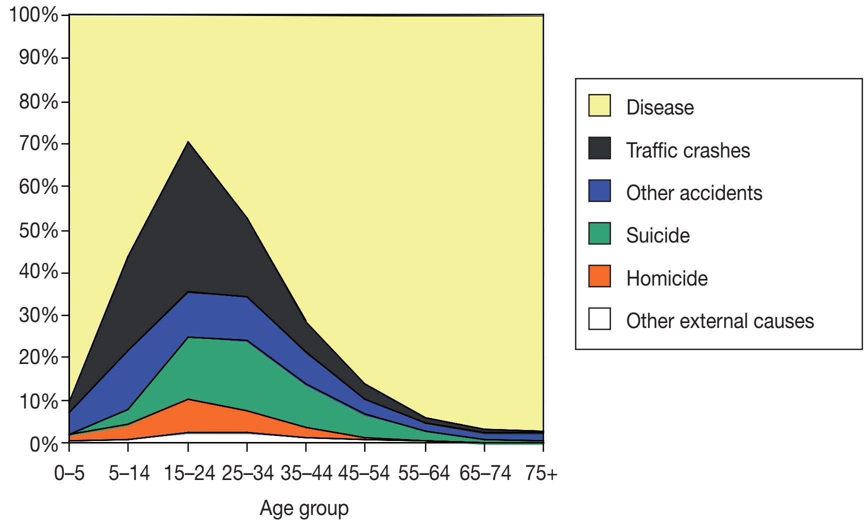
(UN) General Assembly Resolution recognised the high cost of traffic crashes on global human health, and resulted in the UN Road Safety Collaboration led by the World Health Organisation (WHO). Addressing the issue of young driver risk – particularly that of young men – will be essential to achieving the goals of these initiatives.

# What is the scope and nature of the problem?

Traffic crashes are the single greatest killer of 15–24-year-olds in OECD countries. Figure 1 shows how traffic deaths rise sharply in this age group.

It is estimated that over 9,000 young drivers of passenger vehicles were killed in OECD countries in 2004.[3] This included almost 4,000 in the US, over 750 in Germany, 645 in France, and over 300 in both Japan and Spain. As Figure 2 shows, this means that young drivers represent about 27% of all drivers killed in OECD countries, although people in the same age groups only account for about 10% of the population.

Figure 1 **Cause of death by age group in OECD countries (most recent year available)**

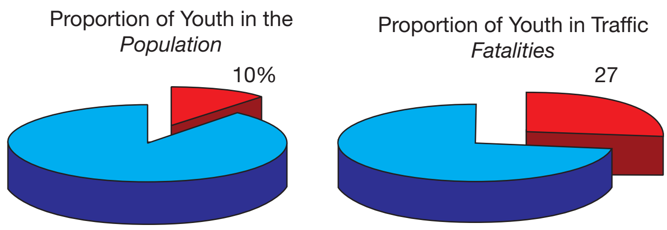



Source: World Health Organization Mortality Database (most recent year available for each country)

Furthermore, for each young driver killed, a likely 1.3 or more passengers or other road users also die in the same crashes, based on findings from the US and the Netherlands. National data from various countries indicate that crashes involving a young driver account for between 20% and 30% of total road traffic fatalities.

3 Based on figures from the International Road Traffic Accident Database (IRTAD).

Figure 2 **Proportion of youth in traffic fatalities and in the population of OECD countries, 2004**



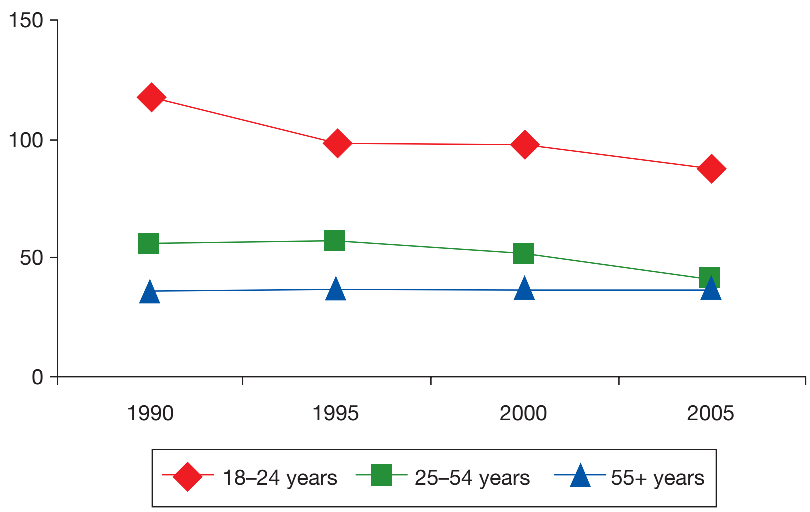

Source: International Road Traffic Accident Database (IRTAD)
Note: Information not available for some OECD countries

Clearly, young drivers play a disproportionate role in the overall public health problem of road traffic safety risk.

While data are not generally available for countries that are not part of the OECD, it must be assumed that their young driver situations are similar. This would include some ECMT countries where overall road safety levels are lower than those of most OECD members. Worldwide, WHO data show that, in 2002, traffic crashes were the second greatest cause of death for persons aged 15–29, and the greatest for men in the same age group.

As Figure 3 reveals, across the OECD, death rates for 18–24-year-old drivers are typically about double those of older drivers. While death rates for young, novice drivers have decreased in many countries in recent decades, these reductions have mirrored overall improvements in road safety, and death rates for 18–24-year-old drivers typically remain more than double those of older drivers. In other words, despite overall improvements in road safety, the specific problem of young driver risk is not being resolved.

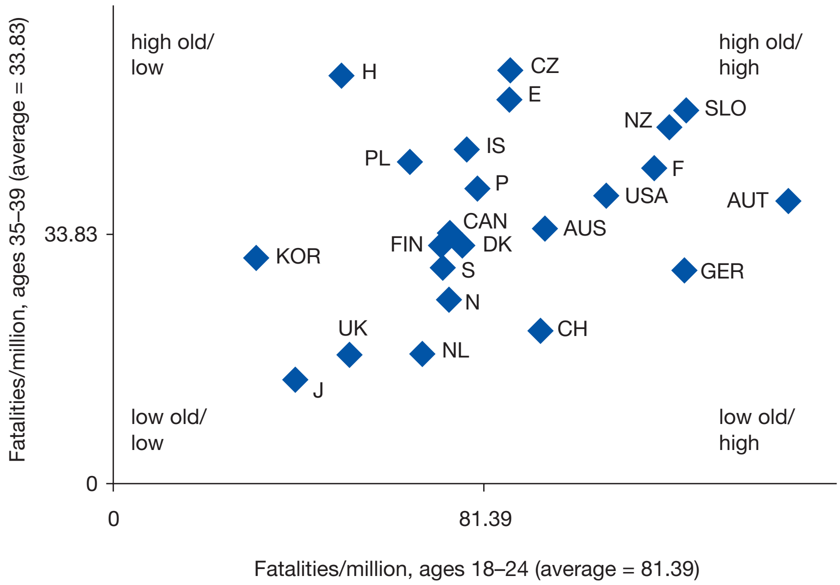
Figure 3 **Driver fatalities per million population for different age groups, over time, in OECD countries**




Source: IRTAD

In general, the situation for young, novice drivers is better in countries with higher overall standards of driver safety. Figure 4 shows us that those countries with lower average death rates for drivers aged 35–59 are also very often those with lower rates for drivers aged 18–24.

Figure 4 **Relative risk/driver fatalities per million population for the 18–24 and 35–59 age groups in OECD countries, 2003**




Source: IRTAD

Key: H: Hungary, CZ: Czech Republic, E: Spain, SLO: Slovenia, NZ: New Zealand, IS: Iceland, PL: Poland, F: France, P: Portugal, USA: United States of America, AUT: Austria, AUS: Australia, CAN: Canada, FIN: Finland, DK: Denmark, KOR: Korea, S: Sweden, GER: Germany, N: Norway, CH: Switzerland, NL: Netherlands, UK: United Kingdom, J: Japan.

However, some caution is called for in considering data regarding improvements in the overall crash fatality rates of young drivers. As seen in Table 1, data for the UK reflect an important decrease in the number of 17–20-year-olds possessing a full licence from the early 1990s to 2004, without a commensurate drop in driver fatalities in the same age group, resulting in an important increase in the number of killed drivers per licence-holder in recent years. Over the same period, the number of killed 17–20-year-old drivers per million 17–20-year-olds in the overall population did not fluctuate significantly.[4]

Death rates for young men are consistently much higher than those of their female counterparts, often by a factor of three or more, as seen in Figure 5. Large differences remain after taking into consideration the fact that men drive more than women. Data from the Netherlands, Sweden and the UK, seen in Figure 6, have shown that young male drivers' relative risk, compared with that of older drivers, has increased considerably over the last decade, although this has not been the case for

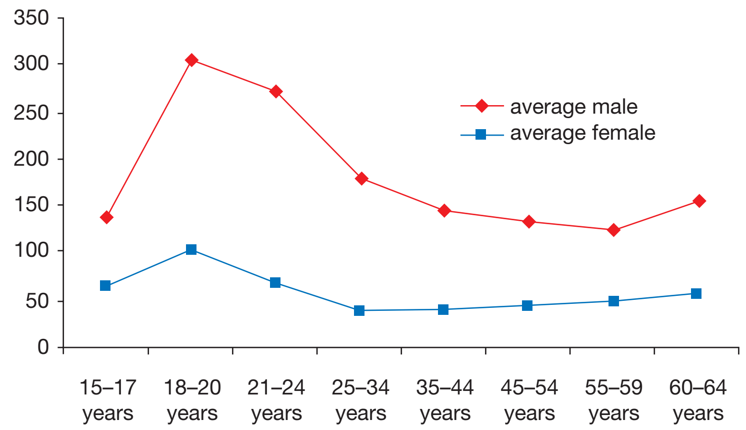
4 Data provided by the UK Department for Transport.

Table 1 **Fatality rates for licensed car drivers aged 17–20 UK, 1992–2004**

| Year | Deaths | Full driving licence figures (thousands) | Rate† |
|---|---|---|---|
| 1992/94* | 167 | 1,326 | 12.6 |
| 1993/95* | 160 | 1,224 | 13.1 |
| 1994/96* | 162 | 1,143 | 14.2 |
| 1995/97* | 168 | 1,107 | 15.2 |
| 1996/98* | 172 | 1,138 | 15.1 |
| 1997/99* | 162 | 1,157 | 14.0 |
| 1998/2000* | 154 | 1,125 | 13.7 |
| 1999/2001* | 154 | 1,001 | 15.4 |
| 2002 | 181 | 920 | 19.7 |
| 2003 | 192 | 806 | 23.8 |
| 2004 | 178 | 787 | 22.6 |

* 3-year averages
† Deaths per 100,000 17–20-year-old licence holders
Source: UK Department for Transport

Figure 5 **Road user fatalities per million population by gender and age, various OECD countries, 2003**



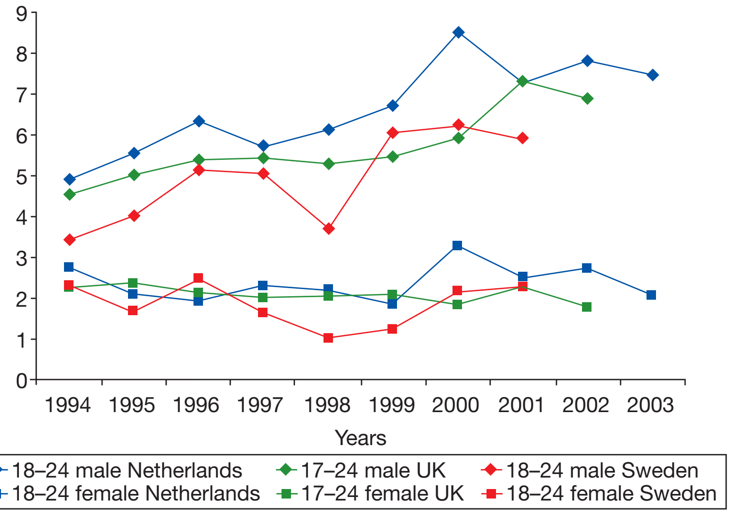

Source: IRTAD

young female drivers.[5] Where the UK is concerned, in 1994, a young male driver's risk of being in a fatal crash was a little over 4.5 times that of a driver aged 30–59; in 2002 this had risen to be seven times greater. Whether adjusted for exposure or not, the high crash fatality and injury rates of young, male novice drivers represent a major public health issue (Lynam et al. 2006).

Young drivers have high numbers of crashes when driving at night and/or on weekends, when carrying similarly aged passengers, and as a result of speeding. Alcohol and driving without seat belts remain key factors in young driver crashes

5 Figure 6 shows, for each year, the number of fatal crashes in which male and female young drivers were involved per kilometre, divided by the number of fatal crashes that all drivers aged 30 to 59 were involved in per kilometre. Thus, when the figure for a particular country for young female drivers is two, this means that young female drivers in that country had twice as great a chance of being involved in a fatal crash per kilometre than all drivers in the same country between 30 and 59 years of age.

Figure 6 **Young drivers' relative risk of involvement in a fatal crash, by gender, over time in the Netherlands, Sweden and the UK**




Source: SUNFLOWER study

and resulting deaths and injuries. Drug-driving, especially involving cannabis, is increasing, particularly among young men, and becomes especially dangerous when mixed with alcohol, and for habitual users. Young people are over-represented in single-car and loss-of-control crashes, and crashes where the driver is turning across oncoming traffic.

Apart from the enormous social costs, young driver crashes impose a huge economic cost burden on societies. In the US alone, government estimates state that crashes involving 15–20-year-old drivers cost $40.8 billion in 2002.

# What are the key factors behind the problem?

Why do young drivers have such high crash rates? The response can be summarised under three general headings: experience, age and gender. The universal problem of young, novice drivers is inexperience. As most people learn to drive while they are young, inexperience explains much of the high levels of young driver risk. Furthermore, a minority of young drivers fails to manage a complex range of additional risk factors – many of which are related to age and gender – and is thus involved in a further disproportionate number of fatal crashes.

## Experience

Where experience-related factors are concerned, learning to drive takes time and needs extensive practice in order to reach a sufficient competence level – this is true for everyone, not just the young. With time, the actions of driving – changing gears, looking in the rear-view mirror, steering, correctly assessing situations, reacting appropriately, etc. – become automated. However, for the novice driver, these actions require consideration, increasing overall mental workload and possibly distracting attention from the road. Thus, novice drivers have more limited attention and dual task performance abilities. At the same time, because serious crashes are relatively rare events, new drivers are not provided with the sort of negative feedback that might induce them to drive more carefully, while they are also motivated to arrive at a destination as quickly as possible, as well as by other factors, such as peer pressure or a desire to 'show off'.

# Age

Data show that novice driver crash involvement decreases as the licensing age for solo driving increases, indicating that age factors play a role in causing crashes. Indeed, physical and emotional immaturity, as well as the lifestyles associated with youth, can increase crash risk and severity. Young people are typically in a period of rapid maturation, whereby they test boundaries and assert independence. They are at a stage in life that is often intensely social, including being active at night and on weekends, in groups, and sometimes involving alcohol and/or drugs.

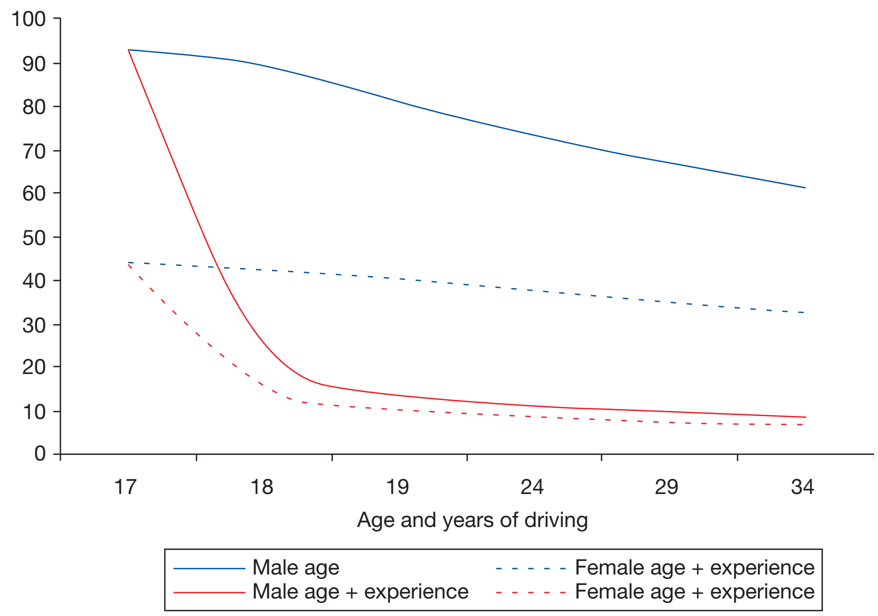
# Gender

Young men drive more than young women, and have more fatal crashes per kilometre driven. Furthermore, research has revealed that they are more inclined towards risk-taking, sensation-seeking, speeding and anti-social behaviour than their female counterparts. They are also more likely to over-estimate their driving abilities and more susceptible to the influence of their friends.

It is precisely the interaction of experience and age-related factors, exacerbated by gender differences, that makes young drivers' risk situation unique. The impacts of both age and experience are shown in Figure 7, where the black lines represent the crash risks of men and women first getting their licence at each different age level, and the red lines show the progression of the crash risk level of men and women who get their licences at 17 years of age. In other words, the black lines show the impact of age, while the grey lines show that of experience. Obviously, the impact on risk of one year of experience is particularly important. However, the higher initial risk associated with acquiring a licence at a younger age cannot be ignored. Furthermore, while men have more crashes than women at any age, the impact of gender is particularly strong among the young and exacerbates the negative effects of both age and inexperience.

The reasons why age, gender and experience combine so destructively in some young people on the road, and why some young people are more risk prone than others, are highly complex. They involve a myriad of interacting factors, including physiological and emotional development, personality, social norms, the role of youth in society, individuals' socio-economic circumstances, impairments to capabilities, the driving task itself, and the type of driving that young, novice drivers often engage in. Certain personality types are particularly subject to high crash risk. Social norms, including peer pressure and the emphasis placed on rebellion in youth culture, affect driving style, as do the examples provided by role models. Alcohol,

**Figure 7 Age, experience and gender – crash liability among male and female novice drivers, Great Britain**




Source: Adapted from Maycock, (2002)
Based on police – reported data

drugs, fatigue, emotions and in-vehicle distractions, such as mobile telephones, all impair a driver's abilities. Based on economic considerations, young people may also drive older vehicles with fewer safety features. Recent research indicates that the parts of the brain responsible for inhibiting impulses and weighing the consequences of decisions may be under development until well after the teenage years, possibly impacting on driving behaviour. Furthermore, different testosterone levels partially explain the divergence in behaviour between young men and women. In short, young drivers' high risk levels are a product of both who they are and the environment in which they exist.

However, it is important to note that, while young drivers are a high-risk group in themselves, most young drivers are not deliberately unsafe. The same may be said of young male drivers. While profiles exist for high-risk young drivers, current knowledge does not allow particular individuals to be singled out with countermeasures before they engage in dangerous driving.

This leaves policy-makers with a complex problem. While young, novice drivers must gain experience to be safer, the process of gaining that experience exposes them, and others, to risk. Also, the mobility associated with driving provides people with access to many social, economic and education opportunities. Individual young drivers are much more likely than older drivers to have crashes, and many do, but only a small share of these results in death or serious injury. With this in mind, how do we tackle the problem of young driver risk without limiting young people's access to experience and mobility, and without appearing to unfairly penalise youth or a sub-group of youth, such as young men?

# What are our options for action?

Given the severity of the problem, it is imperative that governments take action to reduce young driver risk, especially as measures to improve the safety of young and newly qualified drivers can be readily identified.

Reducing the number of young, novice driver crashes and fatalities will require a focused and co ordinated approach, involving education, training, licensing, enforcement, communication and the selective use of technology, in combination with other road safety measures. The success of this approach will require public and political acceptance of the gravity of the problem and acceptance of the need to act, and the proactive participation of

- regulators and lawmakers;
- transport, health, safety and education administrations;
- the police;
- parents; and
- young drivers themselves.

The goal of these efforts should be to create a situation in which overall road safety continually improves while the differences in risk levels between young and older drivers are greatly reduced, especially with regard to young male drivers.

A key first step in reducing young, novice driver risk is to work to ensure the highest possible overall standards of road safety. Given that young people suffer more crashes and fatalities, they can be expected to benefit to a great extent from general road safety measures, especially in countries where the road safety performance is relatively low. Effective enforcement will play a key role, and this can be focused on areas and times when young people are most at risk. It is also a basic prerequisite to implementing some of the more targeted measures noted below. High levels of safety in vehicle and road design will also have an important impact. However, the wide gap between young and older drivers' traffic fatality risks underscores the fact that general road safety measures are not enough – it is also essential to directly address the specific problem of young, novice driver risk.

It is important to implement countermeasures that will reduce the wide gap between young drivers' risk levels and those of older, more experienced drivers. Given the nature of the problem, actions need to be concentrated on breaking the historically developed dangerous link between, on the one hand, immaturity and inexperience and, on the other, unlimited access to unsupervised solo driving in the challenging environment that is traffic. Breaking this link inevitably involves measures that either limit the available choices, or alter the attractiveness of these choices.

Countermeasures for addressing the young driver problem should be put forward based on a careful balancing of the interests and responsibilities of young drivers, as well as of governments' broader social responsibility to provide a safe road transport system.

The licensing process itself presents important opportunities. While countries employ different licensing systems, common objectives for risk reduction are seen throughout the world and there are increasing similarities between different systems.

## Licensing age

As noted above, the younger a person starts unrestricted solo driving, the more likely it is that he or she will have a fatal accident, particularly below 18 years old. Thus, as a first step, it is extremely important to set an appropriate age for first unrestricted solo driving. Administrations should resist, on safety grounds, any pressure to lower current licensing ages; conversely, increasing the licensing age for solo driving would reduce fatalities. Conditions for driving motorised two-wheeled vehicles should be similarly stringent to prevent migration to less safe forms of transport.

## Training

To date, formal training itself has not proven to be highly effective in reducing accident risk. Training should focus on creating drivers who are safe, and not just technically competent, meaning that there should be increased focus on self-assessment and understanding of the factors that increase risk, including the context in which driving is undertaken. Training, stated training objectives and the test should reinforce one another, and a structured approach should be undertaken to ensure that novice drivers get wide experience in all the necessary competencies.

## Increased pre-licence practice

Safe drivers are made and not born – extended practice should be recognised as a precondition for reaching higher cognitive skill levels. Thus, it is particularly important that substantial experience be attained in lower-risk conditions before unrestricted solo driving. High levels of accompanied practice before licensing for solo driving, conducted in a methodical manner that involves a variety of driving circumstances, will result in lower levels of fatalities. While at least 50 hours of pre-licensing practice are recommendable in any system, experience in one country showed that increasing this to approximately 120 hours reduced crashes in the two years following licensing by about 40%.[6]

6 In Sweden, in 1993, the minimum age for accompanied learning was lowered from 17? to 16, while the minimum solo driving age remained 18. Approximately 45–50% of 16-year-olds obtained their learner's licence during the first two and a half years of the new programme. This resulted in an increase to a mean of 117.6 hours of accompanied learning before licensing, compared with a mean of 47.6 hours before the change. In the follow-up period of two years, the crash risk of young, novice drivers who had begun accompanied learning at 16 was reduced by 40%, adjusted to account for confounding factors, and the overall young, novice driver crash risk was reduced by 15%.

# Post-licence protective measures

The greatest risk is experienced immediately following licensing for solo driving, especially during the first year. Passing the driving test should not expose novice drivers to risk that they are not able to manage. Risk can be greatly reduced in the period following licensing by way of protective restrictions that are progressively lifted over time, as seen in graduated licensing (GDL) systems:

- Young drivers have been shown to be more susceptible to the effects of alcohol, even at lower levels, than older drivers. Thus, maximum blood alcohol concentration (BAC) levels of zero or 0.2 g/l for young, novice drivers would be highly desirable.

- Also, important risk reductions have been shown to result from temporarily restricting driving with young passengers and/or at night. The implementation of such measures should be considered on the basis of a solid, evidenced understanding of the nature of the problem in each jurisdiction, taking into account such factors as the severity of the young driver problem, and the age at which people typically learn to drive.

These countermeasures could do much to address the circumstances that contribute to the seriousness of many young, novice driver crashes, such as driving at night, with passengers and/or under the influence of alcohol.

# Enforcement

Clearly, many of the countermeasures inherent to the licensing process will not be relevant without effective enforcement, coupled with serious repercussions that act as disincentives for infringements and unsafe behaviour in general. Novices should thus be subject to a probationary period, during which they could lose their licence and/or have to undergo additional training if they do not comply with the rules of the road or licensing conditions. This could be accompanied by special demerit point scales for novice drivers, whereby they have lower thresholds for punitive action than other drivers. However, it is often difficult to target young, novice drivers in particular, although special plates can be helpful in this way. Thus, effective **general** enforcement is required, although this may focus on areas where young people – especially young men – are particularly over-represented, such as alcohol, speed, drug-driving and non-use of seat belts, and at times and locations where young people are particularly active.

# New technologies

New technologies, such as black boxes, smart keys and alco-locks, offer opportunities to ensure compliance with the conditions attached to licensing. Furthermore, Intelligent Speed Adaptation, Adaptive Cruise Control and Electronic Stability Control could reduce both voluntary and involuntary dangerous driving among all drivers, including the young. More research is required where many of these technologies are concerned, noting that some of these may be of particular benefit in assisting young drivers with the driving task and in addressing problems specific to young and novice drivers.

## Communications and education

Countermeasures, especially enforcement, should be accompanied by communications and education efforts aimed at altering the fundamental attitudes that exacerbate risk, targeting, in particular, inexperienced drivers, high-risk lifestyle groups and males. It should also be noted that many safety-related attitudes are established well before the driving age, and are highly susceptible to the influence of role models.

## Non-road safety measures

Non-road-safety measures – such as the availability and cost of public and school transport, the cost of operating a vehicle, and the location of services of interest to young people – can also have an impact on risk. All public policy decisions should take into account their potential road safety impact.

# How do we manage change?

There is often resistance to change; the public and stakeholders may be reluctant to accept new measures, particularly if they impose higher costs or make it more difficult to obtain a licence, and decision-makers may be reluctant to support measures that are unpopular. Overcoming such barriers to the acceptance of effective measures can be facilitated by carefully managing the process of change.

To begin with, proposed countermeasures should be realistic, and based on thorough research of the problem and the costs and benefits of proposed solutions, which must be clearly communicated. Senior level decision-makers must show courage and leadership in publicly acknowledging the problem and the need to act. Different agencies within government and levels of government should co-ordinate closely, sharing resources and ideas. Stakeholders should be consulted, including young drivers, parents, employers, driving instructors, testing agencies, the police, the health and education sectors, the insurance industry, and road users in general. In some instances, stakeholder groups will play a key role in educating decision-makers and the public regarding the nature of the problem, and in proposing solutions. Finally, countermeasures should be phased in, showing concrete results at each step. Careful consideration needs to be given to ensuring that they do not impact unequally on more disadvantaged sectors of society. They should also be subject to analysis, and adjusted where they are not showing desired or adequate results.

# Taking action

Countermeasures need to be implemented in a strategic manner that show results both immediately and over the longer term. In doing so, particular attention should be paid to the key elements that underlie and exacerbate risk. Furthermore, there are important differences between the various countermeasures in terms of their impact, their costs, and the timelines within which they can be implemented, which will condition the options for action. In particular, those that require new legislation will take considerable time to implement.

The following is a suggested step-wise implementation of countermeasures:

1. **Increase public awareness of the problem**. This could involve undertaking communications campaigns, based on well-researched information, sensitising the public to the nature of the risk and encouraging changes in attitudes and behaviour. Also, political leaders could highlight the problem in speeches and other interventions. This countermeasure may be undertaken immediately. In itself, it is not expected to yield high reductions in risk; however, it is a prerequisite for achieving greater public understanding of the problem and encouraging acceptance of other countermeasures. Furthermore, the combination of other countermeasures, particularly enforcement, with communications can yield changes in attitudes towards safety risk over the longer term. There are obvious costs involved, although these are likely to be uncontroversial, given the importance of the message and the fact that the public is accustomed to seeing communications campaigns from public authorities.

2. **Implement overall road safety improvements that address young driver risk**. This includes ensuring the existence of appropriate legislation and rigorous enforcement of road safety law, focusing on areas where young driver risk is especially high, including speeding, alcohol, drugs and seat-belt use. It is an area where immediate action can be taken, based on existing laws and regulations, and short-term gains will be seen. There will be important costs, in the form of resources applied to enforcement, as well as in the implementation of high standards of safety in vehicles and infrastructure. Effective communication will thus be required to gain public support. However, public resistance may be expected, particularly to enforcement.

3. **Introduce high levels of pre-licensing accompanied practice**. This is potentially one of the most effective countermeasures. However, it may require new legislation, meaning that it cannot be implemented in the immediate term. Costs are relatively low, both to administrations and the public, and primarily consist of demands on the time of young, novice drivers and those who accompany them. In countries where licensing begins at 18 years old, resistance will be less if the accompanied practice is allowed to occur before that age. In countries where licensing begins earlier, there will be resistance from young drivers themselves, as this countermeasure will mean an effective increase in the age for unrestricted solo driving. However, consultation with the community, including co-operation with relevant community groups, may well reveal a widespread demand for action to reduce young driver risks.

4. **Implement protective restrictions during initial solo driving**. This countermeasure holds considerable potential. It should include BAC levels of no more than 0.2 g/l. Limited driving at night and/or with passengers should also be considered. Again, legislation is likely to be required, although the minimal BAC restrictions could possibly be implemented under existing drink-driving laws. The effective enforcement discussed in point 2 is a key pre-requisite to such measures. There will also be additional administrative costs associated with changes to the licensing system. Considerable resistance can be expected to

these measures from young drivers themselves, although an effective communications strategy may reveal substantial support for such measures among society in general.

5. **Provide effective disincentives to inappropriate driving behaviour**. The enforcement of road safety law and special licensing measures will only be effective if they are backed up with concrete repercussions for non-compliance. Novice drivers should be subject to probationary periods during which inappropriate behaviour could result in the loss of driving privileges or obligatory retraining, and this could be reinforced by way of special demerit point scales. Such countermeasures may require new legislation, but would not add important additional costs to those associated with enforcement, as discussed above. While they may be subject to considerable resistance from young drivers, they would likely not be unpopular with society as a whole. Additional disincentives to unsafe driving by young drivers could be provided through vehicle insurance, and road safety administrations and insurance companies could examine means of co-operating in this area.

6. **Improve driver training and testing, including more focus on self-awareness and understanding the circumstances that lead to safer driving**. Such changes will require considerable prior analysis, and probably legislative action, meaning that they will require time for implementation. While they are important, they likely will not have the same impact as countermeasures that effectively limit exposure to risk and increase experience prior to solo driving, such as those noted in points 3 and 4. Initially, there will be new costs associated with changes to the licensing system, and resistance may be particularly expected from the driver instruction industry.

7. **Consider the road safety ramifications, especially for young drivers, of public policy decisions that are not directly related to road safety**. This includes, among others, such issues as the availability and cost of public transport, the costs of operating a vehicle, the availability of parking at schools and other areas frequented by young people, and the locations of bars and discos. The immediate impact of this may not be expected to be particularly large, although over time it could have important cumulative effects. This is an area where action could begin immediately, although more time would be required to formalise such practice. Resistance would be particularly expected in instances where decisions limit the options of individuals and businesses.

8. **Understand the benefits of technological solutions for monitoring and enforcement, and for assisting the novice driver with the driving task, and selectively implement these where they prove to be effective**. This is a longer-term initiative, particularly as it will involve research and development. While the potential is high, the actual gains to be achieved from new technologies are unknown. These will initially generate new costs for implementing technology in vehicles, which could result in resistance from drivers and vehicle manufacturers. Concerns regarding the legal ramifications of new technologies will also need to be addressed, particularly if they are perceived to relinquish the driver of full responsibility for operating the vehicle.

9. **Work to address the problem globally**. While young driver fatalities and injuries will remain a serious concern in OECD countries, the greatest future

impact of traffic safety risk on young people may be expected in non-OECD countries, including some that are ECMT members. Collaborative efforts should be undertaken to reduce the impact of road safety risk on people in developing and transition economies, including the young. For example, the UN Road Safety Collaboration, led by the WHO, provides an effective means for promoting knowledge transfer to developing countries. Of particular note, Road Safety Week 2007, organised by the United Nations Economic Commission for Europe (UN ECE) as part of the Road Safety Collaboration and scheduled to occur on 23–29 April 2007, will focus on young road users.

# Conclusions

Young driver risk represents a serious public health problem. Young people's over-representation in traffic crashes and fatalities results from factors of experience, age and gender, and is exacerbated by a number of circumstances, such as driving at night, with young passengers, at high speed, under the influence of alcohol or drugs, and/or without using seat belts. The solutions lie in the application of a range of countermeasures, which will allow young drivers to gain adequate experience and develop skills before being exposed to the full challenge of solo driving. These countermeasures will include improvements in the areas of training, education, testing, communication, enforcement and technology, among others. This action will not always be popular, and will thus require a strategic approach, based on scientific analysis of the problem and its solutions, clear communication, close co-ordination with stakeholders, and political leadership.

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# Developing simulator-based visual search and hazard perception training

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## Abstract

A series of studies conducted at Nottingham over the last decade have revealed differences in eye-movement patterns between newly qualified and more experienced drivers. Such differences are particularly pronounced in hazardous situations. Unfortunately, for both ethical and practical reasons, the opportunities to train drivers in visual scanning and anticipation in real hazardous situations are extremely limited. Recent advances in low-cost driving simulation provide an ideal opportunity to train drivers to cope with hazardous situations in a safe interactive environment. A three-year project just starting in Nottingham will implement a number of hazard perception training interventions via up to 90 simulators throughout the UK, based in the offices of the British School of Motoring (BSM). Four key elements of hazard perception skill will be trained, and the effectiveness of that training will be assessed in a wide selection of measures, including the difference between pre- and post-training test scores on simulated hazardous scenarios, detailed behavioural measures including eye movement recordings, subsequent driving test success, and the accident liability of these and control drivers in their first year of driving. We anticipate that the simulator-based training will improve performance in hazardous situations in learner drivers and will reduce their subsequent accident liability. The results will also reveal the specific behavioural changes brought about by the different components of the training intervention.

# Introduction

A series of studies conducted at Nottingham over the last decade have explored the way that drivers' skills and attitudes develop over the first year of licensed driving, and the way in which these measures differ from those recorded from older, more experienced drivers (e.g. Chapman and Underwood, 1998; Chapman *et al*., 2002; Crundall *et al*., 2002; Crundall and Underwood, 1998; Underwood *et al*., 2002a,b). One of the most important finding from these studies was that there were clear differences in eye-movement patterns between newly qualified and more experienced drivers. Such differences are particularly pronounced in hazardous situations. Unfortunately, the opportunities to train drivers in how to scan the road in real hazardous situations are extremely limited. In fact, for a long time the opportunities to train drivers in any aspects of dealing with hazardous driving situations have been surprisingly limited. Groeger and Clegg (1993) reported that driving instructors typically mentioned driving hazards fewer than 100 times over the full course of training a pupil up to taking the practical test, and that such mentions were generally provided while drivers were simply proceeding ahead. It is very unlikely that such training actually involved first-hand experience of the hazards that instructors were describing. One approach to rectifying this lack of experience with hazardous situations has been to introduce hazard perception testing into the British driving test.

In November 2002, the Driving Standards Agency (DSA) introduced a hazard perception test to the driver licensing procedure. A typical test usually comprises a series of short driving clips (taken from the forward view of a moving vehicle), with each clip containing at least one hazardous event. Observers are required to make a discrete response to the onset of the hazard. The number of hazards that they respond to, and their response times, are combined to give a measure that is said to reflect the stage of development in the observer's mental model of driving. Several studies have demonstrated differences between drivers' responses to these hazards, with more experienced drivers typically obtaining the highest scores (McKenna and Crick, 1994; Renge, 1998). Similarly, licensed drivers who have had more accidents in the year or two prior to undertaking a hazard perception test, perform worse than drivers with less accident history (McKenna and Crick, 1991), and drivers who have low hazard perception scores are more likely to be involved in a fatal accident in their first year of qualified driving (Drummond, 2000). Though the research suggests that hazard perception is an important skill that can be linked to accident liability, the question remains of how one can successfully train this skill? One possibility raised by the research at Nottingham University is that eye movement training may be an important component of any training regime (e.g. Chapman *et al*., 2002), however, other types of training are possible.

There are many commercial training packages available that use digital video clips of driving situations similar to those produced by the DSA. Such packages have generally not been validated, however, and merely expose learners to similar clips to those that appear in the DSA hazard perception test. Questions remain about whether any training benefit would extend beyond improved scores on the official hazard perception test, and benefit the driver's general mental model.

Driving psychologists have, however, had some success at training hazard perception. McKenna and Crick (1994) trained a group of inexperienced drivers in hazard perception by stopping video clips halfway through and asking participants to predict what happened next. This training improved scores on a subsequent hazard perception test. Verbal commentaries have also been noted to improve subsequent hazard perception skills, regardless of whether the commentaries are generated by the drivers themselves (Horswill and McKenna, 2004) or are provided by an expert driver (McKenna *et al*., 2006). Mills *et al*. (1998) used a combination of group training in the classroom with personal on-road training, emphasising the scanning of critical areas and continued movement of the eyes. This reduced response times to hazards in a subsequent hazard perception test. Deery (1999) summarises several attempts to improve hazard perception, including the use of photographs, video clips and simulated driving. Visual scanning and hazard prediction again appeared to be central to successful hazard perception, though Deery also reports that training drivers to vary the amount of attention to two different tasks improves dual task performance and hazard perception ability.

Pollatsek *et al*. (in press) found effects of hazard perception training upon subsequent eye movements in a simulator. They gave participants plan views of roads and asked them to mark on the pictures the location of hazards which were obscured from the view of the driver. The eye movements of 24 participants who were trained on this task were then compared to those of untrained novices while driving through simulated three-dimensional versions of the plan. They found that the trained group had the better visual search for potential hazards on those scenarios that were structurally the same as the plan views with which they had been trained. More importantly, there was also evidence that eye movements on new scenarios had been affected by the training, suggesting transference of skill between driving situations.

There is even evidence that hazard perception training can transfer to the real world. Chapman *et al*. (2002) trained novices to look in the same areas of hazard perception clips by following markers overlaid on the screen which represented the areas that experienced drivers looked at when watching the same clips. As well as improving markedly the visual scanning of novice drivers when they viewed subsequent hazard perception clips, the training increased the novices' spread of horizontal visual search when they subsequently drove on real roads in an instrumented vehicle. In a follow-up study on the same drivers approximately three months after the training, the changes in visual search patterns were still detectable in a laboratory setting but did not extend to driving on real roads. Of course it is possible that this was because the extra three months of driving experience had allowed untrained novices to catch up with the trained ones, but there were other reasons for concern with the Chapman *et al*. (2002) intervention. Firstly, the changes in eye movements observed while driving were not limited to the road types that distinguished between expert and novice drivers in previous studies (e.g. Crundall and Underwood, 1998), and secondly that changes in eye movements in the laboratory were also equal in safe and dangerous situations, unlike those found by Chapman and Underwood (1998) when comparing novice and experienced drivers. One problem with such eye-movement based training may be that it encourages a use of a general scanning strategy that is not always necessary or appropriate. One reason for this may be that training using video clips does not require the driver to simultaneously control a vehicle. It may be relatively easy to adopt any form of scanning behaviour, irrespective of other levels of skill, if this is required without the need to control the vehicle at the same time. A further criticism that is often levelled at hazard perception training and testing is that a good driver could have avoided many hazards by an appropriate approach speed and direction. Video-based hazard training takes this opportunity out of the hands of the driver and simply allows them to focus on the events unfolding in front of them. This may remove the need to adapt scanning and attentional strategies to the demands of the current road situation. The ideal training regime would thus involve actual driving on real roads in which hazardous situations are encountered and dealt with, however, as has been previously discussed, the opportunities for such training are extremely limited. A clear improvement over training using videos would thus be the use of simulated driving in which car control was required, but hazardous situations could be created for the driver to deal with in a safe controlled environment.

# The current project

Despite the apparent success of certain training regimes, there is yet to be a large-scale study on the application of simulator technology to train hazard perception skills, following the benefits beyond the immediate test period. This paper describes the early stages of just such a study. In conjunction with the University of Nottingham, the British School of Motoring (BSM) has developed a training package that is being rolled out on 90 simulators around the UK during 2005–06. As part of the current project, we will monitor the success of this initial training intervention, whilst also developing further interventions based on the results of experiments assessing expert driver performance in the laboratory simulator (via behavioural responses, commentaries, eye movements, etc.). Our hope is that at the end of the study we will have identified an optimal training package that makes the best use of the available technical resources to produce long-term benefits through improved hazard perception skills, and decreased accident liability of learners and recently qualified drivers.

At the core of the current project are a series of interactive scenarios that will run on the driving simulators around the country. The laboratory simulator has now been installed in the Accident Research Unit (ARU) at the University of Nottingham and linked to an SensoMotoric Instruments (SMI) eye- and head-tracking system. The risk awareness module in the BSM simulator consists of an initial assessment drive (approximately 10 minutes), followed by four development exercises (approximately 10 minutes each) and a final assessment drive (the same as the initial assessment drive but under different conditions of rain and/or darkness). The development exercises are aimed to develop the following four key skill elements:

1. **Predicting the behaviour of other road users** – many hazards are caused by other road users (including pedestrians) and could be anticipated by predicting the behaviour of those around us. For example, is the oncoming car going to turn into a side street in front of our vehicle? Are the two pedestrians walking on the pavement likely to step into the road? Having the ability to judge the behaviour of other road users and pedestrians allows the driver to predict their future actions, priming the driver for the possibility of a hazard. This component of the development exercise is closely related to the ‘knowledge’ component of training in the Chapman *et al*. (2002) intervention.

2. **Developing a mental model of the situation** – some hazards cannot be seen until they become hazardous. For example, a child who steps out into the road from behind a parked ice-cream van becomes an immediate hazard. Experience allows a driver to identify and monitor these dangerous areas prior to the appearance of the hazard. This component is similar to the concept of 'anticipation' as used by McKenna and colleagues (e.g. McKenna *et al*., 2006) and in the Chapman *et al*. (2002) intervention.

3. **Dividing and focusing attention** – the ability to monitor multiple potential sources of hazards is essential when navigating congested urban roads. The driver must prioritise locations in the visual scene according to their importance, and must frequently monitor the most likely hazard spots, while inhibiting the impulse to fixate non-hazard related information. Such an ability is similar to the concept of 'scanning' training, as proposed by Chapman *et al*. (2002). However, one particular focus is the need to not just scan the road continually but, particularly, to disengage from hazards once they have been detected. Crundall and colleagues (e.g. 1999, 2002) have observed a reduction in the ability to detect peripheral targets in hazardous situations and it is easy to see that there may be situations where a novice driver's attention is so consumed by a primary hazard that they may not disengage from this in time to assess subsequent developments in the driving situation.

4. **Hazard management** – many hazards can be caused by the drivers themselves through inappropriate driving. For example, following the car in front too closely or poor lane maintenance can create hazardous situations. Such hazards cannot be adequately assessed in traditional hazard perception tests since they require a real or simulated driving scenario in order to allow the drivers' behaviour to be free enough for assessment.

# The simulator assessments

Within each of the first three key skill elements there are three scenarios included in each assessment drive designed to measure performance:

1. **Predicting the behaviour of other road users:**

   (a) The driver is following the road ahead and approaches a side road on the left where there is a vehicle waiting to emerge. The vehicle emerges in front of the driver. This hazard (the car) can be detected 85 metres before the driver reaches the hazard.

   (b) A child can be seen stood between parked cars on the left-hand side of the road. As the driver approaches, the child runs into the road. This hazard (the child) can be detected 137 metres before the driver reaches the hazard.

   (c) There is a motorbike heading towards the driver on the other side of the road. It makes a right turn into a side road, crossing the driver's path. This hazard (the motorbike) can be detected 68 metres before the driver reaches the hazard.

2. **Developing a mental model of the situation**

   (a) As the driver is driving round a bend, there is a broken down lorry on the inside lane that only becomes visible once the driver is into the bend. This hazard (the lorry) can be detected 74 metres before the driver reaches the hazard.

   (b) There is an ice cream van parked on the left-hand side of the road and a hidden child steps out from behind it. This hazard (the child) can be detected 8 metres before the driver reaches the hazard.

   (c) There is a delivery van parked on the right-hand side of the road and a hidden man steps out from behind it. This hazard (the man) can be detected 81 metres before the driver reaches the hazard.

3. **Dividing and focusing attention**

   (a) A bus pulls up at a bus stop on the left and a pedestrian runs across the road from the right to catch the bus. This hazard (the pedestrian) can be detected 88 metres before the driver reaches the hazard.

   (b) At a crossroads with many potential vehicles, a car emerges from the right. This hazard (the car) can be detected 48 metres before the driver reaches the hazard.

   (c) There are pedestrians on both sides of the road, waving to each other and one runs across the road to the other. This hazard (the pedestrian) can be detected 37 metres before the driver reaches the hazard.

To provide detailed analysis of performance around hazards, the simulator records a variety of summary information around each of the nine specific hazards. An output file contains information regarding a number of variables for different checkpoints before the location of the hazard (at 10 metre intervals from 100 to 10 metres before the hazard, and then every metre up to the hazard). For each of these checkpoints the simulator records speed, accelerator and brake pedal pressures, steering wheel angle, lane positions, and any collisions.

4. **Hazard management**

In additions to the measures recorded around each of the nine specific hazards, a number of general measures are available to describe driving performance across the whole drive. Some specific summary information regarding general hazard management is automatically recorded by the simulator:

| | |
|---|---|
| Crash | number of crashes |
| WrongRoute | number of times a wrong route is taken |
| Speedinfractions | number of times the speed limit + margin (10 km/h) is exceeded |
| Speedtime | duration of exceeded speed limit (seconds) |
| SpaceCushion | number of times the driver gets too close to the vehicle ahead |
| SpaceCushionTime | duration of being too close to vehicle ahead (seconds) |
| LanePosition | number of times not kept to lane position |
| LanePositionTime | duration of not keeping to lane position (seconds) |

| | |
|---|---|
| TurnSignals | number of times driver forgot to signal |
| IntersectionCrossings | number of times driver crossed intersection when they should have stopped |
| ScenarioTime | total time of the assessment (in seconds |

The simulator also records a continuous data file at the rate of one sample per second. These basic measures allow us to calculate a variety of composite measures such as:

- **Speed maintenance:**
  - the total time to complete the entire drive (calculated as the total number of seconds to complete the simulation from start to finish);
  - average speed for each assessment (velocity = distance/time);
  - speed variability (standard deviation of average speed); and
  - maximum speed.
- **Acceleration/deceleration profiles**. Rakauskas *et al*. (2004) have performed a number of measures of performance in simulated driving. For example, they measured accelerator position variability (calculated as the standard deviation of the accelerator pedal position). We plan to calculate this variable in addition to other measures of acceleration and deceleration (potentially including acceleration signatures – Robertson, 1992).
- **Lane positioning:**
  - average lane position (can be calculated from 'shift' in stats file or from the 'position' in the events file (in millimetres from centre of the lane));
  - lane position variability (standard deviation of average lane positioning) – degree of adjustment that a driver implements to maintain position within the lane. The greater the lane positioning variability, this indicates poorer driving precision;
  - steering wheel angle (values can either be taken from 'steering' column in stats file or from the events file); and
  - steering wheel angle variability (standard deviation of average steering wheel angle).

# Three types of research study

With the previous data available from everyone taking part in the risk awareness component of the BSM simulator, we have the capability to undertake three different types of study within the time frame of the current project. We will undertake a laboratory study (split into the expert and learner cohorts), a local study and a national study. The expert cohort (laboratory study) will be tested first to provide baselines against which all learners can be judged. From these results we will develop a training intervention that will be assessed in the local study. A further training package (designed prior to the start of this project and loosely based on Chapman *et al*., 2002) will be tested in the national study. The second phase of the laboratory study (learner cohort) will compare performance on both the local and national training packages in a series of in-depth studies with more sensitive measures than can be collected in the field (e.g. eye movements). The results will lead to a blueprint for an optimum training package, including elements from both the national and local interventions.

# The laboratory study: expert cohort

We will test driving instructors on the hazard perception scenarios to create baselines against which all learner performance can be judged. The eye movements of these drivers will also be monitored. It is expected that we will be able to predict an expert response to a hazard from their eye movements prior to hazard onset, and their driving behaviour at the time of hazard onset. A number of additional measures will be taken from the expert drivers to form the basis of the local training intervention:

- **Predicting other road users' behaviour** – the experts will be shown video clips of driving which will be periodically stopped and they will be asked to predict the next event. Their performance on this task will provide the baseline against which learner drivers will be compared in later studies, and will form the basis of a five-minute video clip training the key elements of this predictive skill (to be used as a module in the local training intervention).

- **Developing a mental model of the driving situation** – drivers will be shown a simulated scenario from a different point of view (such as top down) and will be asked to mark areas that they cannot see from their perspective as a driver. Pollatsek *et al*. (in press) have produced evidence that suggests that training in this task increases awareness of the environment. Again, the performance of the expert drivers will provide the baseline to which we will compare learner driver performance in the laboratory. Expert driver performance will also contribute to a five-minute, video-based training module which will explain and aid the development of the driver's mental model.

- **Dividing and focusing attention** – on the basis of the averaged eye movements of the expert drivers, we will instruct learners where to look for each clip. Previously we have done this by developing an overlay for scenarios with an ellipse representing the average location of the experts' point of fixation at every point during every clip (Chapman *et al*., 2002). The centre of the ellipse represented the average fixation location, while the size of the ellipse represented the variance in fixations across the expert cohort (i.e. the wider the ellipse at any one point, the less agreement there was in fixation location across the experts). We aim to modify this procedure for the simulated scenarios in the current study.

- **Hazard management** – expert drivers will view replays of their drives through the scenarios and give a commentary on their driving behaviour (speed, positioning, etc.). Those comments that have high consistency across the expert cohort will be included in a general commentary that will be played with the clips to provide a five-minute training module for the intervention. Previous studies have found commentaries to improve HP scores (Horswill and McKenna, 2004).

# The local study

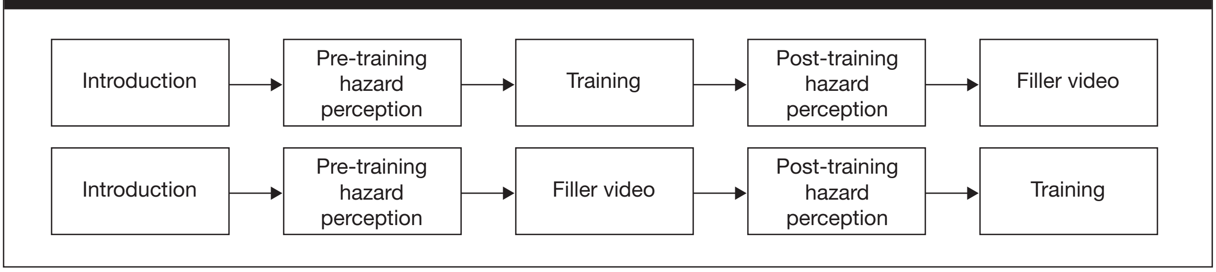
We hope to introduce the local training intervention, developed on the basis of the expert cohort results, into a few local branches of BSM. The effectiveness of this passive but cost-effective intervention will be compared against other forms of training (see the national study) and no training. It is anticipated that the training videos will improve learner driver performance on the sub-tasks that the experienced drivers took part in (e.g. selecting those areas from a plan view of the road ahead which cannot be seen from the driver's point of view). Success of the intervention will be measured via performance on pre- and post-training hazard perception tests, learners' scores on the official hazard perception test and the practical driving test, and accident and near-accident statistics in a year-long follow up of all participants (using self-report and dictaphone diary studies, a technique which we have successfully used in the past – Underwood *et al.*, 1999). This wide range of measures should ensure that the full impact of training is recorded.

# The national study

Every BSM office will be introducing the risk awareness training in 2005–06. Half of the simulators in the country will present an introduction, a pre-training assessment, an interactive training intervention based on the four skills, a post-training assessment and a short filler video at the end. The remaining simulators will present the same information, but the training and filler video will swap places (see Figure 1).

This allows a comparison of trained and untrained learners via the second assessment, while still providing all the same information to all. It would be

Figure 1 **The two presentation schedules for BSM simulators**



unethical to withhold training from half of the learners in the national study. When BSM learners pass their test we hope to invite them to take part in a follow-up study. For ethical reasons and to encourage participation, we cannot link individual scores on the simulator to follow-up questionnaires, but any follow-up measures will be compared between those learner drivers who undertook the hazard perception training session and those who did not (judged by self-report).

# The laboratory study: learner cohort

The local and national studies allow large-scale tests of two training regimes, with follow-up studies to assess the long-term effects of training. They do not, however, allow us to deconstruct which training elements are most effective, nor do they permit analysis of the effects of training on learners' eye movements. This will be done in the laboratory with a learner cohort who will be tested and trained on various combinations of the training elements that make up the local and national interventions.

# Summary

The proposed research over the next three years thus builds on previous studies that have explored hazard perception training and visual search strategies in learner and novice drivers. The current research programme has a number of key advantages over previous studies:

- the use of simulated hazardous situations for training and assessment allows us to monitor hazard perception performance and drivers' eye movements in a safe but realistic and interactive environment;

- the national study allows us to perform some behavioural assessment of the effects of hazard perception training on the skills of large numbers of real learner drivers in natural situations;

- the laboratory study will allow us to decompose the potential elements of hazard perception training and assess the degree to which different components of training may be effective in altering behaviour in advance of specific hazards and also in terms of general hazard management when driving; and

- the local study will allow us to test the effectiveness of our best candidate training intervention on real drivers undergoing actual driver training and follow up this training over the first year of licensed driving.

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# Can we use the Cohort II data to explore the effects of taking Pass Plus?

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## Introduction

Newly qualified drivers have a high probability of being involved in a road traffic accident relative to other drivers, and their lack of driving experience is one of the main reasons for their relatively high accident liabilities (e.g. Forsyth *et al*., 1995; Maycock, 2002; Maycock *et al*., 1991; Wells and Baughan, 2003). In Great Britain, the Cohort I study represented the first investigation into the new driver problem on a large scale (e.g. Forsyth, 1992a, 1992b; Forsyth *et al*., 1995; Maycock and Forsyth, 1997). The results of that study provided a valuable input into Government policy on driver training and testing. However, with the passage of time, changes have been made to the training and testing regime, notably the introduction of a separate theory test, as well as changes to the practical test itself. A Cohort II project has therefore been carried out in order to provide up-to-date information about learner and novice drivers that can be used to inform Department for Transport (DfT) policy.

The Cohort II study utilises a self-report methodology. Samples of 8,000 candidates taking their practical driving test in a particular week have been selected every three months since November 2001. Initially, candidates were sent a 'Learning to Drive Questionnaire' (LTDQ) that asked them about their learning experiences, attitudes and reported behaviours during the learning period and immediately post-test. The LTDQ was sent to candidates about two weeks after taking their practical driving test. Respondents who passed their practical driving test were subsequently sent a Driver Experience Questionnaire (DEQ) at 6, 12, 24, and 36 months after test pass. The DEQs include measures of self-reported driving behaviour, accidents, offences, exposure to various driving situations and the types of post-test training taken. Therefore a large amount of information has been collected on a large sample of new drivers as they develop their skills and experience over the early driving period. This enables the Cohort II dataset to investigate many issues related to new drivers. Those issues that the project was set up to investigate include:

- a detailed analysis of performance in both the theory and the practical driving tests in relation to candidate characteristics;
- an investigation into the methods used and experience gained while learning to drive, and in preparation for each part of the test, and following test failure;
- an investigation into the relationship between learning methods and driving test performance;
- an investigation into the attitudes and reported behaviour of drivers in the early post-test period; and
- an evaluation, based on the data collected, of the effectiveness of measures introduced during the period of the project (e.g. the introduction of hazard perception testing in the theory test in autumn 2002).

However, given that the Cohort II study represents one of the largest, most representative and up-to-date sources of information on new drivers that is currently available, the question arises as to whether the data can be used for other purposes. An issue that has arisen is whether the data can be used to evaluate the effectiveness of pre-existing, non-mandatory road safety interventions. The purpose of the present paper, therefore, is to consider the potential for using the Cohort II data for this purpose, using the example of Pass Plus: a post-test training programme that is designed to give newly qualified drivers some formal driving experience shortly after passing the practical driving test.

# Pass Plus

In the first few months and years of driving after passing the practical driving test, 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 (Grayson, 1991). 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. Therefore, it would be desirable if the lessons of experience could be supported by some formal intervention, rather than being acquired in an uncontrolled learning situation.

Pass Plus is such a training scheme. It is designed to enable new drivers to gain experience and confidence, especially in conditions they may not have met during the pre-test training. It was designed by the Driving Standards Agency (DSA), with the help of the motor insurance and driving instructor industries. The training is delivered by approved driving instructors (ADIs) who are registered to deliver Pass Plus. It was introduced in November 1995 and since then there has been a steady increase of new drivers taking the training. 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.

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.

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 take-up rate for Pass Plus is currently around 16% (Driving Standards Agency, 2005).

The characteristics of Pass Plus 'takers' versus 'non-takers' within the Cohort II sample of respondents has previously been reported (Wells, 2005). However, a simple comparison of the Pass Plus takers with the non-takers provides little information on the potential effectiveness of Pass Plus on new driver safety. This is of applied importance because, to date, no empirical evidence on the effectiveness of Pass Plus exists – although it is acknowledged that there have been studies examining drivers' and ADIs' views about the content and delivery of the training as well as the reasons for taking Pass Plus (e.g. Simpson *et al*., 2002) and evaluations of enhanced Pass Plus schemes (Edwards, 2005). Therefore, the following sections of the present paper consider:

- what more can be done with the Cohort II data to provide an indication of how well Pass Plus is working on a national level in terms of improving driving standards; and
- the associated data limitations.

# Available data from the Cohort II study: limitations and potential for investigating effects of Pass Plus

When assessing the effectiveness of any intervention it is necessary to define an outcome variable (or set of outcome variables) which can be used to assess the intervention's effectiveness. Clearly, in the present domain, the major criterion for effectiveness is that the intervention promotes road safety, either in terms of reduced accident risk or in terms of proxy measures, such as safety-related attitudes or behaviours. Ideally, measures of such variables would be obtained for an experimental group prior to receiving the intervention (baseline) and at some time point(s) after receiving the intervention (follow-up). Identical measures, obtained at the same time points as the experimental group, would also be obtained for a control group, who do not receive the intervention. The gold standard is to use a randomised controlled design in which participants are randomly assigned to experimental and control groups. This controls for self-selection biases: biases which, if not controlled, make it difficult to assign any observed effects (e.g. changes in safety-related behaviour) to the intervention itself.

Unfortunately, the Cohort II data are not ideal for assessing interventions such as Pass Plus. The main data limitations stem from the fact that the Cohort II study is not an experimental study; it is essentially a survey of the experiences of learner and newly qualified drivers, meaning that any evaluation of pre-existing road safety intervention, such as Pass Plus, is post hoc. In each of the DEQs, respondents have indicated whether or not they have taken Pass Plus and measures of self-reported accident involvement have been taken in addition to various attitude and behaviour measures. Prior to this, participants have completed the LTDQ in which various psychological variables have been measured (see below for details about the measures used in the present analyses). However, most of the psychological measures obtained in the LTDQ are not identical to the measures obtained in the DEQs. The important limitations that arise here are as follows:

1. It is questionable whether the use of some DEQ outcome variables (e.g. accidents during the first six months of driving after test pass) can be regarded as being follow-up measures when compared with the reported taking of Pass Plus during that same period (i.e. Pass Plus taken versus not taken during the first six months of driving after test pass). First, a substantial proportion of the accident reporting period may have occurred before Pass Plus was taken and, second, some people may have decided to take Pass Plus because they had an accident.

2. While there are some appropriate outcome variables within the Cohort II dataset that can potentially be used for assessing the effectiveness of Pass Plus, many of these variables have been measured in the DEQs only. These can be considered as follow-up measures (but see point 1, above). However, we do not have comparable baseline measures, meaning that a within-subjects analysis cannot be conducted (e.g. assessing changes in outcome variables from baseline to follow-up). Rather, we have to rely on only a between-subjects analysis comparing Pass Plus takers versus non-takers on the ‘follow-up’ outcome measures.[1]

1 The only exceptions are self-reported driving style and confidence. Respondents completed measures of driving style in the LTDQ and the DEQs using the standard items developed by Guppy et al. (1990). These items produce three scales covering the following dimensions of driving style: (a) attentiveness/carefulness/responsibility/safety; (b) patience/considerateness/tolerance/placidity; and (c) decisiveness/experience/confidence/speed. For each scale, 2 x 2 repeated measures ANalyses Of VAariance (ANOVAs) with one within-subjects factor (LTDQ versus DEQ1 or LTDQ versus DEQ2) and one between-subjects factor (Pass Plus taken versus not taken – as reported at DEQ1) showed no significant interaction effects. This means that there were no effects detected of taking Pass Plus on participants’ responses to the driving style scales over time. Measures of driving confidence were also obtained in the LTDQ and the DEQs and, once again, 2 x 2 repeated measures ANOVAs showed no significant interaction effects on this variable. Therefore, these results will not be mentioned further in this paper. However, these findings should be treated with caution as they are vulnerable to the same criticisms as the analyses reported in the main text (i.e. volunteer biases cannot be fully controlled).

3. The use of a between-subjects analysis on only the follow-up outcome measures means that the issue of self-selection, or volunteer, bias becomes particularly important. Pass Plus is a voluntary scheme meaning that participants have not been randomly assigned to experimental (Pass Plus taken) and control (Pass Plus not taken) conditions. In fact, Wells (2005) showed that those Cohort II respondents who took Pass Plus significantly differed from those who did not on age, gender and other background variables. Therefore, any simple between-subjects differences in outcome variables (e.g. attitudes, self-reported behaviours) may not be attributable to Pass Plus.

4. A final data problem considered here is that for some of the outcome variables available in the Cohort II dataset we do not know which direction of difference could be considered as beneficial to safety. For example, items on people's perceived need to improve a number of driving related skills (e.g. merging with traffic) are available, as are items on 'how skilled a driver you are compared with others your age and sex'. The problem is that, leaving aside the important issues described above, the direction of any effects of Pass Plus on these items will be ambiguous from a safety perspective. In other words, if respondents who take Pass Plus are less likely to perceive a need to improve their driving skills, compared with respondents who do not take Pass Plus, then the question arises as to whether that represents a safety benefit or not. On the one hand, an improvement in driving skill is a safety benefit and less perceived need to improve might reflect an actual improvement in skill. On the other hand, when people perceive no need to improve their driving skills, it may represent an inflated sense of confidence in their driving skills, which is considered to be disadvantageous from a safety perspective (e.g. Bartl *et al*., 2002). Therefore, leaving aside the limitations described above, any differences between Pass Plus takers and non-takers on these perceived skill items would not allow us to draw any conclusions about the potential effectiveness of taking Pass Plus on driving safety.

Despite these limitations, the Cohort II dataset is potentially the largest, the most up-to-date and the most representative dataset that is currently available in the UK on learner and novice drivers. It is therefore desirable to explore whether the data can be used to obtain some indication on the effectiveness of interventions such as Pass Plus. Some important issues need to be considered:

- It was mentioned above that any analysis of Pass Plus using the Cohort II dataset would have to rely on between-subjects comparisons at follow-up, for the most part. In the present context, it could be argued that this design is the most appropriate one to use because any within-subjects analyses comparing baseline measures to equivalent follow-up measures may be inappropriate. For example, it is unlikely that baseline measures of accidents and driver behaviour will be appropriate for a vast majority of drivers because people can take Pass Plus very soon after taking their practical driving test.

- It was also mentioned above that, because the Cohort II study is not a randomised controlled trial, possible volunteer biases represent an important limitation of any analyses that can be done to evaluate the effects of an intervention using this dataset. However, when an intervention is already in place and is offered to the population at large, then it is not possible to conduct a randomised controlled trial. Therefore, volunteer bias is a difficulty when assessing many road safety interventions and, in the present context, it is highly unlikely that any evaluation of the existing Pass Plus scheme will completely eradicate self-selection biases. The question then arises as to what can be done to minimise these biases. With respect to this issue, known differences in the characteristics of Pass Plus takers and non-takers can be co-varied out of any analyses in which Pass Plus takers and non-takers are compared on various outcome variables. Such differences have been described by Wells (2005) and include descriptive variables such as age and sex. A problem with controlling for these variables only is that previous research has demonstrated that attitudes and other psychological factors have an effect on behaviour over and above the effects of background/demographic variables (e.g. Elliott *et al*., 2003, 2004; Parker *et al*., 1992). Also, it is known that behavioural factors predict accident liability over and above background variables (e.g. Parker *et al*., 1995). Therefore, merely co-varying the effects of age and sex, for example, and assuming that this would control for differences between Pass Plus takers versus non-takers is not entirely satisfactory. However, in the Cohort II database there are also measures of psychological variables, which have been measured prior to taking Pass Plus (i.e. in the LTDQ). These measures can also be included as covariates in any analyses to investigate the differences between Pass Plus takers and non-takers on appropriate outcome variables. When used in conjunction with demographic variables, these variables might provide a reasonably good control for differences between takers and non-takers. However, it should be borne in mind that this approach may never completely control for volunteer biases.

In sum, it is not possible to use randomised controlled trials to evaluate an existing road safety intervention such as Pass Plus. This is because Pass Plus is a voluntary scheme that is available to everyone on a nationwide scale, meaning that any evaluation will be vulnerable to self-selection biases. Therefore, the best possible evaluation of the existing Pass Plus scheme that can be done is to compare those people who choose to take Pass Plus and those who do not on appropriate outcome variables (e.g. accidents) while controlling for differences between the takers and non-takers on background variables and appropriate psychological variables. While this kind of evaluation is not completely satisfactory for assessing the impact of an intervention, it is entirely possible to do using the Cohort II dataset. The following sections therefore describe the results of such an analysis. However, it is important to bear in mind the limitations that are outlined above, meaning that the following results must be treated with caution.

# Measures and analyses

In order to examine the differences between Pass Plus takers and non-takers while controlling for background variables and psychological characteristics, a series of ANalyses of COVAriance (ANCOVAs) were conducted. The independent variable in each analysis was whether respondents reported taking Pass Plus within the first six months of driving (0 = Pass Plus taken; 1 = Pass Plus not taken). The dependent variables are given below. It should be noted that one set of analyses was conducted using these dependent variables as measured in DEQ1 (first six months of driving after test pass) and another set was conducting using these variables as measured in DEQ2 (second six months of driving after test pass). Therefore, while the first set of analyses are potentially vulnerable to the criticism mentioned above – that accident involvement may have occurred prior to taking Pass Plus – the second set of analyses are not. The dependent variables were as follows:

- **Accident involvement**. Respondents reported the number of accidents that they had been involved in during (a) the first six months of driving after passing the practical driving test and (b) the second six months of driving after passing the practical driving test. In the Cohort II study, respondents were told to report all accidents they had been involved in, regardless of how they were caused, how slight they were or where they happened. It is perhaps useful to note that most of the self-reported accidents reported by the respondents were defined as 'minor bumps or scrapes'. Just over 70% of the accidents that were reported during the first six months of driving after passing the practical driving test were minor bumps or scrapes and about 65% of the accidents that were reported during the second six months of driving were bumps or scrapes.

- **Driver behaviour**. Driver behaviour was measured using the standard questionnaire items from the DBQ (e.g. Åberg and Rimmo, 1998; Parker *et al*., 1995; Reason *et al*., 1990). In total, 34 DBQ items were rated by respondents on scales ranging from 1 (when driving, I **never** do the specified behaviour) to 7 (when driving, I do the specified behaviour **nearly all the time**). The means of the appropriate items were used as the measures of (a) violations, (b) errors, (c) slips, (d) inexperience errors and (e) aggressive violations.

The following variables were used as covariates:

- **Age**. Following previous research (e.g. Maycock *et al*., 1991) a reciprocal age function was used: 1/(age + 9) to control for age.

- **Sex**. Coded: 0 = male; 1 = female.

- **Exposure**. Mileage during the appropriate reporting period (DEQ1 or DEQ2) was used to control for the effects of exposure on the dependent variables. Following previous research (e.g. Maycock *et al*., 1991) the data were transformed by taking the natural log of mileage. Eleven items that were used in the DEQs to measure exposure in different driving contexts were also used as covariates (e.g. reported frequency of driving in busy town centres, country roads and motorways).

- **Pre-test characteristics/learning to drive experiences**. A number of variables from the LTDQ were used to control for possible differences between Pass Plus takers and non-takers in terms of their learning to drive experiences: (a) the number of months taken to reach the practical driving test; (b) the number of practical driving tests taken; (c) the number of hours of driving tuition taken with a professional driving instructor when learning to drive; and (d) the number of hours of driving practice taken with friends or relations when learning to drive.

A number of psychological variables that were measured in the LTDQ were also used as covariates in the present analyses. These were: (a) the three standard self-reported driving style scales developed by Guppy *et al*. (1990); (b) the attitude to driving violation scale developed by West and Hall (1997); (c) confidence while learning to drive, confidence that the practical driving test would be passed, confidence in the ability to drive unsupervised and overall confidence in driving ability when completing the LTDQ; and (d) the perceived need to improve on 15 driving related skills (covering basic control skills, such as the use of car controls, and skills needed to drive in various situations, such as when driving on a motorway or fast dual-carriageway).

# Results

Tables 1 and 2 show the results of the ANCOVAs. The tables show the effects of the independent variable (Pass Plus taken versus not taken) on the outcome variables. The covariates are not shown in the tables, but were present in the analyses. Table 1 shows that, with one exception, there were no differences between those Cohort II respondents who took Pass Plus and those who did not on the outcome variables as measured in DEQ1 (i.e. related to the second six months of driving after passing the practical driving test). The only exception was on aggressive violations: those who took Pass Plus reported committing aggressive violations less often than did those who did not take Pass Plus. However, we can identify no obvious reason why taking Pass Plus may have had this effect on the tendency to commit aggressive violations. It is plausible that this finding is attributable to a volunteer bias that was not fully controlled in the present analyses.

Table 2 shows that there were no differences between those who took Pass Plus in the first six months of driving and those who did not on any outcome variable as measured in DEQ2 (i.e. related to the second six months of driving after passing the practical driving test).[2] Overall, the analyses indicate that there was little or no difference between Pass Plus takers and non-takers in terms of their accident rates or their driving behaviour.

# Discussion

The present paper set out to explore what can be done with the Cohort II data to evaluate the effects of pre-existing, non-mandatory road safety interventions. Pass Plus was used as an example of such an intervention. Given that respondents to the Cohort II study could not be randomised to experimental (Pass Plus taken) and control (Pass Plus not taken) conditions, the best that could be done with the data was to examine differences between Pass Plus takers and non-takers on a number of important outcome variables (self-reported accidents and driver behaviour measures) while controlling for variables that might explain why some people choose to take Pass Plus and others do not (i.e. variables that might help to reduce volunteer biases which can account for differences between takers and non-takers when an intervention is voluntary and made available to all drivers). This approach showed that, with one exception, there were no differences between Pass Plus takers and non-takers in terms of their self-reported driving behaviour and accident rates. The

2 Logistic regressions, in which Pass Plus (taken versus not taken) was used to predict accident involvement, confirmed the results from the ANCOVAs. When controlling for the LTDQ psychological measures and the descriptive variables, Pass Plus (taken versus not taken) did not predict whether respondents reported being accident involved or not at either DEQ1 or at DEQ2.

**Table 1** **ANCOVA results – differences between Pass Plus takers and non-takers on self-reported frequency of accidents and DBQ driving behaviour scales (first six months of driving after passing the practical driving test)**

| Analysis | Dependent variable | Estimated marginal means* | | Differences between Pass Plus takers and non-takers† | |
|---|---|---|---|---|---|
| | | Pass Plus takers | Pass Plus non-takers | *F* | *p* |
| 1 | Accidents | 0.27 | 0.24 | 1.96 | NS |
| 2 | DBQ violations | 1.42 | 1.44 | 1.56 | NS |
| 3 | DBQ errors | 1.22 | 1.24 | 3.84 | NS |
| 4 | DBQ slips | 1.66 | 1.67 | 0.30 | NS |
| 5 | DBQ inexperience errors | 1.66 | 1.65 | 1.51 | NS |
| 6 | DBQ aggressive violations | 1.34 | 1.39 | 13.51 | < 0.001 |

* Estimated mean values on the dependent variables after taking into account differences between takers and non-takers on the descriptive and the LTDQ reported psychological variables (i.e. the covariates).
† These are the differences after having taken the covariates into account.
NS = not statistically significant at alpha = 0.05.
*n* = 5,609 (1,047 takers and 4,562 non-takers) in each analysis.

**Table 2** **ANCOVA results – differences between Pass Plus takers and non-takers on self-reported frequency of accidents and DBQ driving behaviour scales (second six months of driving after passing practical driving test)**

| Analysis | Dependent variable | Estimated marginal means* | | Differences between Pass Plus takers and non-takers† | |
|---|---|---|---|---|---|
| | | Pass Plus takers | Pass Plus non-takers | *F* | *p* |
| 1 | Accidents | 0.16 | 0.15 | 0.31 | NS |
| 2 | DBQ violations | 1.51 | 1.51 | 0.01 | NS |
| 3 | DBQ errors | 1.25 | 1.26 | 1.10 | NS |
| 4 | DBQ slips | 1.70 | 1.69 | 0.41 | NS |
| 5 | DBQ inexperience errors | 1.64 | 1.63 | 0.32 | NS |
| 6 | DBQ aggressive violations | 1.43 | 1.43 | 0.01 | NS |

* Estimated mean values on the dependent variables after taking into account differences between takers and non-takers on the descriptive and the LTDQ reported psychological variables (i.e., the covariates).
† These are the differences after having taken the covariates into account.
NS = not statistically significant at alpha = 0.05.
*n* = 3,003 (539 takers and 2,464 non-takers) in each analysis.

one exception was on the variable ‘aggressive violations’. Pass Plus takers were less likely to report this form of aberrant driver behaviour during the first six months of driving than were non-takers. However, this finding is potentially problematic and could be due to the failure of the present analyses to fully control for volunteer biases. It is highly unlikely that, when delivering Pass Plus, ADIs give messages to drivers that might be expected to reduce this form of driving violation. In fact, if this finding were attributable to taking Pass Plus, the question arises as to why there were no effects on ‘ordinary’ driving violations. More probable is that Pass Plus would have had an influence on other forms of driver behaviour, such as driving errors. This is because ADIs are likely to focus more on skill training rather than higher order cognitions and motivations that influence driving violations (support for this argument can be found in recent attempts to enhance Pass Plus by incorporating theory-based elements that do address driver motivations and attitudes – e.g. Edwards, 2005). However, the present analyses found no differences between Pass Plus takers and non-takers on self-reported driving errors.

Although the present analyses do not present a positive picture for Pass Plus, the results should be treated with caution because of the possible volunteer bias that is associated with this sort of evaluation. With regard to the present findings, it is not known whether volunteer biases would have masked any effects of taking Pass Plus. In other words, it is possible that people who volunteer to take Pass Plus are those who recognise they may need it (e.g. people who chose to take Pass Plus might have been more ‘unsafe’ drivers than non-takers and, therefore, were more likely to have had high accident rates and report aberrant driver behaviours). Conversely, if it was found that there were differences between Pass Plus takers and non-takers, such that takers had fewer accidents or reported committing aberrant driving behaviours less often, then one could not have been entirely confident that Pass Plus was having a road safety benefit. If that result was found, it could also have been attributable to a volunteer bias (e.g. people who chose to take Pass Plus might have been less ‘safe’ drivers than non-takers and, therefore, were less likely to have had high accident rates and report aberrant driver behaviours). Essentially, the problem is that we do not know how volunteers to Pass Plus might have differed from those who did not volunteer to take Pass Plus on the outcome variables of interest. This makes it difficult to interpret any results.

While this issue poses a limitation for the present analyses, the implications for future evaluations of road safety interventions are clear. If evidence is required on the effectiveness of an intervention, that intervention should be properly tested before being rolled out on a national scale (although it is acknowledged that practical considerations sometimes make doing this difficult). For non-mandatory interventions, it is possible to conduct a randomised control trial by asking drivers to volunteer to take part in a research project that involves them undergoing a driver training intervention. Those volunteers can then be randomised to experimental and control conditions. Possible ethical concerns of withholding treatment from participants can be overcome by offering the intervention to control participants after the study window (i.e. after all follow-up measures of outcome variables have been taken). This method will control for volunteer biases and, therefore, will be suitable for assessing the effectiveness of non-mandatory road safety interventions.

With regard to mandatory road safety interventions, it is not entirely appropriate to use the above mentioned design. Instead, a mandatory intervention would need to be evaluated using a sample of drivers that contains not just people who would volunteer to take the training but also people who would not have volunteered. Therefore, when a mandatory intervention is being evaluated, it would be appropriate to introduce the intervention in certain areas first, in which every driver would be required to take the training, before being rolled-out on a national scale. This would allow suitable control areas to be identified in which drivers do not take the training. Baseline and follow-up measures could then be taken from drivers in the experimental and control areas. These measures would be used to evaluate the effectiveness of the intervention. It is again acknowledged that there may be practical considerations that make it difficult to implement this design in practice. However, if appropriate experimental designs are not used, it becomes very difficult to obtain data that can be used to conclusively determine the effectiveness of road safety interventions.

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