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Fourteenth Seminar

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An in-depth case study of motorcycle accidents using police road accident files

DD Clarke, P Ward, W Truman and C Bartle
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This paper reports the findings relating to 1,790 road accidents involving motorcycles (over 1,000 of them in detail) from Midland police forces, along with results of a questionnaire study. Significant differences were discovered with respect to types of accidents involving motorcyclists (and their blameworthiness). There seems to be a particular problem surrounding other road users’ perception of motorcycles, particularly at junctions. Such accidents often seem to involve drivers with relatively high levels of driving experience who nonetheless seem to have problems detecting approaching motorcycles. Motorcyclists themselves seem to have far more problems with other types of accident, such as those on bends, and overtaking or ‘filtering’ accidents. The implications of all these findings are discussed.

Introduction

Though there was a fall in the number of motorcyclist casualties in the early 1980s and mid-1990s, this trend has reversed in more recent years. Possible reasons for this include the increasing sales of mopeds and scooters. Between 2001 and 2002, two-wheeled motor vehicle traffic rose more than other categories, with motorcycle traffic seeing a rise of 5.5% (Department for Transport statistics, 2003). There are also increasing numbers of older motorcyclists returning to the road on fairly powerful machines after a long break; killed and serious injury (KSI) casualties in age groups between 30 and 59 have increased in the last ten years.

Motorcycle accidents have somewhat different characteristics when compared with other vehicle groups. Motorcycles are over-represented in right of way violation accidents, high speed accidents involving running off the road on bends, and accidents that are related specifically to the sort of manoeuvres that motorcycles can perform, e.g. overtaking other traffic without crossing the centre line, or ‘filtering’ between lines of traffic. Perhaps the most widely quoted in-depth U.S. study, by Hurt et al. (1981), highlighted the high frequency of right of way violations and
single vehicle accidents on bends in a sample of over 3,000 motorcycle accidents. Moss (2000) focused attention on rural motorcycle accidents in Cheshire, and found that sports’ bikes, and riders in the 26–40 age group accounted for the majority of rural bend accidents.

Concerning ‘Right of Way Violation’ (ROWV) accidents, the Hurt et al. (op. cit.) study found that, in multiple vehicle accidents, the driver of the other vehicle violated the motorcyclist’s right of way and caused the accident in two thirds of all such accidents. A review by Brown (2002) of work relating to drivers’ ‘looked but failed to see’ accidents, examined some of the psychological processes that might occur in drivers reporting this type of accident. Perception experiments by Mack and Rock (1998) have shown that subjects may be less likely to perceive an object if they are looking at it directly than if it falls outside the centre of the visual field, a phenomenon which they call ‘inattentional blindness’.

Much of the literature suggests that rider attitudes and the perception of the risks involved in motorcycling are the most important consideration when considering to what extent motorcyclists are at risk from injury compared with other road users. Mannering and Grodsky (1995) surveyed motorcyclists’ perceived likelihood of being involved in an accident and concluded that motorcyclists do have a reasonable grasp of factors that can increase the likelihood of accident involvement, highlighting in particular miles ridden, speeding and dangerous overtaking manoeuvres. Their findings suggest that for the most part motorcycle accidents are not the result of misjudgement regarding the overall risk of motorcycling.

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 judgment methodology proves more useful than more traditional statistical methods applied to aggregated data. Full details of our method can be found in previous reports and papers (e.g. Clarke, Ward and Jones, 1998).

The data was entered into a FileMaker Pro database, customised to handle the information and search parameters required for this project. Data is entered describing the relatively objective facts of each case: time of day, speed limit, class of road etc. A ‘prose account’ is also entered for each case giving a step-by-step description of the accident. These accounts give a detailed summary of the available facts, including information from witnesses that appears to be sufficiently reliable. A minimum set of possible explanations for each accident is recorded from a standard checklist adapted and developed from a previous study (Clarke, Ward and Jones, 1998). The ultimate aim of the database was to build a library of analysed cases stored as a series of case studies.

Taking just the most detailed, or ‘A’ class, cases, the next step was to consider simple behavioural countermeasures which could have made a substantial difference to the outcome of each accident in turn, either by preventing it or reducing its severity. A list of 19 possible behavioural strategies for avoiding typical motorcycle accidents
was drawn up using established texts such as *Roadcraft* and *The Highway Code*, together with prior knowledge of the data.

An examination of the attitudes of motorcyclists was the final phase of the research process. A questionnaire was designed, to be completed anonymously by members of the Motorcycle Action Group (MAG), a political pressure group with approximately 45,000 members in the UK. Branch representatives were contacted via email to ask if they would be willing to ask their members to complete the questionnaire. In addition, there was a copy of the questionnaire on the group’s website for riders to complete electronically. A notification of the questionnaire was included in a monthly email sent to all MAG members in summer 2003 alerting them to the questionnaire.

## Results

We have examined 1,790 motorcycle accident files in total, and over 1,000 of these were of the most detailed ‘A’ grade type. Our initial findings were reported in the proceedings of the thirteenth seminar on ‘Behavioural Research in Road Safety’ (Clarke *et al*., 2003).

### Right of way violations

Of the total cases, 681 (38%) involve right of way violations (ROWVs). However, less than 20% of these involve a motorcyclist who rated as either fully or partly to blame for the accident. The majority of motorcycle ROWV accidents have been found to be primarily the fault of other motorists. This is an even higher level of ‘non-blameworthiness’ in ROWV accidents than that observed in other in-depth studies, e.g. Hurt *et al*.* (op. cit.).

The majority of ROWVs occur at T-junctions, which are three times as common as roundabouts or crossroads. This finding is in accordance with the work of Hole *et al.* (1996), who found that the majority of such accidents occurred at ‘uncontrolled’ (i.e. no stop light or sign with only give-way markings and/or signs present) T-junctions in urban environments.

Over 65% of ROWV accidents where the motorcyclist is not regarded as to blame involve a driver who somehow fails to see a motorcyclist who should be in clear view, and indeed frequently *is* in view to witnesses or other road users in the area. Failures of observation that involve drivers failing to take account of restricted views of one kind or another, and failing to judge the approach speed and/or distance of a motorcyclist are *not* included in this category.

### Losing control on bends

Over 15% of total cases involve loss of control on a bend. This type of accident is almost always regarded as primarily the fault of the motorcyclist rather than other road users, and it has already been shown (in our past work) that such accidents are...
more associated with riding for pleasure than accidents of other types. Hurt *et al.* (op. cit.) found that rider error in such cases consisted of ‘slideout and fall due to overbraking, running wide of a curve due to excess speed, or under-cornering’, which seem also to be the most frequent rider errors in bend accidents in this sample.

Riders having this type of accident are nearly three times as likely (compared with the whole sample) to be rated as ‘inexperienced’ riders by researchers. Though excessive speed is implicated in a large proportion of cases, there are also a number of cases where there seems no evidence of any failure except ones relating to lack of experience.

The riders in this ‘going out of control’ category seem to fall into two groups. There are those riders who have a full motorcycle licence, but perhaps either have not held it for a long time, or have returned to motorcycling after passing a test some years ago (so called ‘born again’ bikers). The mean age of all these riders considered together is 29.7 (sd 10.3), and of those cases with licence records available, they have a lower mean number of years’ experience (5.3 years of full licensure) than the equivalent group derived from the sample by excluding ‘going out of control’ accidents (7.2 years of full licensure). Nearly one third of the accidents in the 31–35-year-old age-range where the rider is considered at least partly to blame involve going out of control on a bend.

Then there is a group of riders who either have only a provisional licence, or sometimes, no licence at all, who can be regarded as perhaps the least experienced riders in the whole sample. The mean age of this group is 22.6 (sd 8.8). The latter group has approximately twice the proportion of fatalities found in the former group (though caution must be exercised in the interpretation of these findings, as frequencies are quite low). Again, 20% of the accidents in the 16–20-year-old age-range where the rider is considered at least partly to blame involve going out of control on a bend.

**Motorcycle manoeuvrability accidents**

We have identified a sub-group of the sample cases that comprise accidents specifically related to the way motorcyclists are able to manoeuvre their vehicles in ways that are frequently not appreciated by other motorists.

If all accident cases where the rider is judged either fully or partly to blame are examined (*n* = 919), 16.5% involve a motorcyclist overtaking other vehicles and causing an accident. These riders have a tendency to be slightly younger than the rest of the sample, and the indications are that they have a tendency to be riding machines of a higher engine-capacity than other accident-involved drivers (mean cubic centimetres of capacity = 507, as opposed to 431 for riders to blame/partly to blame in other types of accident).

However, motorcycle accidents also occur when riders are given the opportunity to pass slow-moving or stationary traffic, which is often referred to as ‘filtering’. Though only slightly more than 5% of the whole sample identifiably involve a rider filtering, other drivers are more than twice as likely to be considered at fault in such accidents as the motorcyclists involved, though there is also evidence for an
increased proportion of ‘combined fault’ accidents in this category. It seems that motorcyclists are, as it were, ‘subverting’ other drivers’ expectations of how traffic behaves, in some cases. A typical driver quote from such an accident is: ‘There could be nothing coming from behind me because the car and lorry to my rear were stationary.’

**Questionnaire results**

Some of the findings that have emerged from the questionnaire survey are now considered. These results will be considered alongside results from the motorcycle accident database.

The total number of questionnaires returned was 147. Due to the distribution method it is impossible to know exactly how many people actually saw the questionnaire so the proportion of questionnaires returned cannot be calculated. The questionnaire respondents appeared to be very experienced road users. The majority (63.3%, \( n = 147 \)) of the riders rode in excess of 5,000 miles per year and all but four of the respondents were regular users of other vehicles.

Riders were encouraged to comment on their riding habits. Speeding was found to be common among the respondents with 58% (\( n = 143 \)) admitting to always, or frequently, breaking the speed limit. The remaining respondents admitted to ‘occasionally’ breaking the speed limit but only when they thought it was safe to do so. Travelling in excess of the speed limit was considered to be a contributory factor in just 3.5% of accidents on the motorcycle accident database. Of these 62% were a result of the motorcyclist speeding. Misjudging or negotiating the correct speed for conditions however, accounted for a further 5.6% of accidents where the speed limit itself was not broken. Speeding whether in excess of the speed limit or travelling too fast for the conditions was therefore a factor in a total of 9.2% of accidents on the motorcycle accident database.

The respondents also admitted to frequently speeding while overtaking other road users with 38.6% (\( n = 145 \)) of the respondents claiming to regularly pass vehicles travelling ‘at or above the speed limit’. Only 9.7% of the respondents claimed to never pass a vehicle travelling at or above the speed limit. Just under half of the respondents regularly passed two or more vehicles at the same time while overtaking, with only 3.4% (\( n = 145 \)) of the respondents claiming never to have done this. Overtaking accidents only account for a total of 6.6% of motorcycle accidents held on the motorcycle accident database and only a quarter of these were the fault of the rider.

The motorcycle accident database has shown that the most common cause of single vehicle accidents is as a result of riders misjudging the speed needed to negotiate a bend in the road. A question was therefore included on the questionnaire asking the respondents how often, if ever, they have misjudged the speed required to negotiate a bend in the road. Even though 69% of respondents appeared to be very experienced, they admitted to occasionally miscalculating bends. There were over 200 accidents on the motorcycle accident database that were a direct result of a rider losing control on a bend in the road and although the reasons for losing control were often unknown or not recorded, it is known that excess speed was the main cause of 27.5% of the accidents.
A total of 141 respondents to the questionnaire listed what they considered to be the three main causes of motorcycle accidents. There were five broad categories that focused on poor observation and inattention, environmental concerns, inexperience, risk-taking and poor training. A direct comparison of perceived and actual causes of motorcycle accidents (as revealed by the accident database) can therefore be shown in Figure 1 below.

![Bar graph showing the perceived and actual causes of motorcycle accidents](image)

Poor observation and/or inattention was the most common cause of motorcycle accidents given by the respondents to the questionnaire as well as being the most common actual cause shown on the motorcycle accident database. The questionnaire respondents clearly stated that it was not poor observation on the part of the motorcyclist but specifically on the part of other road users with 43% \((n = 141)\) of the respondents saying that one of the main causes of motorcycle accidents was ‘other road users failing to see riders’.

The specific reasons given by the respondents in this category included other motorists’ inattention, motorists changing lanes without looking properly and motorists being distracted while in their vehicles by passengers, mobile phones etc. ‘No continuity of observation’ was the biggest cause of accidents; that reason alone being the cause of over a third of all motorcycle accidents in the database.

Another major cause of accidents was, perhaps surprisingly, seen by the questionnaire respondents as being the fault of the motorcyclists as opposed to other road users, and concerned accidents that were as a result of deliberate risk-taking by the riders. 14.7% of the responses \((n = 361)\) referred to causes that were as a result of deliberate risk-taking with just under a tenth of the respondents \((9.9%, n = 141)\) simply stating that it was riders taking unnecessary risks that caused motorcycle accidents. A quarter of all respondents \((25.5%, n = 141)\) said that riding bikes ‘too fast for conditions’ was a major cause of accidents. The emphasis being placed on riding too fast for conditions and not necessarily breaking the speed limit.

Risk-taking was found to account for 20.8% of the causes listed on the motorcycle accident database and of these causes 12.9% were as a result of the motorcyclist...
taking risks and 4.69% were as a result of other road users taking risks. Factors included within this category included all actions that could be seen as putting the rider or other road users at risk. These included travelling at excess speed for conditions, driving recklessly, driving while tired or under the influence of alcohol, disobeying road signals and specific manoeuvres such as overtaking in inappropriate situations or close following.

Figure 2 shows which category of road user the questionnaire respondents thought were the main cause of motorcycle accidents.

![Pie chart showing the category of road users the questionnaire respondents thought were most likely to cause a motorcycle accident](image)

Just under 80% of the respondents thought that car drivers were primarily to blame for accidents involving motorcycles. Cyclists, large commercial vehicles, pedestrians and animals in the road were each only mentioned once.

The motorcycle accident database recorded who was to blame for the 1,790 accidents splitting the accidents into five main categories. Rider 1 was the motorcyclist involved in the accident. Driver 2 was the second vehicle involved in the accident. The third category was where a pedestrian was to blame. The remaining two categories were joint/combined blame and the final category, other/unknown. The split can be seen in Table 1 below:

<table>
<thead>
<tr>
<th>Primary blame</th>
<th>Number of accidents</th>
<th>Percentage total (n = 1790)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rider 1</td>
<td>754</td>
<td>42.1</td>
</tr>
<tr>
<td>Driver 2</td>
<td>788</td>
<td>44.0</td>
</tr>
<tr>
<td>Pedestrian</td>
<td>35</td>
<td>1.9</td>
</tr>
<tr>
<td>Unclear/combined</td>
<td>165</td>
<td>9.2</td>
</tr>
<tr>
<td>Other/unknown</td>
<td>48</td>
<td>2.7</td>
</tr>
</tbody>
</table>

The table shows an even split of responsibility for accidents with driver 2 and rider 1 to blame in around 40% of the accidents respectively. However, just under a third of
Driver 2 is now clearly shown as being responsible for over 50% of accidents involving two or more vehicles.

There appears to be a fairly even spread of opinion about the riskiness of some types of accidents. In the case of collisions while overtaking, loss of control and overshooting bends, similar proportions of respondents saw these accident types as ones in which riders were most at risk, as respondents who saw them as being least risky. However, respondents clearly saw riders as being especially vulnerable to collisions with right-turning vehicles and least at risk from being hit from behind by a vehicle (rear end shunt).

### Countermeasures

<table>
<thead>
<tr>
<th>Countermeasure</th>
<th>All motorcyclists</th>
<th>All other riders/riders</th>
<th>Riders &lt;25 years</th>
<th>Riders 25 years +</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vision</td>
<td>2.2</td>
<td>25.4</td>
<td>3.42</td>
<td>1.3</td>
</tr>
<tr>
<td>2 Stop at junction</td>
<td>1.3</td>
<td>4.9</td>
<td>1.28</td>
<td>1.3</td>
</tr>
<tr>
<td>3 Right re-check</td>
<td>–</td>
<td>4.8</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>4 O/C speed check</td>
<td>0.7</td>
<td>3.0</td>
<td>0.85</td>
<td>0.3</td>
</tr>
<tr>
<td>5 Speed check/junction</td>
<td>9.9</td>
<td>0.2</td>
<td>11.1</td>
<td>8.6</td>
</tr>
<tr>
<td>6 M/c position</td>
<td>5.8</td>
<td>–</td>
<td>5.13</td>
<td>6.0</td>
</tr>
<tr>
<td>7 Safe distance</td>
<td>8.8</td>
<td>3.7</td>
<td>11.5</td>
<td>7.3</td>
</tr>
<tr>
<td>8 Distraction</td>
<td>7.3</td>
<td>2.3</td>
<td>9.4</td>
<td>5.6</td>
</tr>
<tr>
<td>9 Look ahead</td>
<td>0.9</td>
<td>0.2</td>
<td>0.43</td>
<td>1.3</td>
</tr>
<tr>
<td>10 Speed for conditions</td>
<td>19.0</td>
<td>0.5</td>
<td>20.5</td>
<td>17.9</td>
</tr>
<tr>
<td>11 Speed for bend</td>
<td>14.7</td>
<td>0.9</td>
<td>11.54</td>
<td>16.3</td>
</tr>
<tr>
<td>12 Position on bend</td>
<td>3.2</td>
<td>0.2</td>
<td>2.5</td>
<td>2.0</td>
</tr>
<tr>
<td>13 Brake on bend</td>
<td>0.7</td>
<td>–</td>
<td>–</td>
<td>1.3</td>
</tr>
<tr>
<td>14 Mirrors &amp; blind spot</td>
<td>0.6</td>
<td>21.0</td>
<td>0.85</td>
<td>0.3</td>
</tr>
<tr>
<td>15 Indication</td>
<td>0.6</td>
<td>4.0</td>
<td>0.43</td>
<td>0.7</td>
</tr>
<tr>
<td>16 O/T at junction</td>
<td>16.4</td>
<td>1.1</td>
<td>12.0</td>
<td>19.9</td>
</tr>
<tr>
<td>17 White line cross</td>
<td>0.6</td>
<td>0.4</td>
<td>0.43</td>
<td>0.7</td>
</tr>
<tr>
<td>18 Filtering caution</td>
<td>7.3</td>
<td>0.2</td>
<td>6.8</td>
<td>7.6</td>
</tr>
<tr>
<td>19 Speed – O/Ts</td>
<td>1.3</td>
<td>0.5</td>
<td>1.3</td>
<td>1.3</td>
</tr>
</tbody>
</table>
(Figures indicate the percentage of all cases involving that type of driver/rider where one or more countermeasures were judged to have been applicable. Countermeasures are not mutually exclusive.)

The next two figures (3 and 4) show how these countermeasures, considered *cumulatively*, could prevent large proportions of all motorcycle accidents. The top two or three countermeasures can affect a large proportion of the accidents under consideration. Three simple countermeasures covered nearly 50% of the cases where it was felt that a rider could have done anything to avoid the accident, and two main countermeasures covered nearly the same proportion in the case of the behaviour of other drivers involved in motorcycle accidents.

The overriding message to motorcyclists is that they must slow down, not merely in relation to mandatory limits, but also in consideration of various normal road hazards, particularly bends. In addition, they must avoid overtaking slower-moving vehicles in the vicinity of junctions, even if the traffic is stationary and they are ‘filtering’ past it.

The overriding message to other drivers is that they must look more carefully for approaching motorcycles at junctions of all types, and also make careful rear observations, including the use of side mirrors and ‘blind spot’ checks, before many manoeuvres.
Discussion

It is clear from this research that any initiatives in motorcycle safety should address the behaviours of both motorcycle riders and other road users. Overall, motorcyclists have been found to blame (or at least partly to blame) in around half of all the accidents they become involved in, so any countermeasures should be targeted equally at riders and other road users.

‘Right of way’ accidents

In right of way violation (ROWV) accidents in particular, there is a marked problem with other road users observing motorcyclists. This is commonly referred to as ‘Looked But Did Not See’ (LBDNS), in a review of work by Brown (op. cit.), for example.

The phenomenon whereby drivers overlook a motorcyclist in the immediate foreground seems to be in agreement with the work of Mack and Rock (op. cit.), whose theory of ‘inattentional blindness’ showed that subjects may be less likely to perceive an object if they are looking at it directly than if it falls outside the centre of the visual field. ‘Inattentational blindness’ is suggested by research to be affected by four main factors: conspicuity, expectation, mental workload, and capacity. Some results would seem to permit the discussion of conspicuity and expectation. The fact that many motorcyclists in our sample appear to be trying to make themselves more

![Figure 4: Histogram showing the top two measures that could be taken by other drivers to alter the outcome or likelihood of an accident as a cumulative percentage of cases](image-url)
conspicuous but are not seen, nevertheless lends credence to the idea that there is something amiss in the cognitive processes of the other involved driver.

The ‘expectation’ factor, in particular, raises the possibility that some road users have a poor perceptual ‘schema’ for motorcycles in the traffic scene, and therefore do not process the information fast enough when motorcyclists are observed. Green (2002) comments that, ‘It is one of the ironies of inattentional blindness that highly skilled and highly practiced ‘experts’ are more susceptible than are beginners. In fact, when we say someone is skilled and experienced, we usually mean that he has developed expectations which allow fast and accurate prediction and behavior.’ If this was so, it would be expected that drivers at fault in ROWV accidents involving motorcyclists as innocent parties might be, on average, older than an equivalent group of drivers at fault in non-ROWV accidents with motorcyclists. Our research shows this to be the case; the average age of drivers in ‘at fault’ ROWV accidents involving motorcycles, 41 years, is significantly higher than the equivalent group in non-ROWV accidents, 36 years ($t = 3.45, p < 0.05$).

For right of way accidents that involve other drivers pulling out in front of motorcyclists who are perhaps further away, it could also be that more global visual failings are contributing to the age effect outlined in the previous paragraph, and detailed in Figure 5, below. When ratios of LBDNS accidents against other

![Figure 5](image-url)
non-ROWV ‘at fault’ accidents for involved drivers in the sample are examined, it can be seen that the proportion of this visual error compared with other ‘at fault’ errors rises with age. The change in ratio occurs at too greater an age (65’ years plus) to be related purely to driver skill factors, and suggests an age-related deficit. The scatter plot in Figure 5 shows this, but ratio plots comparing LBDNS with other types of visual and non-visual errors that have been produced from the data do not show any significant rise with age.

Reasons for such an increase in global visual failings with age are many. Isler et al. (1997) found, in an analysis of the effect of reduced head movement and other deteriorations in the visual system on the useful field of view for the drivers aged 60 years’ plus, 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. Isler et al. also point out the large numbers of visual deficits, such as scotoma, that occur naturally with ageing, and which may not be appreciated by the driver due to their gradual onset. Figure 5 appears to show some evidence of increasing global visual failures with age. Drivers with ‘at fault’ accidents that might be said to have less of a visual search component (or at least, a very different search component), such as overtaking accidents, have not been found to show the same general increase with age in our analysis.

Two possible explanations therefore exist for ‘looked but did not see’ accidents involving motorcycles, both of which would appear to affect older drivers more than younger ones. This is an area of potential concern due to ageing population demographics throughout the UK and the greater European Union. In any case, past safety campaigns that put the emphasis on other drivers to be more vigilant regarding motorcycles (e.g. ‘Think Bike’) would seem as relevant as ever.

**Bend accidents**

Bend accidents are a particular area of concern as our analysis shows that they are over twice as likely to cause a rider or pillion’s death when compared with the sample as a whole, and over one-and-a-half times more likely to cause serious injuries. This seems to be linked with more than one type of inexperience. Young riders with no licence, or only a provisional licence seem to lack the skills needed, and to take more risks, which contributes to their increased likelihood of this type of accident.

In contrast there is some evidence that an older ‘born again biker’ subgroup seem to be mismatching the performance of new machines with their own previously learned abilities. If motorcycle category is examined (using Motorcycle Industry Association definitions), it is shown that over 40% of ‘super-sport’ bike riders at fault in the sample come to grief on bends. This is over twice the proportion of ‘at fault’ bend accidents found with all other types of machine, and ‘super-sport’ bikes are over-represented in ‘at fault’ bend accidents relative to their numbers in the sample as a whole. Riders in this category are more likely than others to be travelling at speed, riding for leisure purposes, and riding in groups with other riders. Moss (op. cit.), in his report on rural motorcycle accidents, was more specific regarding the type of behaviour these riders are exhibiting, saying that ‘…riders are failing to ride their...
machines within their personal capabilities even though the bike itself may have been well within its performance envelope at the time of the crash…riders had either braked or shut their throttles mid-bend, resulting in understeer crashes.’

Possible solutions to at least one of these forms of inexperience-based bend accident may include more advanced rider training in such areas as the use of so-called ‘countersteering’. A skill that has only become widely recognised relatively recently, countersteering is the technique of using gyroscopic precession to cause the motorcycle to change direction quickly and accurately. However, skill-based interventions in training have a somewhat mixed track record. An ‘assessed riding’ course offered by Bikesafe in Scotland (Ormston, op. cit.) found that motorcyclists’ reported speeds fell in urban areas after the completion of the course, but rose in rural areas (where most serious and fatal bend accidents occur), possibly as a result of rider over-confidence post-course.

Motorcycle manoeuvrability accidents

The high speed, acceleration and manoeuvrability of motorcycles cause further accident risk. Riders, particularly younger riders on high-capacity machines, can be presented with overtaking opportunities that they find hard to resist. Riders of ‘super-sport’ classed motorcycles who are aged under 25 have approximately a third more overtaking accidents in which they are at fault than do riders of similar machines who are over 25 years of age.

Other drivers on the road often fail to take account of the fact that much smaller vehicles can overtake or pass their own where cars or lorries might not be able to. Accordingly, they completely fail to take into account the possible approach of motorcyclists and thus further contribute to the risk of an accident. Drivers need to be made more aware that motorcycles can be approaching from unexpected directions, perhaps through advertising campaigns such as the recent ‘Now You See Him, Now You Don’t!’ advert, part of the Department for Transport’s ‘THINK!’ campaign.

Riders’ attitudes

There were many causes of motorcycle accidents given on the motorcycle accident database that involved an element of risk-taking. The most interesting finding was that a quarter of the respondents (25.5%, n = 141) thought a major cause of motorcycle accidents was riders riding too fast for conditions. Despite this, however, 58% (n = 143) of the respondents admitted to always or frequently breaking the speed limit with the remaining occasionally doing so. The riders therefore made a clear distinction between breaking the speed limit and driving at speeds that are too fast for conditions (but not necessarily breaking the speed limit). One of the respondents to the questionnaire who wished to remain anonymous attached a letter to their questionnaire, summarising the feelings of many riders:

‘I find that the speed limits set are often completely inappropriate depending on the circumstances…I would consider riding at 30mph past a school when the children are leaving as being far too fast but on the other hand what possible danger could result from travelling along an open stretch of motorway at 11pm at night without another vehicle in sight at 80 or even 90mph?’
An examination of the causes on the motorcycle accident database would seem to indicate that the respondents may have a point, as travelling in *excess of the speed limit* was only a causation factor in a minority of accidents on the accident database, though travelling *too fast for conditions* accounted for a greater number of accidents. The figures would suggest therefore that the riders are correct in making this distinction.

Overtaking in risky situations was a further cause for concern and overtaking accidents accounted for 260 out of the 1,790 on the motorcycle accident database. The questionnaire respondents admitted to regularly passing vehicles, sometimes two or more at the same time, and it is reasonable to assume that motorcyclists have the opportunity to pass other vehicles more often than drivers of other vehicles due to the size and power of their machines. Despite this, only a quarter of the overtaking accidents where blame was known were the fault of the motorcyclist, which would indicate that riders have a good knowledge of the risks associated with overtaking.

Finally it is important to note that the literature suggests that age is the most important factor in risk-taking. Rutter and Quine (1996) and Keskinen *et al.* (1998) both emphasised the importance of age over actual experience stating that young riders are far more likely to be involved in motorcycle accidents. Our research appears to support this as the motorcycle accident database shows a steady reduction in the numbers of accidents as the age of the riders involved increases from 35 years of age upwards. Rutter and Quine stressed the importance of making young riders aware of the consequences of dangerous riding. The evidence presented here indicates that a further study focusing exclusively on the attitudes and beliefs of younger riders should be beneficial in helping to understand why this age group is so at risk or prone to risk-taking.

**Conclusions**

The accident database in combination with the rider questionnaire showed that rider skills, while seeming proficient in certain areas were also found to be lacking in others. The project has successfully highlighted several of these areas and further examination of the cornering techniques of the riders, the ability of riders to plan ahead and the importance of riding within an individual’s ability would all be beneficial to motorcyclists. As far as other (particularly older) road users are concerned, drivers have to be made aware of the numerous ways that they can fail to perceive a motorcycle in the typical ‘right of way’ violation accidents that are most frequently not the fault of the rider involved.

What is needed is an approach that targets both the problems of other driver in ‘right of way’ collisions, and further initiatives focusing on motorcyclists’ specific problem areas. Initiatives such as Bikesafe in Scotland, described by Ormston *et al.* (2003) have reportedly had some success in using ‘assessed ride’ techniques to teach vulnerable motorcyclist groups more defensive riding techniques. However, while this leads to an apparently favourable adoption of lower speeds in built-up areas, it can increase motorcyclists’ confidence and thus their likelihood of adopting faster speeds in rural areas. As a large proportion of serious and fatal accidents happen in rural areas, it is far from clear that increasing motorcyclists’ confidence in this area
would be productive. An approach is therefore clearly needed that targets riders’ attitudes to risk, as well as the effective measures that can be taken in the area of defensive riding skills. The results of this study suggest that, as far as motorcyclists’ specific problems are concerned, there are two main groups of riders that should be concentrated on using such an approach. The first is young and inexperienced riders of smaller capacity machines such as scooters (which experienced a sales increase of 16% last year); and the second is older, more experienced riders of higher capacity machines (which now account for around half of all motorcycles registered today), who still come to grief even though they are relatively experienced road users.

References


Isler, RB, Parsonson, BS and Hansson, GJ (1997). Age-Related Effects of Restrictive Head Movements on the Useful Field of View of Drivers. Accident Analysis and Prevention, 29 (6), 793–801.


2

Motorcyclists’ accident risk: results from a new survey

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Introduction

Motorcyclists are more at risk of being killed or injured in a road traffic accident than any other type of vehicle user. In 2001 there were over 580 motorcycle riders or passengers killed in road accidents, 7,305 killed or seriously injured (KSI) and over 28,800 involved in reported injury accidents (all severities).

The trends in motorcyclist injury accidents over the last decade or so are shown in Figure 1. After a substantial fall during the early 1990s, total casualties and killed and seriously injured (KSI) casualties started to rise again in the later years of the decade.

![Figure 1: Number of casualties involving motorcyclists (and pillions)](image)

Figure 2 shows how the numbers of licensed motorcycles have changed since 1988. The total number of machines rose faster after the mid-1990s than the number of
casualties, such that size of the motorcycle fleet in 2001 had increased to its 1989 level. The trend towards machines of over 500cc engine capacity is also apparent.

![Figure 2 Number of motorcycles currently registered by engine capacity](image)

Source: Transport Statistics GB, 2002

Figure 3 shows the changes in casualty rates per 100 million km during the period. After a fall in 1991 the rates for all casualties, and for KSI casualties, remained fairly stable.

![Figure 3 Rate of killed or seriously injured and all casualties per 100 million km](image)

Trends in the age of motorcycle casualties are shown in Figure 4. During the first half of the decade there was a substantial fall in the number of young riders (aged 16–24 years) being killed or seriously injured. However, for the 25–59 age group there was a steady rise in KSI numbers throughout most of the decade.

Although published statistics do not show how far this trend is consistent with changes in numbers and exposure of motorcyclists of different ages, there have
certainly been substantial shifts in the age distribution of riders. For example, in an earlier survey of motorcyclists (Taylor and Lockwood, 1990) about 15% of respondents were aged less than 20 years. The survey reported here had only 4% of respondents under 20 years of age.

The foregoing suggests that recent trends in motorcycle casualties can be broadly explained in terms of changes in numbers of motorcycles, and the mileage that they cover. The rising trend in motorcycle casualties since 1996 does not, in itself, indicate the emergence of new or previously unrecognised risk factors for motorcyclists. Nevertheless it is highly desirable to find ways of improving motorcyclists’ safety — and to do this an understanding of the factors underlying motorcyclists’ accident risk is needed. Such factors potentially include the age and experience of the rider, ‘rider type’, attitudes, motivations, riding style, skills, and behaviours such as errors and violations. The survey described in the remainder of this paper was commissioned by Road Safety Division, Department for Transport, to provide further insight into many of these issues with a view to identifying measures that will improve motorcycle safety. The full study is reported by Sexton et al. (2004).

The survey

The sample

The issued sample consisted of approximately 28,400 registered keepers of privately-owned motorcycles that had been taxed during the previous 12 months, selected at random from the DVLA database. Questionnaires were posted during the last two weeks of June 2002. A reminder was issued after one month, and the survey closed in early September. 11,360 people returned a questionnaire — a response rate of 40%.
The questionnaire

Focus groups of motorcycle riders helped to develop the questionnaire, which was then piloted using a postal survey of about 1,000 motorcyclists sampled at random by DVLA. Questionnaire coverage was guided by the model of motorcycle accident liability shown in Figure 5.

The dotted line joining the descriptive variables to the attitudes/motivations/perceptions’ box represents correlations. Link L2 is shown as a broken line because it was allowed to be present in one version of the model ‘Model I’. The other version, ‘Model II’, assumed that age and experience do not influence accidents directly, but only through the mechanism of an attitude, motivation and/or behaviour (i.e. the L2 link is omitted).

Behaviours, motivations and riding style were covered in the questionnaire by three multi-item instruments:

(a) A motorcycle rider behaviour questionnaire (MRBQ) required respondents to rate how often they engage in certain behaviours while riding a motorbike. The MRBQ was based on the driver behaviour questionnaire (DBQ) developed at Manchester University (Reason et al., 1990); items from the original 50-item DBQ pool being deleted, modified or added to make the pool appropriate for motorcycling. Following factor analysis of the pilot survey data, 43 items were retained for the main questionnaire, loading onto five underlying factors as follows:

- Traffic errors — e.g. attempting to overtake someone you had not noticed to be signalling a right turn; failing to notice pedestrians crossing when turning into a side street.
- Control errors — e.g. running wide when going round a corner; having difficulty controlling the bike at speed; braking or throttling back when going round a bend.
- Speed — e.g. exceeding speed limits; opening up the throttle and just going for it on country roads. This variable is called ‘Speed1’ in the tables to follow.
- Stunts — e.g. doing wheelies or wheelspins.
• Safety equipment — mainly to do with wearing protective clothing, but including items on use of dipped headlights and having bright or fluorescent strips on clothing.

(b) A motorcycle rider motivation questionnaire (MRMQ) required respondents to rate, on a five point scale, how strongly they agreed or disagreed with statements about motorcycling. The starting point for developing the MRMQ was a 57 item questionnaire reported by Brendicke (1991). Further items were added to the pool for the pilot survey. Factor analysis of the pilot survey data identified three underlying factors (pleasure motives, speed motives and convenience/economic motives). 24 items to measure these factors were retained for the main questionnaire.

(c) A riding style scale based on the driving style scale reported by Guppy et al. (1989), but worded in terms of motorcycle riding as opposed to car driving. It required respondents to rate their own riding style on twelve, seven-point semantic differential scales. This produced the usual three factors:

• careful, safe, responsible, attentive vs. the opposite;
• tolerant, patient, considerate, placid vs. the opposite; and
• decisive, confident, fast, experienced vs. the opposite.

Modelling the survey data

Modelling methods

An important focus of the project was to identify factors influencing motorcycle accident risk so that they can be used (a) to help explain trends in accident numbers and (b) to help identify priorities for remedial measures. To accomplish this, given the interrelationships between the possible explanatory variables, multivariate analysis was needed. Two approaches were taken: first, the generalised linear modelling method used extensively in earlier studies was used to investigate the relations between accidents and variables such as rider age, experience, exposure, and bike size. Secondly, a hybrid approach, combining elements of structural equation modelling, factor analysis and generalised linear modelling was used to provide an insight into the contribution of rider-centred variables (attitudes, motivations, behaviours) to accident risk.

Generalised linear modelling of age, experience, mileage, training, bike size and ‘rider dedication’ as risk factors

In previous TRL studies of accident liability (Taylor & Lockwood, 1990; Maycock et al., 1991; Maycock & Forsyth, 1997) a multiplicative model of the following form
was found to be suitable:

\[
\text{Log}_e (\text{accident liability}) = b_0 + b_1 \log_e (\text{miles}) + b_2 f(\text{age}) + b_3 f(\text{experience}) + b_4 f(\text{other factors}) + \cdots + \text{error}
\]

Where \(b_0, b_1, b_2\) etc are coefficients to be estimated and ‘error’ is the residual error that is not accounted for by the fitted model.

Reciprocal age and experience functions were found to be appropriate in previous studies (Taylor & Lockwood, 1990), and were again used in this analysis.

One of the ‘other factors’ included in the model was a ‘rider dedication’ variable, constructed by classifying riders according to whether (at one extreme) they rode all year and in all conditions or (at the other extreme) they rode only monthly, in summer, and avoiding wet or dark conditions. Six categories were used altogether, as shown in Table 1.

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of riding</th>
<th>Number of riders</th>
<th>%</th>
<th>Average mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ride at least daily or weekly in the wet and/or dark during winter, i.e. ride in all conditions</td>
<td>5,154</td>
<td>45%</td>
<td>6,070</td>
</tr>
<tr>
<td>2</td>
<td>Ride at least daily or weekly during the winter but not in the dark or wet</td>
<td>877</td>
<td>8%</td>
<td>4,300</td>
</tr>
<tr>
<td>3</td>
<td>Ride in all conditions during the summer months but not ride in the winter</td>
<td>3,405</td>
<td>30%</td>
<td>3,690</td>
</tr>
<tr>
<td>4</td>
<td>Ride daily during the summer, but not ride in the wet or dark or during the winter</td>
<td>64</td>
<td>&lt;1%</td>
<td>1,980</td>
</tr>
<tr>
<td>5</td>
<td>Ride weekly during the summer, but not ride in the wet or dark or during the winter</td>
<td>520</td>
<td>5%</td>
<td>2,330</td>
</tr>
<tr>
<td>6</td>
<td>Ride monthly during the summer, but not ride in the wet or dark or during the winter</td>
<td>462</td>
<td>4%</td>
<td>2,050</td>
</tr>
<tr>
<td></td>
<td>Not definable or not known</td>
<td>878</td>
<td>8%</td>
<td>2,630</td>
</tr>
</tbody>
</table>

Table 2 shows the model fitted to the survey data. In addition to annual mileage, age and experience, the model includes two-level categorical variables for training and bike size, and the six-level categorical variable for rider dedication. For these categorical variables, one of the levels is taken to be a reference and the coefficients then quantify the differences between the other levels and the reference level.

The model in the table does not include the sex of the rider nor does it include a variable corresponding to ‘taken a break from riding’ because neither of these was statistically significant\(^1\).

The table also shows the z-statistic (the coefficient’s value divided by its standard error) which is a convenient way of assessing the statistical significance of individual coefficients, \(z\)-values greater than 1.96 being statistically significant at the \(p = .05\) level. Deviance difference (which applies to complete terms, not

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\(^1\) The training term was retained in the table because it approaches statistical significance, and is of interest for discussion.
necessarily to the individual coefficients of a category variable) is also given. If the deviance difference is greater than 3.84 for 1df (degree of freedom) or 11.07 for 5df, then there is a 95% chance or better that the variable is contributing to the explanation of some of the variation between observations.

### Relationships between behaviour and accidents

Generalised linear modelling was used to examine links L1, L2 and L5 in Figure 5.

Separate analyses were conducted for three overlapping classes of accident as the dependent variable:

- the total number of accidents that a rider reported being involved in during the past 12 months;
- non-minor accidents (i.e. all accidents that were not classified by the respondent as a ‘minor spill’ or a ‘low speed manoeuvring accident’); and
- all accidents where the rider accepted some blame.

Tables 3a to c show the estimated parameters for the links between accidents and the five behaviour factors, age, experience and mileage. Six sets of results are shown — i.e. for Models I and II applied to each of the three categories of accidents.
### Table 3a Parameter estimates for links L1, L2 and L5 between accidents and background or behaviour factors (all accidents)

<table>
<thead>
<tr>
<th>Behaviour or descriptive variable</th>
<th>Model I — All accidents</th>
<th>Model II — All accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>estimate</td>
<td>s.e.</td>
</tr>
<tr>
<td>TRAFFIC ERRORS</td>
<td>0.80</td>
<td>0.20</td>
</tr>
<tr>
<td>CONTROL ERRORS</td>
<td>0.22</td>
<td>0.19</td>
</tr>
<tr>
<td>SPEED1</td>
<td>0.12</td>
<td>0.09</td>
</tr>
<tr>
<td>STUNT</td>
<td>0.14</td>
<td>0.10</td>
</tr>
<tr>
<td>SAFETY EQUIPMENT</td>
<td>0.002</td>
<td>0.061</td>
</tr>
<tr>
<td>IAGE (1/(age + 9))</td>
<td>53.55</td>
<td>7.06</td>
</tr>
<tr>
<td>IXPER (1/(experience + 6))</td>
<td>7.59</td>
<td>1.07</td>
</tr>
<tr>
<td>LMILES (log of miles)</td>
<td>0.50</td>
<td>0.04</td>
</tr>
</tbody>
</table>

### Table 3b Parameter estimates for links L1, L2 and L5 between accidents and background or behaviour factors (accidents where rider accepts some blame)

<table>
<thead>
<tr>
<th>Behaviour or descriptive variable</th>
<th>Model I — Rider accepts blame</th>
<th>Model II — Rider accepts blame</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>estimate</td>
<td>s.e.</td>
</tr>
<tr>
<td>TRAFFIC ERRORS</td>
<td>1.04</td>
<td>0.26</td>
</tr>
<tr>
<td>CONTROL ERRORS</td>
<td>0.59</td>
<td>0.24</td>
</tr>
<tr>
<td>SPEED1</td>
<td>0.30</td>
<td>0.12</td>
</tr>
<tr>
<td>STUNT</td>
<td>0.002</td>
<td>0.124</td>
</tr>
<tr>
<td>SAFETY EQUIPMENT</td>
<td>0.09</td>
<td>0.08</td>
</tr>
<tr>
<td>IAGE (1/(age + 9))</td>
<td>41.56</td>
<td>9.462</td>
</tr>
<tr>
<td>IXPER (1/(experience + 6))</td>
<td>9.65</td>
<td>1.47</td>
</tr>
<tr>
<td>LMILES (log of miles)</td>
<td>0.40</td>
<td>0.06</td>
</tr>
</tbody>
</table>

### Table 3c Parameter estimates for links L1, L2 and L5 between accidents and background or behaviour factors (non-minor accidents)

<table>
<thead>
<tr>
<th>Behaviour or descriptive variable</th>
<th>Model I — Non-minor accidents</th>
<th>Model II — Non-minor accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>estimate</td>
<td>s.e.</td>
</tr>
<tr>
<td>TRAFFIC ERRORS</td>
<td>1.80</td>
<td>0.49</td>
</tr>
<tr>
<td>CONTROL ERRORS</td>
<td>0.29</td>
<td>0.48</td>
</tr>
<tr>
<td>SPEED1</td>
<td>0.29</td>
<td>0.22</td>
</tr>
<tr>
<td>STUNT</td>
<td>−0.11</td>
<td>0.15</td>
</tr>
<tr>
<td>SAFETY EQUIPMENT</td>
<td>0.66</td>
<td>17.74</td>
</tr>
<tr>
<td>IAGE (1/(age + 9))</td>
<td>4.66</td>
<td>2.74</td>
</tr>
<tr>
<td>LMILES (log of miles)</td>
<td>0.77</td>
<td>0.11</td>
</tr>
</tbody>
</table>

### Links between motivations and behaviour

Table 4 shows the links between behaviour and motivations/attitudes derived by fitting a path analysis model. The parameter estimates are given as ‘standardised’ coefficients — i.e. the coefficients have been adjusted in relation to the absolute scales of the variables so that they give an unbiased assessment of the relative magnitudes of the strengths of the various effects in the model: standardised regression coefficients can be thought of as correlation coefficients. Only variables with parameter estimates greater than 0.2 are shown.
Summary of motorcycling risk factors

Accident trends

Examination of the trends over recent years shows that although there has been a worrying increase in numbers of motorcycle casualties, the trends are broadly consistent with changes in the numbers of machines and the mileages they cover. However, motorcycle riders face much higher levels of risk than car drivers. This is particularly true for accidents resulting in serious injury or death, where the casualty rate per mile is 30 times’ higher for two-wheeled vehicles than for cars (Road Casualties GB, 2002). Moreover, the upward trend in the numbers of larger machines on the road, and in mileages ridden, means that motorcycle accidents are likely to make an increasing contribution to national casualty figures.

The sections below summarise the main factors identified in the present study and other research as influencing motorcyclists’ accident risk.

Annual mileage

When the effects of age, experience, and rider dedication were adjusted for statistically, accident liability was found to be proportional to (mileage)0.4. This non-linear relation between accidents and mileage is familiar from previous research.
Rider age and experience

Figure 6 illustrates the modelled age and experience effects. The upper curve represents the accident liabilities of novice riders of differing ages (a novice rider in this context is one who has been riding for one year only). Thus the left-hand end of this curve is the accident liability of a 17-year-old rider with one year’s riding experience (i.e. he or she started riding at 16), whilst the right-hand end of the curve is the accident liability of a 60-year-old rider with one year of riding experience (i.e. he or she started to ride at 59). The lower curves represent the accident liabilities of riders who started to ride at ages 16 and 39 (and whose accident liabilities after the first year of riding correspond with the upper curve at ages 17 and 40). Their experience then increases in step with their age.

Figure 6 shows that increasing age has a dramatic effect on a rider’s accident liability, which falls by 70% over the age range. The effect of riding experience alone is to reduce accident liability by 52% as experience increases from one to 44 years. Clearly, age and experience (or, rather, youth and inexperience) are both important risk factors in motorcycling as they have been shown to be in car driving (Maycock et al., 1991). However, the experience effect for motorcyclists is not nearly as large relative to the age effect as it is for car drivers. A speculative explanation is that, as motorcyclists become more experienced and develop improved riding skills they also tend to make more demands on those skills, buying faster, more demanding machines, riding faster, and generally continuing to have fun and excitement from motorcycling.

Training

The two level training variable distinguished only between riders who had taken Compulsory Basic Training (CBT) and those that had not. (A training variable with more than two levels was not appropriate because of the small number of riders with other types of training). No statistically significant effect of training on accident liability was found. However the study cannot provide a powerful test of the effects
of training. One reason for this is that effects of CBT might be expected to diminish as riders gain experience, and so become highly diluted in this sample. It should be noted, though, that some types of training may indeed have a negative effect on safety; for example, by improving control skills but not ability to judge risk and self-limitations.

### Rider dedication

Another variable that the generalised linear modelling showed to be related to accidents was that labelled ‘rider dedication’—effectively a measure that distinguished summer riders from people who ride in all conditions throughout the year. This was strongly associated with accidents, even when age, training, experience, exposure and size of bike were all controlled for in the modelling.

Table 2 shows that all the coefficients for this variable other than that for the reference category (category 1) are negative: riders in dedication categories 2–6 have lower accident liabilities than those in category 1. Put the other way round, the model shows that those who ride on a regular basis during the winter irrespective of the weather have a higher accident liability than the other categories of rider even when age, experience and mileage effects have been allowed for. People who ride in all weather conditions in the summer only (category 3) have an accident liability which is \( \exp\left(-0.521\right) = 0.59 \) times that of category 1 riders (i.e. 41% lower). Those who avoid bad weather conditions even in the summer (categories 4, 5 and 6) have an accident liability which is approximately \( \exp\left(-0.9\right) = 0.41 \) times that of category 1 riders (i.e. 59% lower) and \( \exp\left(-0.9 + 0.521\right) = 0.68 \) times that of category 3 riders (i.e. 32% lower).

Since these accident liability differences have been estimated taking into account annual mileage differences, the higher accident involvement associated with riding in winter and in poor conditions may be a reflection of the adverse riding conditions encountered in these circumstances (wet roads, icy roads, and darkness). Differences between types of rider, and types of journey undertaken, may also be important.

### Bike size

The steady rise in the numbers of motorcycles of over 500cc, the rise in casualty numbers for these machines and the emergence onto the market of very high performance motorcycles, has led to some speculation and concern that powerful machines might pose a particularly high risk. The possibility of placing limits on engine size, power, or some other index of performance such as power to weight ratio, has been considered in the past by the European Commission.

The multivariate modelling described above examined the effect of engine size on accidents once a number of variables, including age, experience, mileage, training etc. had been taken into account. Engine size (up to 125cc vs. 126cc and over), was found to have a small but statistically significant effect on accident liability, such that once the effects of mileage, age, experience, training and ‘rider dedication’ had been allowed for, riders of bikes of over 125cc had an accident liability 15% lower than riders of smaller bikes. This finding, together with other evidence discussed by
Sexton et al. (2004) leads to the following conclusions on the relationship between bike size and accidents:

- Small bikes tend to have more minor accidents (and total accidents) per year than bigger bikes, but for higher severity accidents Stats19 shows that this relationship reverses direction.

- Small bikes tend to be ridden by younger, less experienced riders, and to cover fewer miles per year, than bigger bikes.

- After adjusting for these differences, there is a tendency for bigger-engined motorcycles to have a lower mileage-adjusted ‘all accident’ rate than smaller motorcycles. Note, however, that in the present study the important division was between motorcycles of up to 125cc and those over 125cc.

- The increase in accident severity with bike size means that, for severe accidents, the mileage-adjusted accident rate may be higher for bigger bikes than for smaller bikes. Broughton’s study indicates that in 1986 this was true for fatal accidents, but not for the totality of injury accidents reported in Stats19 or, indeed, for accidents involving serious injury. In the present study it was found that, for ‘non-minor’ accidents and ‘serious injury’ accidents there was little relationship between bike size and accidents per bike, implying that the mileage-adjusted accident rate would decrease with bike size for these classes of accident.

Taking a break from motorcycling: is there a ‘returned rider’ effect?

It is sometimes suggested that riders who return to motorcycling after taking a long break may carry a particularly high level of risk. Clearly this is an important possibility, given the trend for people to return to motorcycling as a leisure pursuit.

Figure 7 shows the mileage-adjusted accident rate (a) for riders who returned from a long break (of more than a year) within the two years preceding the survey, and (b) for other riders. It shows no strong evidence that riders returning from a recent long break have a higher mileage-adjusted accident rate than other riders. Indeed, Figure 8, which focuses on riders of bikes over 500cc, shows that riders of the larger bikes who return to riding after a break are generally at lower risk than other riders. Note that, of breaks of more than 12 months, 68% lasted for more than five years and 48% for more than ten years.

These simple analyses provide little evidence of any unwanted ‘returning rider effect’ — a conclusion supported by the multivariate modelling, which did not find taking a long break (recently or ever) from riding to be a significant predictor of accident liability when the effects of age, experience, annual mileage, type of riding, training, and size of bike were taken into account. It is possible that a finer-grained analysis, able to look at the accident liability of returning riders very soon after their break, or at riders who had taken a much longer break from riding, might find an effect — but this would require a more extensive survey. Clearly, for very long
breaks, and/or for riders with very little pre-break experience and training, the returning rider is in many respects a novice. He or she is likely to have an elevated accident liability as a result — at least in comparison with other riders of the same age. However, in general, it appears that returning to riding after a long break is not an important risk factor.

This is not the same as saying that a trend for people to return to motorcycling is unimportant from a road safety standpoint. Returnees increase total motorcyclist numbers, and total mileage, and hence total motorcycle accidents. It would be highly desirable to reduce their accident liability if ways could be found to do so. Returnees might well form a good target group for countermeasures such as training, since (a) they tend to be easily identifiable — for example, when they purchase a new motorcycle, (b) it is possible to deliver training literature (and even offers of free training courses) along with the new machine and (c) returnees may often be well-motivated to improve their safe riding skills.
Rider motivations and behaviour

As Tables 3a–c show, of the behavioural factors investigated, it was self-reported errors that most consistently predicted accident liability. Traffic Errors figured in both models and for all three categories of accidents; Control Errors were significant predictors in some of the analyses. The ‘violations’ factors, Stunt Behaviour and Speed1 also appeared as predictors in some analyses.

The apparent dominance of errors over violations as predictors of accidents distinguishes the motorcyclists in this study from the car drivers who have been the subject of most previous studies of factors underlying accident liability (e.g. Reason et al., 1990; Parker, 1995a and 1995b). Typically, in those studies, violations were much more important than self-reported errors as predictors of accident liability. One possible explanation of this difference is that motorcycles are more demanding to control and less forgiving of errors than cars — that is, the relative instability of motorcycles means that error recovery is more difficult, so that an error is more likely to lead to an accident. It also seems possible that difficulty of error recovery, and vulnerability to injury, will make motorcyclists more aware of their errors than car drivers are of theirs, and therefore more able to report them.

The distinction between errors and violations should not be taken too far, however. Examination of the items making up the Traffic Errors factor suggests that many of them are to do with a careless, inattentive, rider style, not particularly focused on safety. They include failing to notice pedestrians, missing give-way signs, riding too close, and overtaking someone without noticing they are signalling a right turn. Similarly, many of the Control Errors are to do with inability to cope with the consequences of riding too fast (e.g. ‘ride so fast into a corner that you feel like you might lose control’, or ‘find you have difficulty in controlling the bike when riding at speed’). It appears, then, that these errors (failures of hazard perception skills and control skills) are closely linked to underlying riding styles — styles that could properly be described as violational in that they depart from good normative rules of safe riding. The link between traffic errors and the careless, risky, irresponsible riding style factor (RS1) reinforces this interpretation.

When age and experience are not permitted to influence accidents directly (Model II), stunt/high risk behaviours become significant predictors of accidents. This is consistent with the explanation that one of the risk-increasing characteristics of young or inexperienced riders is their tendency to indulge in overtly risky behaviours.

Riding style and a liking for speed were identified as predictors of behavioural errors (that were, themselves, predictors of accidents). These predictors were also inter-correlated. Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations for choosing to ride motorcycles. This presents a challenging problem for road safety.

The appearance of the factor Safety Equipment as a significant predictor of accident liability in Model II is interesting. Some of this may be a direct effect on accidents of the improved conspicuity provided by some safety clothing or the use of dipped headlights. The factor may also be acting as a proxy in the model for other variables — for example, the increasing judgement that comes with maturity. Wearing protective clothing would also be expected to reduce the severity of accidents, and
perhaps therefore to reduce the likelihood of the accident being serious enough to remember and report.

Conclusions

The upward trends in motorcycle casualties over recent years do not in themselves indicate the presence of a new risk factor — the trends are broadly consistent with trends in motorcycle numbers and motorcycle mileage. However, motorcyclists face much higher levels of risk than car drivers, and their contribution to national casualty figures is increasing. Reducing motorcycling accidents is an important task for road safety policy.

The survey found a very strong effect of age on accident liability. Young riders are at much higher risk of accidents than older riders. This suggests that changes to the testing/training/licensing system to protect young riders are warranted.

In addition to reducing with age, motorcyclists’ accident risk reduces as they gain experience, indicating that they are learning something useful during their early riding. This reinforces the belief that there is scope for improving safety by enhancing the learning process and/or attempting to control risk in some other way until the learning has taken effect. This might be achieved by introducing further elements of graduated licensing, as well as improvements to training and education.

The effect of experience on motorcyclists’ accident liability, though substantial, is relatively weak in comparison with that of age — a finding that contrasts with the situation for car drivers. A speculative explanation is that, as motorcyclists become more experienced and develop improved riding skills they also tend to make more demands on those skills. If this were true, one way forward might be to assess whether there is further potential in the training and rider development provided by the advanced motorcycling organisations to promote a careful, safe, responsible riding style.

Self-reported behavioural errors showed a consistent relationship with accident liability. Taken at face value, this suggests that interventions based on improving traffic skills such as hazard perception, and control skills associated with cornering and speed, would be effective at improving safety. However, the link between these errors and accidents may be as much to do with a careless, inattentive riding style and excessive speed as it is with lack of skill. For example, the control errors factor is dealing largely with errors and skills’ deficiencies that come into play when the motorcycle is being ridden enthusiastically. Improved skills (hazard perception, speed selection, control) should better enable riders to cope with such situations, but a more sedate riding style would reduce the need for such skills. Certainly, attempting to improve control skills without a concomitant attempt to improve insights into risk and self-limitations may increase rather than decrease accidents.

Riding style, getting pleasure from motorcycling, and a liking for speed were identified as predictors of behavioural errors (that were, themselves, predictors of accidents). Such relationships lend support to the view that an important part of the motorcycle safety problem stems directly from the motivations that lead
people to ride motorcycles in the first place. This presents a challenging problem for road safety.

The relationship between engine size and accident risk is a complex one. The survey showed that mileage-adjusted ‘all-accident’ rates for bikes up to 125cc is significantly higher than that for larger capacity bikes even when the effects of rider age and experience have been adjusted for. However, accidents involving bigger bikes tend to be more severe than those involving smaller machines: earlier research indicates that mileage-adjusted fatality rate increases with bike size. This, together with the continuing upward trend in the numbers of bigger machines on the road, and the fact that as people trade-up to bigger machines their annual mileage (i.e. exposure to risk) is likely to increase as well, means that attention needs to be given to devising safety interventions for riders of bigger motorcycles. It would be valuable to explore how to use the purchase of a new bike as a way of targeting safety interventions for these users.

Riders who ride all year round, including in the wet and dark, were found to be at much higher risk than those who ride only in the summer, even when the effects of annual mileage, age, experience, training and bike size have been adjusted for. The reasons for the excess risk of all-year, all-conditions, riders merit further investigation, since they might indicate measures that could mitigate this risk.

There was no evidence of a ‘returned rider effect’ whereby people returning from riding after long breaks are at increased risk (though the study was not able to rule out a short-term increase in risk after a return to riding). This is not to say that the trend towards people taking up motorcycling after a long break is irrelevant to road safety. Returning riders increase the amount of motorcycling, and therefore total number of motorcycling accidents. They may also form a receptive target group for interventions based on training and education, since they can be easily reached (i.e. when they purchase a motorcycle). Consideration should be given to developing training and educational interventions suitable for people returning to motorcycling, and to finding ways of encouraging returnees to participate. This might be done in collaboration with manufacturers, insurers and/or motorcycling organisations.

Given the very striking facts about the risks faced by motorcyclists, it would seem desirable to make sure that riders are actually aware of these risks. This might possibly reduce the numbers of people taking up or returning to motorcycling, and it might also encourage riders to modify their riding behaviour or to take up further training. Ways of communicating the risks of motorcycling should be explored, and riders’ current understanding of these risks assessed. The potential for road-based interventions designed to increase perceived risk levels at high risk locations needs further investigation.

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References


3

The prevalence and antecedents of risky motorcycling behaviour

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Project background

The ‘Older Motorcyclist’ project was undertaken by the University of Leeds in response to the increasing number of motorcycling accidents observed since 1996. In addition to a steady year on year increase in the total number of motorcycle casualties since 1996, when the casualty statistics are examined by age group, it becomes clear that this rise is specific to those aged between 25 and 59 (see Figure 1).

The remit of the project was to examine differences between groups of motorcyclists aged under and over 30 years of age. The project aimed to collect information from a sample of UK motorcyclists in order to analyse whether there was a readily identifiable group of ‘older motorcyclists’ in terms of vehicle ownership, riding history, experience and attitudes to risk. In turn, this would help identify countermeasures or interventions to support safe motorcycling. The main part of the project consisted of two surveys. The first examined ownership characteristics in
terms of machine type and size, motorcycling activity and a retrospective analysis of patterns of motorcycle ownership. Not only was the age of the motorcyclist taken into account, but also their experience of motorcycling. In this way it was possible to derive distinct groups of motorcyclists. The results of this survey can be found in Chorlton and Jamson (2003). The second survey used these groupings and examined whether there were differences in their propensity to engage in a number of risky riding behaviours — the results are presented below.

**Survey content**

Items sought information regarding the respondents’ demographics and motorcycle ownership. In addition, the survey aimed to identify a set of common risky riding behaviours and to explore the personality and motivational factors influencing riders’ intentions to engage in them. The ‘Theory of Planned Behaviour’ (TPB) is a model that describes an individual’s perception of the ease or difficulty of performing any given behaviour (Ajzen, 1991). The model states that intentions are influenced by three factors: attitudes, subjective norms and perceived behavioural control (PBC).

- **Attitudes** towards a behaviour reflect the degree of positive or negative evaluation the individual has towards performing the behaviour e.g. *I think exceeding the speed limit is exhilarating.*

- **Subjective norms** refer to the perceived social pressure to engage or not engage in a behaviour. This reflects what one’s ‘important others’ would think about the behaviour and how important one thinks their opinions are e.g. *My family would disapprove of me exceeding the speed limit.*

- **PBC** reflects the perceived ease or difficulty of undertaking a given behaviour. These ‘control factors’ can be internal or external e.g. *If I wanted to, I could easily exceed the speed limit.*

The TPB was applied to seven risky riding behaviours. When selecting these behaviours it was important to identify both contexts (e.g. road conditions) in which motorcycling accidents commonly occur and the actions/behaviours of the motorcyclists (e.g. travelling fast) which contribute to accident involvement. An extremely useful database for the selection of motorcycling behaviours linked to accidents was that collected by the Transport Research Laboratory (TRL) with funding from the Department for Transport (Elliot, Sexton and Keating, 2003). A total of 30,000 surveys was sent out to a random sample of motorcyclists identified from the DVLA database. After two mailings, roughly 10,656 usable responses were obtained. As our interest was in the older motorcyclist, we focused on the approximately 9,000 responses obtained from motorcyclists over the age of 30 years. From this sample, approximately 8,000 had not been involved in an accident and a further 1,000 had been accident-involved. The TRL survey also employed a driver behaviour questionnaire (Reason, Manstead, Stradling and Baxter, 1990) modified for use with motorcyclists. This provided motorcyclists with 32 ‘behaviours’ with which they were requested to indicate frequency of performance. The extent to which these behaviours could distinguish between accident-involved and non-accident-involved motorcyclists was statistically tested, using the frequency data.
A number of these behaviours had now to be selected for inclusion in the TPB survey: the first criterion for selection of a behaviour was that it was significantly related (p < 0.01) to accident involvement — 23 behaviours met this criterion. The second criterion was that each behaviour represented an action engaged in — 18 behaviours met this criterion. Selecting those most strongly related to accidents in each category would have identified: motorway speeding, vehicles pulling out, overtaking, racing away from lights, riding too close to the vehicle in front. However, this was not necessarily the best criteria for selection as the above analyses fail to control for the influence of other variables. In addition, we also had reason to believe (from discussions with several police forces) that one behaviour which was particularly related to accident involvement in older motorcyclists was group riding. Following further discussions with TRL, police forces and the University of Nottingham (also involved in an ongoing Department for Transport-funded motorcycling accident analysis) we developed seven scenarios relating to speeding: close following; ‘going for it’; lack of awareness; riding into a corner; drink riding; and group riding.

A photograph depicting the type of road described was also provided to encourage the respondent’s visualisation of the scenario. In order to ensure ecological validity, a small pilot study was undertaken and provided the key TPB measures. Six of the most commonly-expressed behavioural beliefs, five of the most frequently-mentioned control factors and four of the most frequently-identified referents were selected for each behaviour. Respondents were required to circle the most appropriate response on bi-polar anchored scales. Given the lengthy nature of each TPB questionnaire, it was deemed inappropriate to require the respondents to complete every questionnaire. Each respondent therefore received three of the TPB questionnaires with the additional demographic, sensation seeking and accident history items.

Results

Response rate

The survey was distributed to 30,300 registered keepers of motorcycles. 4,929 riders responded to the survey, representing a 16% response rate. At the time the survey was conducted, 4,757 respondents (97%) owned a motorcycle. The analyses focused on 4,304 males (age range 16–85 years, M = 44.65, SD = 11.89) and 437 females (age range 16–77 years, M = 39.13, SD = 12.92). As with the previous study, the survey was lengthy and a number of riders omitted certain items. In order for a respondent to be included in the TPB analysis, they had to provide responses to all items, therefore the number of riders included in the analysis varies throughout. The survey was reasonably successful in acquiring a representative sample of the UK motorcycling population (Table 1). However those riders owning the larger capacity machines were somewhat over-represented.

Classification of the motorcyclists

The sample of riders obtained was insufficient to allow a statistically robust comparison of the under and over 30s since the number of riders aged below 30 years was modest (11.4% of the sample). In order to provide comparable results,
riders were therefore classified on the same basis as our previous survey. Using data supplied regarding their number of years of riding experience and whether they reported taking a break of ten years or more, riders were classified as new (n = 1127), long-term (n = 2518) or returning (n = 1091) riders. An additional classification was used based on the type of motorcycling activities the sample engaged in. Riders were asked to report the main purpose of trips for which they use their motorcycle and were then classified as ‘commuter only’ riders (n = 1094), ‘leisure only’ riders (n = 1940), ‘multi-use’ riders (n = 1575) and ‘miscellaneous’ riders (n = 121).

### Demographics and motorcycle ownership

Of the 4,754 respondents, 90% were male and the majority were aged between the mid-thirties and early fifties (Figure 2). The new riders have the lowest mean age (33 years) and there is little difference between the long-term (47 years) and returning riders (48 years).
Figure 3 shows that it is the long-term and returning riders who are most likely to own larger capacity machines. Indeed just under half of both groups (46% of long-term riders, 42% of returning riders) ride machines with an engine capacity of 751cc or more.

Sports/touring bikes were the most popular motorcycles across all rider types. New riders were, however, more likely to own mopeds and scooters than any other rider type and given our previous results, differences here are likely to be a reflection of the way in which each group uses their machine. Indeed, when we examine motorcycle engine capacity and type by trip type we can see that it is the leisure rider that tends to own the larger capacity machines and the commuter rider who tends to rely on the lower capacity machines (Figure 4).

Intention to engage in risky riding

There were three scenarios that were related to excessive speed. An example of one of these is shown below. All the speeding scenarios gave similar results, so for brevity’s sake, only the results from the motorway scenario will be discussed.
Intention to speed

Imagine you are riding alone along a motorway. It is a fine, dry day and the traffic is fairly light. You move into the outside lane where you exceed the 70mph speed limit.

42.5% of the riders expressed an intention to exceed the 70mph speed limit. They:
- were younger;
- had engaged in more speeding in the past;
- possessed a positive attitude toward speeding;
- did not perceive it morally wrong to speed;
- did not feel pressure from others not to speed; and
- tended not to have a self-identity as a safe rider.

Intenders were defined as those riders who tended to agree that they would intend, plan and want to exceed the speed limit (i.e. a mean behavioural intention score above the neutral point zero). The mean scores for the behavioural beliefs are shown in Figure 5.

When the individual components of the TPB were analysed, it was found that intenders could be differentiated in a number of ways. They associated positive feelings with speeding, including exhilaration and the ability to beat the surrounding traffic. In contrast to non-intenders, they did not associate speeding with feelings of anxiety or an increase in the risk of being involved in an accident.

Both groups believed that speeding would result in them being caught by the police, and that it was not an appropriate test of their motorcycles’ top speed.

Those who intended to exceed the speed limit believed that whilst the police would disapprove of this behaviour, significant others (other riders, family) would not
disapprove of them speeding. In any case, intenders’ motivation to comply with these significant others was weak. When considering the external influences on behaviour, those who intended to exceed the speed limit were more likely to do so when these external influences were conducive (i.e. on dry days, good roads and in light traffic).

Maintaining a safe distance

Imagine you are riding along an urban road which you know has pedestrian crossings at various points. You are riding alone. It is a fine, dry day with good visibility but the road is relatively busy. You are paying attention to the main traffic and you maintain a safe distance to the vehicle in front.

96% of riders intended to maintain a safe distance to the vehicle in front. They:
- had frequently done so in the past;
- believed more positive outcomes would result from maintaining a safe distance;
- held positive attitudes towards maintaining a safe distance;
- would regret not maintaining a safe distance; and
- perceived not maintaining a safe distance to be a risky behaviour.

Intenders were defined as those riders who tended to agree that they would intend, plan and want to maintain a safe distance from the vehicle in front (i.e. a mean behavioural intention score above the neutral point zero). The mean scores for the behavioural beliefs are shown in Figure 6.
Those riders who did not intend maintaining a safe distance felt that doing so would lead to feelings of frustration. Intenders also expressed stronger beliefs that maintaining a safe distance would make them feel safe, give them longer to brake and reduce their risk of hitting the vehicle in front. The non-intenders expressed a stronger belief that maintaining a safe distance would not allow them to keep up with the traffic.

Compared to non-intenders, those who intended to maintain a safe distance believed that other riders would approve of this behaviour, and also had a stronger belief that their family would approve of this. The non-intenders also expressed a weaker motivation to comply with all the significant reference groups.

Concerning the external influences on behaviour, those who did not intend to maintain a safe distance were significantly more likely to ride when they were in a hurry and when their behaviour would be affected by the speed of the vehicles in front and behind them (and by the possibility of emerging vehicles from side roads).

**Pay attention to emerging vehicles**

Imagine you are riding along a residential road with cars parked either side and side roads at various points. You are riding alone. Because of the parked cars it is difficult to see any vehicles emerging from the side roads or for them to see you. You try to pay attention to these emerging vehicles.

99% of the riders intended to pay attention to emerging traffic. They:
- tended to perceive more positive than negative outcomes would result from paying attention;
- had tended to pay attention in the past;
- possessed a positive attitude to paying attention;
- perceived not paying attention to be risky;
- had accrued a lower annual mileage.

Intenders were originally defined as those riders who tended to agree that they would intend, plan and want to pay attention to emerging vehicles (i.e. a mean behavioural intention score above the neutral point zero). Non-intenders were riders whose mean behavioural intention score fell below the neutral point zero (i.e. they did not intend, plan nor want to pay attention to emerging vehicles). However, 99% of the riders intended to pay attention to emerging traffic reflecting an overwhelming appreciation of the profit of vigilance on the road. In order to allow more statistically-robust comparisons, riders were split at the median (3). Intenders were defined as those falling on or below the median (1,059 riders) and non-intenders were defined as those falling below the median (511 riders). The mean scores for the behavioural beliefs are shown in Figure 7.
Those riders who intended to pay attention to emerging vehicles, were more likely to believe that this would make them feel safe and that this would reduce the severity of impact in an accident. The non-intenders however, were more likely to believe that engaging in such behaviour would distract them from the road ahead and that this behaviour would also increase their mental workload significantly. Those who intended to pay attention to emerging vehicles were more strongly influenced by significant others than non-intenders. The family was the most influential referent group for both intenders and non-intenders. Concerning external influences, those who intended to pay attention were less likely to ride when they were in a hurry or when tired.

Figure 7  Behavioural beliefs for paying attention

Those riders who intended to pay attention to emerging vehicles, were more likely to believe that this would make them feel safe and that this would reduce the severity of impact in an accident. The non-intenders however, were more likely to believe that engaging in such behaviour would distract them from the road ahead and that this behaviour would also increase their mental workload significantly. Those who intended to pay attention to emerging vehicles were more strongly influenced by significant others than non-intenders. The family was the most influential referent group for both intenders and non-intenders. Concerning external influences, those who intended to pay attention were less likely to ride when they were in a hurry or when tired.

Ride even though they may be over the legal limit

You have been out for a few drinks. It is a relatively easy ride home on an urban road and so you decide to ride even though you suspect you may be over the legal limit for alcohol.

4% of riders intended to ride despite suspecting being over the legal limit. They:

- held positive attitudes towards this behaviour and were not morally opposed to the behaviour;
- had frequently indulged in the behaviour in the past and did perceive the behaviour as risky;
- did not anticipate regretting the behaviour;
- had a lower annual mileage; and
- did not perceive pressure from significant others not to engage in the behaviour.

Intenders were defined as those riders who tended to agree that they would intend, plan and want to ride (i.e. a mean behavioural intention score above the neutral point zero). Non-intenders were riders whose mean behavioural intention score fell below the neutral point zero (i.e. they did not intend, plan nor want to ride). However, of the 1,220 riders, only 49 riders were classified as intenders. In order to allow more
statistically-robust comparisons, riders were split at the median (−3). Intenders were defined as those falling above the median (379 riders) and non-intenders were defined as those falling on or below the median (841 riders). The mean scores for the behavioural beliefs are shown in Figure 8.

Intenders believed that riding even though they suspected they were over the limit would be convenient and would not increase their risk of an accident, compared to non-intenders. In addition, non-intenders were less likely to believe that such a behaviour would be exhilarating, and that instead they would feel anxious and be vulnerable to being caught by the police.

Both groups agreed that significant others would disapprove of such behaviour, however non-intenders believed this more strongly. The police were the most influential group for the non-intenders, whereas intenders were more likely to comply with their family members.

**Implications for speeding**

Of the three scenarios that related to speeding, around 40% of riders expressed an intention to speed. The powerful influence of past behaviour presents a difficult problem however as the behaviour is much more resistant to change. Change could either be enforced (using road engineering or intelligent transport solutions) or encouraged within the training regime. This could be achieved most effectively within the hazard perception test and the practical test. Since most riders are car drivers too, the hazards of speeding should also be directly tackled in the car driving test.

Riders expressing strong intentions to speed regarded the control factors as facilitators of the behaviour. In order to lessen riders’ intentions it would therefore seem appropriate to convince them that they are in control of their actions and that these specific situations should inhibit their propensity to speed. Those intending to speed believed that this would be aided by good road and weather conditions, and given our previous evidence that the nature of motorcycling is changing to that of a leisure activity enjoyed throughout the summer months, targeted campaigns would
be best suited to the dry summer months when motorcycling and the propensity to speed is at its peak. A high police presence was rated by both groups as inhibiting their propensity to exceed the speed limit. Steps should be taken to ensure police presence is directly or indirectly felt, particularly near popular motorcycling routes. Although direct policing may not always be appropriate, indirect measures such as speed cameras, police warning signs and information leaflets endorsed by the police might prove beneficial additions to any targeted campaign.

Attitudes were also a powerful determinant of intention to speed. Changing road users’ attitudes is a common focus of safety campaigns. Our research would suggest that it is important to challenge riders’ positive beliefs surrounding speeding and attempt to instil a negative attitude emphasising that speeding is an unsafe, useless, unsatisfying, harmful, negative, reckless violation that will not evoke any enjoyment. In order to promote behavioural beliefs that are in line with those upheld by non-intenders, the results suggest that campaigns should focus on highlighting the direct link between speed and accidents, the increased chance of being caught by the police, and emphasise the potential negative emotive reactions to succumbing to speeding (i.e. feelings of anxiety). Similarly, care should be taken to express the negative consequences of these situations; the threat to riders’ and other road users’ lives, the financial cost of being caught for speeding and the inconvenience of losing their licence. Since intenders were significantly more likely to believe that speeding would allow them to beat the traffic and cause feelings of exhilaration, it follows that campaigns might down play the thrills and benefits gained from speeding and counteract these by emphasising the potential negative consequences (see Stead, Tagg, MacKintosh and Eadie 2002 for examples of how to operationalise the TPB components within a media campaign).

Given that those riders expressing stronger intentions to exceed the speed limit perceived little normative pressure not to engage in this behaviour, it would seem appropriate to raise riders’ awareness of the impact of speeding on their significant others. It is important that riders begin to believe that their significant others (i.e. the police, other road users, their family, other riders) would disapprove of them exceeding the speed limit and that it is important to consider their beliefs when they are on the road. In view of the fact that the family was the most influential referent on intenders and that intenders believed they were unlikely to disapprove of speeding, campaigns should promote the importance of family, their disapproval of speeding and the potential impact of speeding on their lives. Since the police was the most influential referent group for non-intenders, the idea that direct and indirect policing should be increased is confirmed.

Since it was found that younger riders are those most likely to intend to exceed the speed limit, any successful campaign must set its tone at this age group, actively publicising the campaign in places and at times where this age group is most likely to pay attention. Rider training would seem a particularly appropriate place to step up campaigns against speeding since we have shown that new riders are, on average, younger than those who have been riding for a considerable length of time.

The influence of a strong sense of self-identity suggests that riders who perceive themselves as a safe motorcyclist express weaker intentions to engage in speeding. It becomes important therefore to address those riders who do not regard themselves as a safe motorcyclist, emphasising that it would benefit them, their family and improve their role in society if they did begin to act and regard themselves as a safe and responsible rider. Encouraging the formation of such a self-identity is clearly a
complex process. Nevertheless campaigns which attempted to emphasise the positive aspects of this identity (e.g. thoughtful of others, calm) and counter the negative aspects (e.g. carefree, living for today) might increase this self-identity.

Implications for other behaviours

Maintain a safe distance

96% of the riders intended to maintain a safe distance from the vehicle in front, suggesting that training and experience are adequate. For the minority of non-intenders, past behaviour was again the strongest predictor of intentions. Intenders believed that positive outcomes would arise from such behaviour (e.g. less chance of an accident) thus safety campaigns should challenge negative behavioural beliefs. Since non-intenders were less likely to believe that maintaining a safe distance would give them longer to brake and reduce the risk of them hitting the vehicle in front, these actual benefits should be made real to the rider. As with driver campaigns, adverts might visually demonstrate the effect of longer braking distances versus shorter braking distances.

Those who intended to ride closely believed that a slow driver in front and a pressing driver behind would make it difficult for them to maintain a safe distance. It should be impressed that riding closely to another vehicle will not get them to their destination any faster and that it is their, not others, decision to ride at a certain following distance. Similarly, since non-intenders also reported that being in hurry would make them less likely to adopt safer following distances, they should be reassured that the safety benefits of maintaining a safe distance for themselves, other road users and their family far outweigh the benefit of arriving at their destination in a shorter period of time.

Although normative pressure was not directly predictive of riders’ intentions to maintain a safe distance from the vehicle in front, those who intended not to thought that other bikers were unlikely to approve of them maintaining a safe distance. They should be made to realise that they are the minority amongst the motorcycling population and that as they were also less likely to believe that their family would approve, campaigns should again highlight that a rider’s family has their safety interest at heart.

Pay attention to emerging traffic

Here, behavioural beliefs were the strongest predictors of intention. The results suggest that non-intenders should understand that paying attention will lead to a stronger feeling of being safe on the roads, will not distract them from the road ahead, will reduce the severity of an accident, will not make them feel frustrated and will reduce the risk of an accident. Past behaviour was again a strong predictor of intentions.

Although normative pressure did not provide a significant predictor of intentions, comparisons across intenders and non-intenders suggest that riders agreed the
referents would approve of this behaviour but that intenders are significantly more motivated to comply with these referents. Since the family was the most influential referent for both groups, it follows that campaigns should promote the importance of family and their approval of riders engaging in pro-safety behaviour. Similarly campaigns might highlight how riders’ safety behaviour impacts upon other road users, the police and other bikers.

**Riding whilst over the limit**

Attitude was the strongest determinant of riders’ intentions. Those riders who held positive attitudes towards riding even though they suspected they may be over the legal limit expressed significantly stronger intentions. It is important to challenge riders’ positive beliefs surrounding drinking and riding and attempt to instil a negative attitude emphasising that this behaviour is an unsafe, useless, unsatisfying, harmful, negative, reckless violation that will not evoke any enjoyment. In order to promote behavioural beliefs that are in line with those upheld by non-intenders, the results suggest that campaigns should focus on dissuading intenders that drinking and riding is an easy and convenient option. Intenders were more likely to believe that riding even though they suspect they may be over the legal limit would be more convenient and get them home more quickly. Riders should be made aware that the potential consequences of riding even though they suspect they may be over the legal limit far outweigh the short-lived benefits. Similarly, it should be emphasised that engaging in this behaviour would evoke feelings of anxiety and not feelings of exhilaration, increase the risk of an accident and being caught by the police.

Moral norms were also a significant predictor such that those riders who did not perceive riding even though they suspect they may be over the legal limit as morally wrong expressed significantly stronger intentions. It is therefore necessary to impress the social unacceptability of drink riding in today’s society, emphasising that this behaviour does not only put the rider at risk but that his/her behaviour has serious potential consequences for other members of society (i.e. road traffic accident victims, victim’s family, financial cost of RTAs) which will not be tolerated. Thankfully, only a small minority of our sample intended to engage in the behaviour.

When riders did not anticipate regretting riding even though they suspect they may be over the legal limit, intentions to engage in this behaviour were significantly stronger. Riders should be reminded that their actions have serious consequences for themselves, their family and other road users and that engaging in this behaviour can only lead to uneasy feelings of guilt. They should be reminded that their behaviour does not only impact upon themselves but many others.

Those riders who perceived the external factors as facilitators rather than inhibitors of the behaviour intended to ride even though they suspected they may be over the legal limit. Although both intenders and non-intenders believed that little traffic, drinking a short distance from home and drinking an easy ride from home inhibited the behaviour, intenders were significantly weaker in their evaluation. It follows therefore that campaigns should highlight that accidents can occur even on the shortest, simplest trips and no matter how quiet the traffic may be there is always a potential conflict when an individual is riding under the influence of alcohol. Both also agreed that a police presence and other onlookers would inhibit their propensity
to ride even though they suspect they may be over the legal limit. Steps could be taken to increase direct or indirect policing in popular drinking locations. Police-endorsed information leaflets could be placed near entrances to remind riders of the implications of their actions.

Normative pressure significantly predicted intentions such that those riders perceiving little pressure not to ride even though they suspect they may be over the legal limit expressed significantly stronger intentions to engage in the behaviour. Although intenders agreed that all the referent groups would disapprove of this behaviour, intenders were weaker in this belief and less motivated to comply with these groups. Given that the family was the most influential referent group for non-intenders and the police the most influential group for intenders, campaigns should promote their disapproval of drink riding and the far reaching impact this behaviour could potentially have on their and other people’s lives. As before, campaigns would benefit from emphasising the disapproval of these groups and increasing the direct or indirect presence of the police, highlighting their power to impose fines and endorsement points.

Summary

This paper summarises a survey of nearly 5,000 motorcyclists. The survey examined their views in relation to various risky riding behaviours. Across a diverse sample the predictors of intentions to engage in seven risky riding scenarios were explored. The selection of predictors was based on the theory of planned behaviour but included a number of additional variables plus demographic, and rider/bike characteristics. On average the predictors explained 50% of the variance in intentions to engage in risky riding behaviours. Past behaviour, measures of attitude and measures of control emerged as the most consistent predictors of intentions across scenarios. A number of beliefs distinguishing intenders from non-intenders that might form the basis of interventions to change these intentions and behaviour was identified.

References


Daytime running lights: effects of a brief, intensive campaign for voluntary use

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Introduction

Failure to detect a vehicle, or to detect it in time, are contributory causes of a proportion of crashes on the road. Brown (2002) reported that ‘looked but failed to see’ errors constituted up to 23% of unimpaired drivers’ errors during daylight. Under these conditions, vehicle conspicuity can be increased through the use of ‘Daytime Running Lights’ (DRLs). At a sufficient level of intensity, DRLs increase the visual contrast between the vehicle and its background.

Progressive introduction of DRLs

Scandinavian countries were the first to require the use of headlights for all motor vehicles: Finland on rural roads in winter in 1972; Sweden on all roads and throughout the year in 1977 (Farmer and Williams, 2002). Norway required automatic DRLs on all new cars from 1985. Canada followed suit from 1989 and Hungary from 1994 (outside built-up areas). Now many jurisdictions in the US, Europe and the Middle East either require or are considering requiring the use of DRLs by all vehicles, and many motor manufacturers are producing vehicles with this function as standard equipment (e.g. Volvo, VW, Saab, Suzuki, General Motors).

Safety effects of DRLs

The contribution to safety of DRLs was first determined for motorcycles with reported reductions in daytime collisions with other vehicles of between seven and 18% (Zador, 1985). With the more widespread introduction of DRLs in cars, many studies have reported estimates of their contribution to safety, although their interpretation is not without controversy (see, for example, Theeuwes and Riemersma, 1995). Elvik (1996) presents the results of a meta-analysis of evidence...
from 17 studies in nine countries that have evaluated the safety effects of DRLs. Although studies vary in experimental design (simple before-after implementation, with and without control groups, and comparisons between cars randomly assigned to a DRL or a no DRL condition), Elvik concluded that the use of DRLs on cars reduces the number of multi-party daytime accidents by about 10–15%, and that there is no evidence to suggest that DRLs adversely affect other kinds of accident (e.g. rear-end collisions). Furthermore, DRL use appears to be effective in all types of multi-party daytime crash, including front and side impacts and collisions with pedestrians. These conclusions have subsequently been confirmed by Hollo (1998), who evaluated the impact of legislation requiring DRL use outside built-up areas in Hungary and found a 13% reduction in collisions, and by Farmer and Williams (2002), who, in a study of nine US states over four years, found 3.2% fewer multiple-vehicle crashes in passenger cars and light trucks equipped with automatic DRLs.

**Meaning of DRL**

Despite this evidence, some words of caution are perhaps in order. Although researchers talk about DRLs as if the term represents a standard feature, in fact the term carries rather different meanings in different jurisdictions and at different times. Thus, for example, initial introduction of the DRL requirement typically involves the use of dipped headlights, before eventually progressing to automatic DRLs, simply because initially vehicles are not fitted with functionally-specific DRLs (e.g. as was the case with Hungary). Apart from any differences in luminosity between dipped headlights and DRLs, use of dipped headlights also includes activation of rear lights. In addition, drivers have to activate dipped headlights intentionally: automatic DRLs typically come on with engine ignition. Finally on this issue of what the term DRL might mean, in the United States, the National Highway Traffic Safety Administration (NHTSA) restricts the output of DRLs to a maximum of 7,000 candela (about one-tenth the intensity of a high beam headlamp). According to Farmer and Williams (2002), this limit is equivalent to that in Canada, but is more than four times the maximum output allowed in most European countries. They report that the NHTSA is now considering lowering the maximum output of a DRL to 1,500 candela. The European Safety Council recently stated that ‘…it is very important that (the) daytime running lights should conform to a specification, which includes beam pattern and light intensity requirements’ (Crash, January 2002: 6).

**Effects of latitude**

In his meta-analysis, Elvik makes the observation that there is probably a relationship between the latitude of a country and the safety effect of DRLs, with some evidence showing the effect increasing as one proceeds progressively further north of the equator. However the exact nature of this relationship cannot be determined from currently available data. Ireland, at a mean latitude of approximately 53N, is relatively northern in the latitudes evaluated in the studies reviewed by Elvik, ranging from Israel at a mean of 33N to Finland at a mean of 63N. Hungary, which has a mean latitude of 46N, (i.e. seven degrees’ further south than Ireland), has seen a positive safety effect of the introduction of DRLs. Thus there is no geographical reason why the introduction of DRL use should not have at least as great an effect in Ireland.
The Dublin daytime running lights campaign

In this climate of evidence and in the context of an ongoing strategic plan to reduce traffic accidents in the Dublin metropolitan area, the Office of the Director of Traffic of Dublin City Council launched an experimental intensive five-week daytime running lights campaign in July 2002. The campaign included the following elements:

- launch and media briefing;
- radio ads on Dublin radio stations;
- outdoor posters, banners and electronic messaging displays; and
- targeting of fleet operators to promote the concept and require drivers to use DRLs.

Compliance with DRL use, though strongly encouraged, was entirely voluntary. Its launch at the height of summer was designed to reinforce the message that DRLs are not just for conditions of poor visibility but are of use even on the brightest of days.

From its very inception, the campaign was situated in an evaluative framework that enabled obtaining comparative data before, during and after the campaign. Confining the campaign to Dublin also enabled the selection of Cork city as a control location. The campaign evaluation had four main objectives:

- assessing awareness of the target group of the campaign;
- assessing the impact of the campaign on actual DRL use;
- assessing the impact of the campaign on the behaviour and attitudes of road users towards DRLs; and
- estimating the impact of the campaign on accidents.

Method

Assessing the impact of the campaign on actual DRL use

Dublin city traffic was monitored for the use of DRLs prior to, during and after the intensive five-week campaign (July 17 to August 17 2002). Control observations were also made in Cork city prior to and during the campaign. Dublin monitoring took place on the following dates: July 9, 11 and 13 (prior to the campaign); July 17, 18, 20 and 30 and August 1, 3, 13, 15 and 17 (during the intensive campaign); September 3, 5 and 7 (after the intensive campaign but with the campaign still in operation through outdoor posters, banners and electronic messaging displays) and November 5, 7 and 9 (post-campaign). The monitoring in Cork took place on July 5 (prior to the campaign); on July 25, 26 and 27 (during the campaign) and on 11 November (post-campaign).
On each day (except for the post-campaign samples), monitoring took place over three two-hour periods: the morning period between 07.00 and 09.00, the midday period between 11.00 and 13.00, and the evening period between 16.00 and 18.00. Because of daylight changes, however, the post-campaign sample was from 09.00 to 11.00 in the morning period, from 11.30 to 13.30 in the midday period and from 14.00 to 16.00 in the evening period. Within each two-hour period, observations were made at each of four sites for 25 minutes.

**PROCEDURE**

A data record sheet was used to record observations during monitoring. Data for vehicles that stopped at red lights at each observed junction was recorded in sequence. Typically between six and ten vehicles were observed at each red light with a guiding figure of 125 vehicles to be observed in each 25-minute period. Observers recorded the type of vehicle (car, bus, truck, van, taxi, motorbike) and whether or not DRLs were in operation on that vehicle. In addition, the weather conditions were noted (sunny, cloudy and raining, cloudy and no rain, foggy). Light conditions were recorded using a light meter held at a 45 degree angle to the road surface and oriented away from the sun. These recordings were made at each of the four locations across the two-hour period and an average derived. Average readings (in Lux) for each two-hour session were ultimately recorded as one of three light categories — dull (0–200 Lux), moderate (200–400 Lux) or bright (400–1100 Lux).

**Assessing exposure of the target group to the campaign and the impact of the campaign on the behaviour and attitudes of road users towards DRLs**

A prototype questionnaire was designed to assess exposure of the target group to the campaign and the impact of the campaign on the behaviour and attitudes of road users towards DRLs. Apart from individual driver characteristics and information on type of vehicle normally driven, the questionnaire focused on the driver’s DRL use under various conditions, on positive and negative attitudes to DRL use, on views of DRL effectiveness and lastly on attitudes towards DRL implementation. The prototype questionnaire was piloted with a sample of ten respondents (five male, five female, age range 22–60 years and driving experience range 4–40 years), from which a refined version was generated. This version was then finalised in discussion with a market survey company, who undertook to carry out the administration of the questionnaire to drivers.

The questionnaires were administered in Dublin’s central motor tax office before, during and after the campaign. Surveying took place between the 1 and 9 of July (prior to the campaign), between the 6 and 9 of August (during the intensive campaign), and between 18 and 22 of November (post-campaign). Control surveying also took place in the motor tax office in Cork between the 8 and 12 of July. Questionnaires were distributed between 10.00 and 15.00 each day during the above periods.

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PROCEDURE

Males and females of legal driving age, waiting in line for the services of the tax office, were approached and asked to complete a five-minute questionnaire for a study being undertaken by Dublin City Council. Any questions were answered and then participants were left to complete the questionnaire in isolation. Participants were approached sequentially from the rear of the queuing-line forward.

Estimating the impact of the campaign on accidents

The original intention of the study was to obtain accident data for all daytime collision accidents in the Dublin metropolitan area during the intensive period of the campaign which would indicate the vehicle(s) involved, type of road user hit, status of DRLs (on/off) and whether or not the colliding vehicle was seen. To this end the cooperation of An Garda Síochána Dublin metropolitan area Road Safety Unit was requested and willingly offered and an accident report form was designed for distribution to all officers recording collisions during the intensive campaign phase. In the event, the administration of the accident report form fell between two Garda divisions and was never distributed.

As a fall-back measure, a questionnaire was designed to be completed by participants in daytime collision accidents with a motor vehicle in the Dublin metropolitan area during the intensive period of the campaign (and immediately after). This was distributed by the Garda Dublin metropolitan area Road Safety Unit to 960 participants identified from the accident database for that period. The questionnaire requested information about date, time and location of the accident, whether driving and if so whether DRLs were in use at the time of the collision, whether persons hit by a vehicle saw it before impact, whether DRLs were observed by victims and whether hit vehicles were using DRLs. The questionnaire was distributed by mail (with an enclosed prepaid return envelope) four weeks after the end of the campaign in the period 25 October to 22 November, 2002.

Finally, injury accident frequency data and numbers of injury casualties for 2002 were analysed comparing pre-, during- and post-campaign periods for Dublin and Cork and further compared with the same monthly samples for the previous year.

Results

Overall level of cooperation with DRL campaign

The effects of the DRL campaign on the level of DRL use in Dublin can be seen in Figure 1. This shows a progressive increase in the use of DRLs from the start of the campaign in July 2002 (15.2% of all vehicles), a trend that continues right through to the post-sampling period in November 2002 (44.4% of all vehicles). The observed
increase in the proportion of drivers using DRL over time (combining the two samples taken during the campaign) is highly significant ($\chi^2 = 1542$, df = 2, $p < .001$). In contrast to this pattern of change observed in Dublin, are the results from Cork, where a stable level of use of DRLs over time may be noted (9–10%)\(^1\). Not surprisingly there is no significant change over time in the Cork data ($\chi^2 = 2.56$, df = 2, $p > 0.2$) and the proportion of drivers using DRLs in Dublin during the campaign is significantly greater than in Cork ($\chi^2 = 264$, df = 1, $p < .001$).

Given that the campaign had been completed several weeks before the post-campaign sampling period, it is perhaps surprising that DRL use levels in Dublin were so high at that time. However a breakdown of levels of use by day in that sample reveals a very high use on the final day, which happened to be very cloudy and dull, with low light levels (<200 Lux). The effects of this may be seen in Figure 2, which describes the level of DRL use on each of the three post-sampling days in Dublin and also, for contrast, the post-level for Cork. On the non-gloomy days the level of DRL use in Dublin was between 28% and 34% and on the gloomy day rose to nearly 70%. Results for the four main time periods of the study, but excluding

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\(^1\) Data for Cork in the original post-campaign period was not considered necessary to obtain. Hence the ‘during minor’ data for Cork are estimates based on interpolations between the ‘during major’ period and the true ‘post’ period, when data were obtained.
the final ‘gloomy’ sampling day in Dublin, are presented in Figure 3.Quite independent of this day, the persistence of use of DRLs is still very evident. Motorcyclists had a relatively high rate of DRL use before the campaign, in both Dublin and Cork (see Figure 4).

Effects of weather and light conditions

To determine the effects of weather and light conditions on DRL use, the data for Dublin over the entire sampling period (from pre-campaign through to post-campaign) were analysed and yielded the results presented in Figures 5 and 6.

It may be seen in Figures 5 and 6 that there is a clear relationship between level of visibility and DRL use: as visibility or light levels decrease, more drivers switch on their DRLs. To explore further this phenomenon, data for Dublin and Cork were analysed for the post-campaign sampling period (which included the very ‘gloomy’ day in Dublin) and the results are presented in Figures 7 and 8. We can see that the effect of deteriorating weather and light conditions is considerably more evident in Dublin compared with Cork (note that there are no data for a day on which it rained or on which light levels fell below 200 Lux in the Cork post-sample).
In these results we can also see a much more marked effect of rainy and dull conditions on DRL use in the post-period. Figure 9 makes this clear by presenting a comparison between the percentage of drivers using DRLs under various light levels in the period before and during the campaign with the period after it. Subsequent to the campaign, drivers in Dublin have become much more prepared to switch on DRLs in conditions of poor visibility.
Effects of time of day

The relationship between DRL use and time of day for the Dublin sample over the entire study is presented in Figure 10 which shows that drivers are less likely to use DRLs over the midday period than during the morning and evening commuting.
Effects of DRL campaign on collisions

For the period of the campaign, 174 reports were received from accident participants, which is estimated to represent approximately 8.7% of all accidents recorded by the gardaí in the Dublin metropolitan area over that time. Of the total number of accidents for which reports were received, 57% occurred at a junction, 90% involved drivers of a motor vehicle, 4% involved motorcycles and 4% involved persons in a parked car. 49% of respondents reported using DRLs at the time of the accident. Since during the campaign there was on average 27% of vehicles using DRLs, it is apparent that vehicles with DRLs are over-represented in the reported accident statistics. However, although 49% of drivers, who admitted to colliding with another vehicle, reported using DRLs at the time, the victims who were hit reported that only 5% of the vehicles hitting them were using DRLs at the time. Similarly, of drivers of vehicles which were hit by another vehicle 48% reported that they themselves were using DRLs at the time, although the drivers who collided with them reported that only 2.5% were using DRLs. Thus there is a large discrepancy between the reports of victims of collisions and the reports of those who admitted to doing the colliding, both victims and perpetrators claiming they were using DRLs considerably more than the other recognised. This throws some doubt on the reliability of the evidence of both parties, of course. Nevertheless, these discrepancies in reporting imply that drivers consider having DRLs on preferable to not having them on, and so at the very least the reports indicate a positive attitude to DRL use from a safety perspective.

With regard to estimating the contribution of DRLs to conspicuity, we asked collision participants to report on whether or not they saw the vehicle about to hit them or which they were about to hit. Although there were relatively few reported observations here, it is apparent that there is no effect of DRLs on whether the other vehicle is seen or not (for victim driver report, $\chi^2 = 0.04$, df = 1, $p > 0.8$; for colliding driver report, $\chi^2 = 0.14$, df = 1, $p > 0.7$).

Analysis of actual collision and casualty data for Dublin and Cork was carried out in February 2004, after the publication of road accident data for 2002 by the NRA in
December 2003 (*Road Accident Facts 2002*, Dublin: DoT, 2003). Accident frequency data, fatalities and injuries for Dublin and Cork over the critical time periods are presented in Table 1. Injury accident frequencies are presented graphically in Figure 12.

<table>
<thead>
<tr>
<th>Table 1 Accident frequency data, fatalities and injuries</th>
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<tbody>
<tr>
<td><strong>Injury accidents</strong></td>
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<tr>
<td>Dublin 2001</td>
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<tr>
<td>2002</td>
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<tr>
<td>Cork 2001</td>
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<tr>
<td>2002</td>
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<tr>
<td><strong>Fatalities</strong></td>
</tr>
<tr>
<td>Dublin 2001</td>
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<tr>
<td>2002</td>
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<tr>
<td>Cork 2001</td>
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<td>2002</td>
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<tr>
<td><strong>Injuries</strong></td>
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<tr>
<td>Dublin 2001</td>
</tr>
<tr>
<td>2002</td>
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<tr>
<td>Cork 2001</td>
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<td>2002</td>
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</table>

Three kinds of analysis were carried out on the data, all using the Chi Square statistic (with 2 df): firstly to compare the pattern of change in 2002 with the same period in 2001, separately for Dublin and for Cork; secondly to compare the pattern of change in Dublin for 2002 with the pattern of change in Cork for the same year and thirdly to compare the changes observed in Dublin between the years 2001 and 2002 with the changes observed in Cork for the same period. All three of these analyses were carried out separately for injury accident frequencies and for injury frequencies (i.e. casualty numbers). None of the analyses yielded any statistically significant comparisons. In short there is no evidence here for the effects of the DRL.
campaign on injury accident or injury numbers. Numbers of fatalities were so small (see Table 1) as to pre-empt any further statistical analysis.

One reason for the absence of any apparent effect of DRL use may be that the DRL campaign was launched in a year in which overall injury accidents in Dublin were down by 21% on the previous year and the number of casualties was down by 26%. This contrasts with Cork where injury accidents were down by 4% on the previous year and casualties were essentially the same in both years. Thus the overall success of other interventions in Dublin may have swamped any specific contribution made by the DRL campaign. Furthermore, there are no comprehensive or reliable public records of material-damage-only collisions. Injury collisions are estimated at less than 5% of all collisions — material-damage-only accidents representing the vast majority. If there is an effect of DRLs, it may be reflected in this much larger body of road collisions.

Effects of DRL campaign on awareness, behaviour and attitudes

CHARACTERISTICS OF THE SAMPLE

The questionnaire data on attitudes, values and behaviour regarding DRL use was obtained in Dublin at three stages: pre-campaign, during campaign and post-campaign. One comparison sample of 346 respondents was also obtained from Cork during the pre-campaign period. Sample sizes for Dublin are presented in Table 2. 62% of the respondents in both Dublin and Cork were male.

<table>
<thead>
<tr>
<th>Table 2 Number of respondents in Dublin at each sample time</th>
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<tr>
<td><strong>Pre-campaign</strong></td>
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<td>741</td>
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</table>

In Dublin, the main type of transport used in a typical week by respondents was a car (73.3%), followed by bus (7.8%), motorcycle, van and public transport other than bus (3.6–4.2%), taxi (2.6%), pedal cycle (2.0%), and truck and no transport (1.1%). In Cork, the main type of transport used in a typical week by respondents was also a car (85.0%), followed by van (4.9%), truck and motorcycle (2.9%), bus (1.7%), public transport other than bus (1.2%), taxi (0.9%), pedal cycle (0.3%), and no transport (0.3%). For Dublin users of cars, vans, trucks and motorcycles, 85% were the drivers; for Cork 92% were the drivers. 17% of car drivers in Dublin (about 12% of the Dublin sample of respondents) said their vehicle was fitted with automatic DRLs (12% in Cork).

AWARENESS OF CAMPAIGN

During the campaign, 78.6% reported that they had heard about it or read about it. Very slightly more (80.6%) expressed the same after the campaign. This pattern was
the same for both sexes. However, relatively fewer respondents in the youngest age group sampled (62% of 17–24 years) were aware of the campaign during it, although they were no different from older respondents by the end of the campaign.

BEHAVIOUR IN REGARD TO DRL USE

Percentages of drivers using DRLs under various conditions, before, during and after the campaign are presented in Figures 13–15. Figure 13 shows that the proportion of Dublin drivers reporting that they always used DRLs whilst driving in difficult weather conditions rose from 45% pre-campaign to 58% during it, and 69% after it. For ‘use always of DRLs at twilight’ (Figure 14), proportions rose from 55% pre-campaign to 64% during it, and 77% after it. And for ‘use always of DRLs during normal daylight’ (Figure 15), proportions rose from 10% pre-campaign to 19% during it, and 32% after it, a pattern which was common to males and females. These values correspond fairly well with the direct observations of DRL use described earlier. Pre-campaign levels correspond roughly with the proportion of drivers in the sample whose car was fitted with automatic DRLs. It is noteworthy that further analysis of the post-campaign percentages for the different age groups reporting ‘use always of DRLs during normal daylight’ shows 33–37% respondents in all age groups except the youngest (17–24 years) at 18% and the oldest (65+ years) at 25%. Drivers of cars, taxis and vans range between 30 and 40%, however motorcyclists stand out at 79% reporting ‘use always of DRLs during normal daylight’.
ATTITUDES REGARDING DRL USE

Growing support for the impact of DRLs on accident reduction is reflected in Figure 16. By the post-campaign period, 76% say DRLs will reduce accidents (in detail: car drivers, 76%; van drivers, 72%; taxi drivers 67% and motorcyclists 91%). Furthermore 79% agree or strongly agree that use of DRLs is an effective accident countermeasure. 47% of respondents think the safety effect will be lasting; on the other hand 35% agree or strongly agree that after a while, if everyone uses DRLs, the safety benefits will be reduced. Percentage ratings of the effectiveness of DRLs during weather conditions of poor visibility and during twilight periods reveal that a high and consistent proportion of drivers (≥92%) consider use of DRLs under these conditions makes roads safer.

Respondents were also asked about the general effectiveness of DRLs at different times of the year. The results of this are shown in Figure 17. Not surprisingly, almost no respondents considered DRLs would only be effective during summer months. However what is of particular interest is the increase during the campaign in the proportion of respondents who thought DRLs would be effective all year round (from 36% to 53%).

The logic for the use of DRLs is, of course, that DRLs increase conspicuity of a vehicle and may also enable safer judgements of its speed and distance. Respondents were asked about their views on these potential benefits. With regard to conspicuity, 79% of respondents in Cork agreed or agreed strongly with the statement that DRLs
make vehicles more visible during daylight hours. In the Dublin pre-campaign period, 73% responded in the same way. During the campaign, this figure rose to 77% and finally, at post-campaign, rose to 87%. Similar levels of support were found from car drivers (86%), taxi drivers (83%) and van drivers (86%). Motorcyclists were the greatest supporters, however, at 94% agreeing or agreeing strongly that DRLs make vehicles more visible. Concerning making judgements of approaching vehicle speed safer, 48% agreed or strongly agreed pre-campaign (50% in the Cork sample). This rose to 58% during the campaign and was at 65% in the post-campaign period. Finally, with regard to enabling safer judgements of vehicle distance, 54% agreed or strongly agreed pre-campaign (57% in the Cork sample), 64% during the campaign and 71% after it. Thus the effects of the campaign (assuming no general independent trend upwards) appear to have been to increase the proportion of respondents who viewed the use of DRLs as making approaching vehicles more conspicuous, and enabling safer judgements of their speed and distance.

As well as the potential contribution of DRLs to safety, concerns have been expressed by some road users that their introduction might be detrimental to safety in various ways. Respondents were therefore asked about such concerns. Motorcyclists typically drive with DRLs. One concern is that the universal use of DRLs by other vehicles would make motorcyclists less visible. Figure 18 shows the proportion of respondents agreeing and disagreeing with the statement that if all road users used DRLs during daylight hours, motorcyclists would be less visible. It is notable that in the Cork and Dublin pre-campaign samples, respectively 51% and 50% of respondents disagreed or disagreed strongly with this statement.
During the campaign, this proportion rose in Dublin to 56% and was at 55% in the post-campaign period. On the other hand, respondents agreeing or strongly agreeing with the statement started at 33% pre-campaign (34% in Cork), dropping to 22% during the campaign, but then climbing back to 32% in the post-campaign period. The specific responses of motorcyclists (n = 72) to this statement are presented in Figure 19. In the pre-campaign sample, 42% of motorcyclists disagreed or disagreed strongly with this statement. This rose to 58% during the campaign and ended at 49% post-campaign. Thus, during the campaign, the acceptance by motorcyclists, that general use of DRLs would not make them less visible, increased and increased more strongly than it did for other road users. Nevertheless, the proportions agreeing and strongly agreeing with the statement started at 35% pre-campaign, remained more or less the same during it (at 33%) but then rose to 44% after the campaign. Progressively over time motorcyclists appear to be falling into two camps, either viewing use of DRLs by others as not reducing their conspicuity, or indeed making it worse (Figure 19 shows the ‘neither’ category shrink from 23% to 6% over time).

The final item on the awareness, behaviour and attitudes questionnaire referred to whether or not DRL use should be voluntary or made compulsory. Results for this question are presented in Figure 20. Cork and Dublin clearly share a similar viewpoint prior to the campaign, with about 65% supporting voluntary introduction and 35% supporting compulsory introduction. It may be noted that, from pre- to
post-campaign samples in Dublin, the proportion supporting both possibilities increased (it is, of course, feasible that a respondent might support both options).

On completion of the questionnaire, respondents were given the opportunity to add any further comments they wished about DRLs. 72 respondents in the Dublin sample and 16 in Cork expressed a very favourable opinion regarding DRL use, such as ‘I think it’s a great idea and will save many lives in the future: make it law’; ‘I have lived in Sweden and seen the positive effects of DRLs’; ‘Dipped lights during daytime help others see you coming and also stop children running into your path’. A further 50 respondents in Dublin and 16 in Cork supported the use of DRLs but with qualifications, for example: ‘I think that DRLs are only of use when weather and visibility are impairing vision’; ‘I would welcome DRLs during winter only’; ‘Use of DRLs should be compulsory on motorways’; ‘If DRLs are to be effective, car manufacturers should install them’. 27 respondents in Dublin and four in Cork indicated in various ways that they thought DRLs were a waste of time, for example: ‘It makes no difference’ and ‘I think it’s a stupid idea’. In Dublin, 11 respondents expressed concern about the cost of DRLs (installation, effect on battery) and 34 (two in Cork) mentioned a potential for increased hazards such as dazzling and loss of conspicuity of motorcyclists and vehicles without DRLs. Finally 11 respondents in Dublin and six in Cork suggested that other safety interventions should have greater priority, such as seatbelt and speed limit enforcement, cycle helmet use, and dealing with bad drivers, drink driving, mobile phone use and greater conspicuity of vulnerable road users.

**Summary and conclusions**

It is clear from the evidence presented here that in many respects the Dublin daytime running lights campaign was a success. During the campaign, and several weeks after it, about 80% of survey participants reported that they had heard or read about it. This pattern was the same for both sexes and most age groups except the youngest age group sampled (17–24 years), who were less aware of the campaign during its promotion period. Nevertheless approximately 60% of this group reported that they were aware of it at that time.

From the direct observations of vehicles, there was a large and persistent increase in the level of compliance with the use of DRLs, from 15% to 44%. Drivers became more likely to use DRLs at any time and especially under conditions of reduced visibility, when levels rose to as high as 70%. The effect applied to all types of motorised vehicle with the relative increase in usage of DRLs being most marked by bus drivers. Compared with other road users, motorcyclists started with a high baseline level of DRL usage (51%) but even their level of use increased, both during and after the campaign (to 69%).

Self-reports of DRL use, obtained through the questionnaire survey, were consistent with these direct observations of behaviour. The proportion of drivers in Dublin reporting that they always used DRLs whilst driving in difficult weather conditions rose from 45% pre-campaign to 58% during it, and 69% after it. For twilight conditions, proportions rose from 55% pre-campaign to 64% during it, and 77% after it. And for normal daylight, proportions rose from 10% pre-campaign to 19%
during it, and 32% after it, a pattern that was common to both males and females. Furthermore, during the campaign, the proportion of respondents who thought DRLs would be effective all year round rose from 36% to 53%.

One remarkable feature of the campaign is that after it was over, motorised road users continued to use DRLs. In this post-campaign period, motorcyclists were most likely to report use of DRLs during normal daylight (79%), followed by drivers of cars, taxis and vans (30%–40%). These proportions were similar across different age groups. However slightly lower levels of use were reported by the 17–24 year age group at 18% and the 65+ age group at 25%.

The effects on accidents of this increase in DRL use over time, an increase which was in marked contrast to the low and stable levels observed in the control city, Cork, was not possible to determine during the period of the study. The National Roads Authority data for casualty accidents in the Dublin metropolitan area showed no reliable change compared with the same period in the previous year or with Cork in the intervention year. Nevertheless, it would be useful to disaggregate this data by time of day (the comparisons reported assumed no change in the relative contribution of night time accidents) and to obtain data specifically on pedestrian and damage only accidents.

The retrospective questionnaire study of accident participants, which was introduced as a secondary measure, revealed that both the victims of collisions and those who admitted doing the colliding, claimed that they were using DRLs considerably more than the other reported. This evidence throws some doubt on the reliability of the reports from collision participants. However by biasing their reports in this direction, it is apparent that drivers consider having DRLs on is preferable to not having them on.

Confounding interpretation of the results from the retrospective questionnaire, however, is the fact that it relied on participant recall and it was not possible to demonstrate an effect of DRLs on whether the other vehicle was seen in a collision or not. Nevertheless, research evidence from jurisdictions with a similar latitude to Ireland, which have introduced DRLs, indicates that DRL use does have an impact in reducing collisions and there is no a priori reason why we should not expect a similar effect in Dublin.

The expectations of the questionnaire participants are consistent with this in that over 75% say DRLs will reduce accidents and, under conditions of poor visibility, over 90% consider use of DRLs will make roads safer. Over the period of the campaign, the proportion of respondents who viewed DRLs as making approaching vehicles more conspicuous increased to 87% (a view particularly endorsed by motorcyclists), as did the proportion who thought they enabled safer judgements of vehicle speed and distance (over 65%).

Nevertheless 35% agree or strongly agree that if everyone uses DRLs, after a while the safety benefits will be reduced. One reason for this is that relative to other road users, motorcyclists would become less conspicuous than pre-campaign, when they were over three times’ more likely to use DRLs than other road users. About one in three agreed that universal use of DRLs by other vehicles would make motorcyclists less visible and over 40% of motorcyclists endorsed this view. A second reason has to do with the concept of risk compensation, which applied in this context would
mean that if all vehicles became more conspicuous through DRL use, drivers would eventually become less vigilant and so any initial reduction in collision rate would eventually climb back towards pre-DRL levels. A minority of car drivers, taxi drivers, van drivers and motorcyclists (up to 22%) actually endorsed this view.

The issue of the introduction of DRL use as a permanent feature of daytime driving raises the question of whether or not DRL use should be voluntary or compulsory. Overall there was a high level of support for the introduction of DRLs, with a preference for voluntary (approximately 75%) over compulsory (approximately 50%) introduction across all age groups.

Were the introduction of DRLs to be pursued as a matter of policy, compliance with DRL use would almost certainly benefit from pressures on non-users to conform (‘most others are doing it so I will’), from a reduction in negative experiences such as other drivers flashing because they think the DRL driver has his/her lights left on by accident, and through the gradual incorporation of switching-on-lights-during-daylight into the habitual routines of the driver (such as seat-belt fastening). But as one respondent remarked at the end of his questionnaire, perhaps the optimal strategy would be a legal and technical one: the introduction of a legal requirement on manufacturers that all new vehicles be fitted with automatic DRLs.

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References


Alcohol interlocks: their use, effectiveness and future

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Abstract

The alcohol ignition interlock — also known as the ‘alcolock’ — is an in-vehicle device that prevents a car from starting until the operator provides a breath alcohol concentration (BrAC) test below a predetermined level, usually .02% (20 mg/dl). This paper describes the alcolock device and reviews the development and current status of alcolock programmes including their public safety benefit and the public practice impediments to more widespread adoption of these ‘Driving While Intoxicated’ (DWI) control devices. Despite strong evidence of effectiveness in studies to date, the real potential of this technology to reduce the road toll cannot be estimated until it is more widely adopted.

Introduction

Historical perspective

The notion of a vehicle that drunks couldn’t drive has intrigued scientists for over four decades. The search for such a system began in earnest in 1968 when the U.S. Secretary of Transportation issued a report to Congress acknowledging the potential of an in-vehicle interlock device that could prevent the operation of a vehicle by someone whose ability to do so was impaired by alcohol (U.S. Department of Transportation, 1968). Two different approaches emerged: (1) devices that assessed the degree of motor or perceptual impairment of the driver; and (2) devices that measured the blood alcohol concentration (BAC) of the individual from breath samples.

Performance-based devices required the driver to perform a perceptual or motor task successfully before the vehicle would start. The rationale for such a system was that a driver who had consumed sufficient alcohol to impair performance on the task(s)

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1 Portions of this paper are based on a manuscript prepared by Beirness and Marques for publication in Traffic Injury Prevention.
was deemed too intoxicated to operate a motor vehicle safely. The types of tasks considered for these performance-based ignition interlock systems typically involved reaction time, tracking, hand-eye coordination, divided attention, and/or short-term memory. Laboratory tests found that several of these tasks could discriminate between highly intoxicated (i.e. BACs > .18%) and non-drinking subjects, yet none could successfully discriminate between subjects at mid-range BACs (i.e. BACs between .05 and .15%).

To ensure that all drivers with a BAC over .10% failed the test (thereby disabling the ignition), the performance criteria had to be set at a level that also eliminated a considerable number of individuals who had not been drinking. Obviously, such a system would not be acceptable to the public since many individuals who had not been drinking would fail the test and would not be able to start their vehicles. Indeed, none of the performance-based interlock systems was even close to 100% reliable in discriminating between non-drinking or low BAC drivers and legally intoxicated drivers. Because of the high false positive rates (i.e. prevention of ignition by a non-drinking driver) associated with performance-based alcolock systems, they fell into disfavour.

During the period when performance-based interlocks were being given serious consideration, three significant events occurred that altered the direction of alcolock development. First, the introduction of laws that defined driving while intoxicated (DWI) on the basis of BAC alone (i.e. per se laws) were becoming more widespread in the United States. Such laws made it unnecessary to provide evidence of intoxication or impairment for a person to be charged and convicted of DWI. All that was required was evidence that the person had a BAC in excess of the established per se limit. Second, the technology of alcohol measurement advanced to the point where small, accurate breath testing devices were becoming increasingly available. Third, integrated circuits and computer microprocessors had been miniaturised and were becoming widely available for relatively low cost.

Although the concept had been considered in the early 1970s, in-vehicle breath test devices were not practical at that time. By the mid-1980s, however, virtually all research on ignition interlock systems was focused on breath alcohol measurement devices, effectively precluding further development of the performance-based systems.

All breath alcohol ignition interlock devices — also referred to as alcolocks — are based on the same principle — the driver is required to blow into a small breath-testing instrument installed in the vehicle. If the driver has had too much to drink, the device will not unlock the ignition and prevent the operation of the vehicle.

Several different in-vehicle breath test instruments were developed and tested to determine how reliably each could discriminate between breath samples above and below a specified threshold value. The results showed that such instruments could make the needed distinction virtually 100% of the time (Frank, 1988).

### Equipment and standards

Technological innovations over the past 20 years have made in-vehicle breath test devices viable and practical. Present alcolock systems consist of a small breath-testing device linked to the vehicle ignition system that requires the driver to provide
a breath sample every time an attempt is made to start the vehicle. The alcolock device prevents the vehicle from being started unless the driver provides a breath sample that reveals an alcohol concentration below the present threshold value — often .02% (20 mg/dl), but sometimes up to .04% (40 mg/dl). In the event the breath sample reveals a BAC in excess of the threshold value, the alcolock prevents the vehicle from starting and the driver must wait a period of time before trying again. After several failed attempts, the alcolock goes into an extended lockout period.

At least three government agencies have established standards or guidelines for alcolock devices (Electronics Test Centre 1992; NHTSA 1992; Standards Australia 1993). Devices that meet these standards provide assurance to both the public and users that the device performs as expected and desired. For example, the current generation of alcolock devices have incorporated a fuel-cell sensor that is specific to alcohol (i.e. it eliminates false positive readings due to other organic hydrocarbons) and is capable of preventing ignition at least 90% of the time when the individual’s actual BAC is .01% (10 mg/dl) higher than the threshold BAC. Even under extreme conditions (e.g. temperature of $-40^\circ C$), a person with a BAC of .06% would almost certainly be prevented from starting the vehicle 98% of the time. In such extreme temperatures, the sample head needs to be heated to within a workable range before the devices are ready for use.

Concern continues to be expressed about the possibility of circumventing the device by tampering with the circuitry, introducing a bogus air sample, or filtering the sample to remove some of the alcohol. Protection against potential circumvention of the device is also required by the standards. To meet these standards, alcolock devices contain such features as temperature and pressure sensors (to guard against filtered or stored samples or samples introduced by mechanical devices), a data recorder (to log all attempts to start the vehicle as well as to record the driver’s BAC), and a running re-test requirement (to limit the benefit if a bystander were to provide a start-up breath sample, and to limit the benefit of leaving the car idling for extended periods).

These features have helped to create an alcolock device that does exactly what it is intended and expected to do — that is prevent drivers impaired by alcohol from operating the vehicle in which it is installed. Most alcolocks are quite accurate considering the relatively harsh operating environment that vehicles are exposed to. These are not field forensic test devices, they are simply expected to prevent impaired driving, and they do.

## Level of adoption

Although the initial concept of an alcolock implied the universal application of the technology in every vehicle, there has been little expansion beyond its use as a means of incapacitation for those convicted of a DWI offence.

Recent legislative initiatives in both Canada and the United States have given implicit federal approval to alcolock programmes and have spurred the development and/or expansion of alcolock programmes. In Canada, in 1999, the Criminal Code was amended to allow a reduction in the mandatory period of driving prohibition for a DWI conviction provided the offender participates in an alcolock programme for the remainder of the period of driving prohibition (Criminal Code of Canada 2002).
In the United States, the Transportation Equity Act for the 21st Century (TEA-21) contained a financial incentive for states to strengthen their programmes to control repeat DWI offenders — an alcolock programme is one of the two initiatives that qualifies for incentives.

At present, seven Canadian jurisdictions and 43 American states have legislation that allows the installation of alcolock devices in the vehicles of DWI offenders. Other countries (e.g. Sweden, Australia) have also initiated alcolock programmes. In March 2002, a consortium of road safety research institutes in Europe completed a feasibility study regarding the implementation of alcolock programmes as part of the EU drink-driving policies (Bax, Kärki, Evers, Bernhoff, & Mathijssen, 2001). In September 2003, the European Commission officially approved conducting a field trial beginning in the spring of 2004 (Van Laar & Mathijssen, 2004 forthcoming). In the UK, work is underway to examine the acceptability of alcolocks among drink-drive offenders and their families.

Despite the number of jurisdictions with alcolock legislation, low participation rates plague alcolock programmes. It is estimated that there are currently about 70,000 alcolocks in use throughout North America. Although this number is substantially higher than it was even a few years ago, it pales in comparison with the estimated 1.6 million drivers charged with a DWI offence in North America every year. Typically less than 10% of eligible DWI offenders participate in an alcolock programme. The type of alcolock programme, the degree of discretion, and other DWI countermeasures play an important role in determining participation rates. For example, Voas, Blackman, Tippetts, and Marques (2002) describe a judicial programme in Hancock County, Indiana that coerces DWI offenders into installing alcolocks by giving them a choice between participating in an alcolock programme and house arrest. Even so, only 62% entered the alcolock programme, yet this partial response resulted in significant countywide reductions in repeat DUI (driving under the influence) relative to six nearby comparison counties, testimony to what is possible with a strong incentive.

The structure of alcolock programmes also varies considerably. For example, programmes may be administered either by the courts or by the driver licensing authority. That is, in some jurisdictions, alcolocks are ordered by a judge as a condition of probation; in others, alcolocks are a condition of license reinstatement. Alcolock programmes also differ in the level to which participation in the programme is voluntary or mandatory. Some programmes are mandatory for certain types of DWI offenders either as condition of probation or a condition of license reinstatement. In others, participation is discretionary — either on the part of the court or the individual offender.

The degree of discretion involved in getting offenders into alcolock programmes is further complicated by the fact that even when alcolock programme participation is mandated by law, some judges will not order an offender to participate. For example, in a sample of California DWI offenders DeYoung (2002) reported that just 10% of eligible offenders were ordered by the courts to install an alcolock and only 22% of those complied, a net yield of about 2.2%. To gain participation in voluntary programmes, offenders must be encouraged to elect the alcolock through incentives such as a reduction in the period of license suspension.

For alcolock programmes to achieve their maximum potential, increased participation among drink-drive offenders is an essential first step. The Indiana study suggests that
one approach to strengthening enrolment may be to make the alternative to entering an alcolock programme much less attractive. This is something only the courts can do, but judges, except on an individual basis, seem unwilling to require and enforce alcolock stipulations. As it currently stands, unless an approach is devised that effectively increases the rate of alcolock usage through some combination of positive and negative incentives, the alcolock will not achieve its full promise to reduce impaired driving.

Effectiveness of alcolock programmes

Since the first alcolock programme was introduced in California almost 20 years ago, several studies have evaluated the effectiveness of using alcolock programmes as a means to incapacitate convicted DWI offenders and prevent repeat DWI offences. To date, there have been 11 published evaluation studies. These have been summarised and reviewed elsewhere (Beirness and Marques, forthcoming; Cobden and Larkin, 1999). In general, the research demonstrates that alcolock programme participants have a re-offence rate of up to 90% lower than offenders who do not participate in the programme.

In reviewing the evaluation literature on the impact of alcolock programmes, it must be recognised that no study is without methodological limitations. In general, the evaluation of road safety policies and programmes can be challenging and is often constrained by a variety of factors, including the type and quality of data available, inability to exercise control over and/or account for extraneous events, and the difficulty in obtaining adequate comparison groups. This is a reality of applied research. Nevertheless, such factors can influence the validity of the findings and the subsequent interpretation of the findings.

The generally positive findings from evaluation studies on a variety of alcolock programmes examining different populations of offenders for various lengths of time suggests that the effect of alcolock programmes is robust. The magnitude of the effect, however, varies considerably. To some extent, the measured impact may be related to specific operational aspects of the programme, the types of offenders who participate in the programme, as well as the research design used to evaluate the programme.

It is equally apparent that there is little, if any, residual effect in preventing impaired driving after the device is removed. This latter finding has been somewhat disappointing to those who had expectations that the experience with an alcolock device would provide a constant reminder of the problems associated with driving after drinking and/or reinforcement of sober driving, thereby creating a change in behaviour that would persist after the alcolock was removed. The existing studies clearly indicate that the reduction in recidivism among alcolock participants is limited to the period of alcolock installation, or at best for a limited time thereafter.

The fact that the effect of alcolock programmes is so strong despite the relative ease with which participants can circumvent the alcolock system by simply operating another vehicle, indicates that participants are able to comply with the demands of the alcolock programme and change their behaviour for at least a period of time.
Understanding why and how this behaviour change occurs may provide suggestions for creating longer-lasting change.

The increase in re-arrest rates following removal of the alcolock does not reflect on the efficacy of alcolock programmes, nor should it be used to discount or discredit the beneficial effects of alcolock programmes. First, it should be noted that even though the recidivism rate among alcolock participants following the removal of the alcolock device matches that of DWI offenders (suspended or reinstated) who did not participate in the programme, the significant effect evident during the alcolock period is not lost. For example, the three-year cumulative re-offence rate (minimum two years of the alcolock programme completion) for first-time offenders in the Alberta alcolock programme was 15.3 offences per 1,000 drivers, compared to 43.8 for suspended drivers and 131.2 for the approximately 10% of drivers who were ineligible for the alcolock programme (Voas, Marques, Tippetts, & Beirness, 1999). The five-year cumulative re-offence rate of 63 offences per 1,000 drivers for repeat offenders who participated in the alcolock programme is about half that of eligible non-participants who accumulated 130 offences per 1,000 drivers over a five-year period.

Second, the alcolock device can only prevent impaired driving when it is installed in the vehicle. Long-term behavioural change is an elusive goal of many countermeasures and sanctions, including licence suspension and incarceration. If the factors that give rise to the drink-driving behaviour do not change during the alcolock period, it is likely that the behaviour will re-appear once the physical barrier (i.e. the alcolock) preventing it is removed. It is important to remember that many drink-drive offenders, including those who participate in alcolock programmes, exhibit behaviour consistent with clinical diagnoses of alcohol abuse or dependence. The installation of an alcolock does not change this situation; it merely prevents the individual from operating the vehicle after drinking. Alcolocks were never intended as a treatment for alcohol abuse; therefore, it should not be expected that installation and use of an alcolock device will, by itself, prompt a change in the extent of alcohol consumption.

Representativeness of alcolock programme participants

A criticism of existing evaluation studies concerns low participation rates and the problem of recruitment or selection into alcolock programmes. In general, only a small portion of eligible DWI offenders (generally less than 20%) choose to participate in an alcolock programme relative to those who remain fully suspended (Voas et al., 1999). This suggests that alcolock programme participants might differ on one or more critical dimensions from those who elect to remain suspended (e.g. desire or need to drive, financial resources, etc.), factors that might affect re-offence rates. Accordingly, whether participants volunteer for the alcolock programme or participate as a result of a judge’s order, the process of selecting alcolock participants may result in a bias that favours those with a lower likelihood of recidivism. Hence, it is important to consider that the lower rates of recidivism among alcolock participants observed in evaluation studies may not be attributable to the programme but rather to differences in the characteristics of those who do and those who do not participate in alcolock programme.
A factor that argues against the possibility that electing to install an alcolock attracts only low-risk offenders comes from the evaluation studies, nearly all of which demonstrate strong post-alcolock differences in repeat offence rates among the same people during and after the alcolock. Voas et al. (1999) suggested that the increase in recidivism rates among participants once the alcolock is removed argues against the influence of an initial selection bias, at least in terms of the propensity to drive after drinking. Whatever differences may be created by the self-selection of offenders into the alcolock programme, these differences are probably not sufficient to account for the lower recidivism among alcolock participants during the alcolock period.

The self-selection problem is overcome with a random assignment protocol. Only one study has been able to assign participants to an alcolock programme randomly (Beck et al., 1999). By assigning offenders from a common pool to either an alcolock programme or control condition, this design ensured comparability of the groups. Nonetheless, the results and recidivism rates from this more tightly-controlled design were similar to the findings of studies in which participants were self-selected, or ordered by the court to install an alcolock device. This suggests that the differences in recidivism are attributable to the alcolock and are not just a consequence of differences in the characteristics of participants.

However, there are differences in these types of studies. The random assignment study becomes a test of overall alcolock programme effectiveness whereas the evaluation of alcolock users versus non-users is a study of the alcolock programme efficacy for those who enrol in the alcolock programme (i.e. it is not a system-wide evaluation). These are different questions with different methodologies. The research by Beck et al. (1999) studied a subsample of multiple offenders all of whom were assessed by a medical review board and received approval to participate in the research. Within that subset some were assigned to the alcolock and some were not. Among those offenders assigned to the alcolock, 38% did not install it. Nevertheless, they remained as part of the alcolock group. This renders it a programme effectiveness test. Despite the inclusion of these individuals, the alcolock condition overall still showed a strong benefit relative to the non-alcolock condition.

In summary, differing types of evidence have consistently shown a strong beneficial impact of alcolock programmes at least while the device is installed. Once the device is removed, the recidivism rates among alcolock participants generally do not differ from those of DWI offenders who do not use the alcolock. If there remains an expectation and desire for this beneficial effect of alcolock programmes to persist after the device is removed, then every effort must be made to change the individual’s behaviour — particular the frequency and extent of alcohol consumption — during the period the offender is under the control of the alcolock programme. Or failing to change the behaviour, we must find ways to limit their unmonitored driving.

**Innovations in research and programmes**

Research studies have taken two approaches to overcome the temporary nature of the alcolock benefit. These include: (1) improving the quality, immediacy, and
appropriateness of counselling services while an offender is ‘captive’ of an alcolock programme, and (2) improving the ability of the judicial or motor vehicle authority to predict which offenders pose the highest risks to the public if they became fully relicensed and no longer controlled by an alcolock programme. The ability to predict high risk offenders is greatly improved by using data captured in the alcolock’s recorder, which logs every start attempt and BAC test result while the alcolock is in use.

Counselling interventions

Marques, Tippetts, Voas, Danseco, and Beirness (2000) reported results from a two-city comparison in which 610 alcolock offenders in Calgary, Alberta received an adjunctive intervention during each monthly visit to the alcolock service centre, whereas 747 offenders in the Edmonton area did not. Edmonton, Alberta is a city of comparable size and approximate demographic make-up. The intervention was a composite of motivational enhancement, pragmatic counselling, and anticipatory planning for life after the alcolock (Marques, Voas, & Hodgins, 1998). Among those in the intervention site, a 50% reduction in recidivism rates of first offenders relative to the comparison first offenders was found during the first 12 months after the alcolock was removed (odds ratio = .46); no comparable effect was documented for multiple offenders. Because intervention and city varied together it is not possible to confidently attribute the difference to the intervention protocol. However, it suggests that behaviour can be affected at least temporarily to forestall the return to impaired driving after the alcolock benefit. The intervention could not be uniformly applied to all alcolock clients since they were not ordered by the court to participate. Although over 80% agreed to be in the study, commitment to the programme varied widely.

In an effort to deliver a more systematic and fully-specified intervention protocol, a motivational enhancement intervention for alcolock offenders was devised and is currently being evaluated in Texas.

Predictive models

It was recently shown that the rate of elevated alcolock BAC tests strongly predicts the likelihood of future impaired driving convictions during the first two years after the alcolock is removed. This discovery was first documented in Alberta from data of 2,200 offenders who provided 5.5 million BAC tests (Marques, Tippettts, Voas, & Beirness, 2000) and subsequently confirmed in Quebec with 7,200 offenders based on 18.8 million breath tests (Marques, Voas, & Tippettts, 2003c). The rate of alcolock BAC tests that are elevated above .02% (20 mg/dl) relative to all tests taken strongly predicts repeat DWI likelihood. An evaluation of the relative potency of this effect relative to other known predictors of repeat offending found it to be the best advance indicator yet identified (Marques, Tippettts, & Voas, 2003b), better than prior DWI offences, moving violations, driving while suspended charges, as well as demographic and questionnaire-based information. An indicator like this has particular merit for first-time DWI offenders on whom there is often little advance indication of whether an individual will pose a public hazard if he or she receives an unrestricted licence.

Further analyses of both the Alberta and Quebec data confirmed that in these linguistically- and culturally-distinct provinces, the occurrence of elevated tests
during the morning hours adds substantially to a predictive model for future DWI offences. While the overall highest number of BAC tests taken occurs in late afternoon around 17.00, the highest number of tests with BAC ≥ .02% occurred between 07.00–08.00 on working week mornings (Monday–Friday). These elevated tests reflect the unmetabolised ethanol from a prior night of drinking, and are unobtrusive indicators of level of drinking. Knowing which offenders logged two or more elevated BAC test results during the morning hours strengthened the predictive model by another 45% after accounting for all other factors (Marques et al., 2003b; Marques, Tippetts, & Voas, 2003a), including prior DWI status.

Predictive profiling that makes use of the alcolock record as a partial criterion for full re-licensing may come to be used by courts and licensing authorities. Paradoxically, if it does, it may cause offenders to use their alcolock vehicles less since any positive test results may delay relicensing and this would quickly render the record less valuable as a predictor.

Other advance indicators of drinking problem level will need to be available. So far alcohol biomarkers have seen virtually no use in North America but are increasingly used in Europe (Bjerre, 2003; Gilg, Buchholtz, & Huth, 2000) as part of driver fitness decisions. The use of biomarkers is under investigation in the Alberta alcolock programme and in time may provide useful risk information to re-licensing decisions.

The major difficulty with all of these novel technological approaches to detecting driver risk or intervening to rehabilitate drivers is the need to find a way to do so without forcing more high risk drivers out of compliance, and into the decision that it is simply easier to drive while suspended or revoked.

The future of alcolock programmes

The proliferation of alcolock programmes in North America and around the world indicates that alcolock programmes have finally come of age as a legitimate, viable and effective means of dealing with DWI offenders. As an increasing number of jurisdictions gain experience with operation and demonstrated success of alcolock programmes, they will move away from voluntary programmes and participation in such programmes will become mandatory for an increasing number of offenders. Programmes that are currently restricted to repeat offenders will become more inclusive, expanding to allow — or perhaps require — participation among first-time offenders as well. Many jurisdictions are already making such changes as a means to increase the number of offenders who are exposed to the beneficial effects of the programme. Mandatory participation will undoubtedly create challenges of its own, but until such time as participation rates are dramatically increased, the full potential benefits of alcolock programmes will fail to be realised.

As alcolock programmes become more widespread as a means to control the behaviour of convicted drink-drivers, increasing attention is being given to more universal application of alcolocks. Opposition to the universal installation of alcolocks in all vehicles has centred around the cost and inconvenience as well as the
fact that the majority of drivers do not drink and drive. Nevertheless, having a device in every vehicle that would prevent its use by any driver who has had too much to drink would virtually eliminate the drink-drive problem. An alcolock based on a passive alcohol sensing technology or transdermal ‘touch pad’ sensors may be sufficient to deter and prevent drink-driving among the general population. Considerable research and development — as well as public relations work — is required before this technology can be implemented in this manner.

Conclusion

Almost 20 years since they first introduced in-field trials, alcolock devices and programmes have reached a high level of maturity. Penetration into state and provincial legislation in the US and Canada has been thorough and supporting federal legislation endorsed them in both countries. Following the North American evidence and Sweden’s move to embrace a national alcolock programme, the European Union has moved to implement field trials. In North America, despite supportive legislation the level of adoption of alcolocks by courts continues to be disappointingly low, and motor vehicle authorities have rarely succeeded in getting them on the cars of more than 10% of drink-driving offenders. This is despite evaluation research that has consistently endorsed alcolock programmes as having a net positive benefit for improving highway safety.

Alcolock research has identified promising ways in which the alcolock benefit might be extended beyond the period of active installed use as well as approaches to identify in advance those drink-drive offenders whose drinking behaviour renders them at high risk for full relicensing without extended continuation of an alcolock restriction. However, few of these social benefits may accrue if the application of this technology to DWI control is not embraced by more courts, or unless more creative legislation is advanced by governments.

There remains some reluctance on the part of administrators and the courts to encourage the development of large scale alcolock programmes. Despite the positive research evidence on the effectiveness of alcolock programmes that has accumulated to date, there is an overriding scepticism about the potential of this approach to have a substantial impact on offenders. The legacy of past failures combined with high expectations for a long-term impact typically leads to the conclusion that ‘alcolocks don’t work.’

Overcoming this mental roadblock remains a challenge. Researchers need to continue to strengthen the evidential basis for alcolock programme-effectiveness, not only in terms of reduced recidivism but in terms of reductions in the number of alcohol-related crashes as well. More needs to be done to enhance the impact of alcolock programmes through integration with other countermeasure programmes, most notably rehabilitation.

The widespread adoption of alcolock programmes may require a fundamental revision of the traditional criminal justice approach to dealing with DWI offenders. There is a need to move beyond the crime and punishment mentality that has been pervasive in this field for many years. More severe unenforced sanctions are not only
the answer, they make the problem worse by creating an incentive for unlicensed driving. In this context, implementing an alcolock programme as yet another form of punishment for offenders misses the mark. The primary function of an alcolock is as a means of incapacitation — to prevent repeat occurrences of the behaviour. However, the alcolock also allows for socially-responsible behaviour such as driving to work and participating in family life.

Nonetheless, there are punitive aspects to alcolocks. They are inconvenient and impose a cost on the offender. An alcolock programme also requires some level of administrative control and monitoring — but they work. At this point, further improvements in the overall magnitude of the drinking-driving problem may depend on our approach for dealing with offenders. An approach that incorporates a balance of sanctions, incapacitation, and rehabilitation would appear appropriate. Alcolocks can play a valuable role within this perspective. The key is to break through the belief systems that have become firmly entrenched in the traditional criminal justice model. This will take time and effort and will require the involvement of other professionals. Drink-driving is a problem that exists at the intersection of health behaviour and criminal behaviour; we will benefit if our societal approach recognises both aspects and intervenes appropriately.

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The eleven evaluation studies are:


6

Mobile phones and car driving; cause for concern or action?

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Abstract

The present study attempted to compare the distraction from hands-free phone conversations to other common distractions in vehicles. 30 experienced drivers aged between 21 and 64 years drove a 17 km route in the TRL driving simulator for each experimental condition. Driving performance was significantly better during a baseline drive compared with the task conditions (hands-free conversation, in-vehicle tasks, or talking to a passenger). Overall, driving performance measures did not discriminate clearly between the three task conditions. The main, and most important exception was found with hazard detection performance. When drivers performed a choice reaction time task to warning signs, reaction time was significantly slower for the hands-free phone condition in comparison to the in-vehicle tasks, talking with a passenger, and the baseline drive. Subjective mental effort was rated highest for the hands-free drive and lowest for the baseline drive. Hands-free mobile phone conversation was significantly more demanding than either the passenger conversation or in-vehicle task drives. It is concluded that hands-free phone conversations impair driving performance more than these other common distractions.

Background

A survey in the United States has revealed that the vast majority (84%) of mobile phone users believe that using a phone is a distraction and increases the likelihood of an accident (IRC, 1999). The same respondents report however that 61% of them use their mobile phone while driving, and around 30% use their phone frequently or fairly often. Clearly, there is a common sense appreciation that it is likely to be difficult to concentrate on two things at once, but at the level of the individual driver there is a widespread confidence in the ability to perform such tasks, and the perceived risk increase is offset by the perceived utility of the particular phone call.
Since mobile phone use in cars is a relatively new phenomenon, and since the precise effects of mobile phone use on traffic safety are still unclear, laws regarding this subject vary between different countries. Legislators have been in a difficult position. There has been a willingness and desire to do something useful, but there has been a lack of clear evidence to help the decision process. Some countries use a mixture of legislation and recommendation, but are not consistent about the difference in hands-free and hand-held phone use. For example, in Italy only hands-free phones are allowed by law during driving. At the same time, however, the use of equipment that restricts the hearing senses (which presumably includes all types of mobile phones) is prohibited. The same situation exists in Spain, whereas in the UK, Portugal, Denmark, and Hungary only hand-held use of mobile phones is prohibited by law. Outside Europe, a hand-held prohibition exists in Israel, Malaysia and some states of the USA (Oei, 1998).

At one point in the 1990s, it had looked as though the problem for legislators would become easier. Research had highlighted the potential safety problems with driving and using handheld devices, and it seemed that the market was leading to the point at which car manufacturers would integrate well-designed hands-free telephones into their vehicles. Many interested experts claimed that driving and holding a carphone conversation was no more difficult than talking to passengers, and so removing the handset would, in effect, remove the problem. Unfortunately the market has gone in a different direction. Personal mobile phones are ubiquitous due to aggressive and cheap pricing regimes, but hands-free adaptation kits for use in vehicles, have not been popular. So, the use of handheld devices has actually increased across Europe in recent years.

An increased risk of motor vehicle collision has been associated with mobile phone use while driving using real world collision data (e.g. California Highway Patrol, 2002). This is supported by over 30 years of experimental research showing phone conversations impair driving performance both in driving simulators and in real road trials (e.g. Brown et al., 1969; Burns et al., 2002; Parkes et al., 1993). Despite this research, doubts still remain about the safety of phone use in cars.

Phone advocates argue that phones should not be singled out by safety legislation because they are no worse than the many other distractions in vehicles (e.g. passengers and radio). Conversely, there is some evidence that the act of holding a carphone conversation is fundamentally different to other in-vehicle conversations with passengers (Parkes, 1991a and 1991b). Recent legislation in the UK banning the use of hand-held phones while driving can only be effective if there is both the perception by the public that it is justified, and there is sufficient likelihood of detection and punishment to deter those who still see a benefit to using hand-held devices. The focus on hand-held equipment, whilst entirely understandable from an enforcement viewpoint, might have the undesirable consequence of seeming to some drivers to give tacit support for hands-free equipment. Though the key actors in the UK have been keen to emphasise responsible use of hands-free equipment, and have highlighted the potential to distract from safe driving, the fact remains that it is an allowable act, and that many drivers see it as a perfectly acceptable and routine activity.

A broad brush summary of the research literature might conclude that it has been demonstrated that hand-held devices promote worse driving performance than hands-free. This might be true, but is clearly only relevant at the operational control
level of the driving task. It is also clear that there is a mounting body of evidence to demonstrate that holding the conversation, and the distraction imposed, is the primary concern, as it can lead to reductions in tactical awareness of the traffic situation (Parkes and Hooijmeijer, 2000, 2001). The issue remains whether a conversation, albeit distracting, is of any greater concern because it is conducted on a carphone than if it was conducted with a passenger. There is also the concern that mobile phones are being subject to unfair attention. There are many tasks that can be argued to distract and detract from the primary objective of safe control of the vehicle; using an in-car entertainment system, adjusting the climate control system, and so on, but these are not regulated and legislated against. These other activities are seen as part of a normal set of actions and interactions consequent of driving within a modern social context.

This study aimed to investigate whether hands-free mobile phone conversations should be regarded as something fundamentally different to normal in-vehicle conversations and tasks.

**Objectives**

The objective of this study was to compare the distraction from hands-free phones to the distraction caused by conversations with passengers and in-vehicle tasks. It was hypothesised that hands-free phone conversations while driving are more distracting than talking with passengers. It was also hypothesised that driving performance will deteriorate during the phone conversation — more so than when performing conventional in-vehicle tasks.

**Method**

**Participants**

30 experienced drivers aged between 21 and 64 ($M = 40.9, SD = 12.39$) participated in this study. They were all healthy and experienced mobile phone users. The sample was split evenly by gender. The sample of mobile phone users was randomly selected from the TRL volunteer database, a pool of over 1,300 drivers representing a cross section of the local driving population.

**Equipment**

The TRL full-mission car simulator was used to perform this study. It consists of a medium size saloon car surrounded by $3 \times 4$ meter projection screens, giving 210 degree front vision and 60 degree rear vision, and enabling the normal use of all vehicle mirrors. The road images are generated by advanced silicon graphics’ computers and projected onto the screens. The car body is mounted on hydraulic rams that supply motion to simulate the heave, pitch and roll experienced in normal braking, accelerating and cornering. The provision of car engine noise, external road
noise, and the sounds of passing traffic further enhance the realism of the driving experience.

A professionally-fitted Nokia hands-free phone kit was used with a Nokia 3310 phone, the most common phone in the UK at the time. The phone bracket was mounted on the upper left side of the centre console of the dashboard within easy reach and view from the driving position. The in-vehicle radio tasks were performed on an aftermarket radio/CD player (Sony CDX — CA600). The original climate controls of the Rover 400 series car were used for the climate tasks.

Procedure

Participants were asked to drive as they normally would and to respond to the requests of the experimenter at various times during their drive. The order of the conditions was balanced. There were four driving conditions:

1. baseline drive;
2. in-vehicle tasks;
3. passenger conversation; and
4. hands-free carphone conversation.

The baseline condition consisted of driving only, without other tasks. Drivers performed in-car tasks while driving during the in-vehicle condition. These tasks consisted of adjusting the fan, fan mode and temperature on the climate system, turning on/off the CD player, adjusting the volume, changing track and searching through the tracks on the CD. The CD tracks were recordings of weather reports, traffic reports, news and various music styles taken from popular radio stations. These tasks were designed to represent tasks performed during a typical drive. The passenger condition consisted of set conversations with the experimenter sitting next to the driver. Conversations were also held with the experimenter using a hands-free phone during the hands-free condition. To complete the experimental design it was also decided to complete a conversation only condition as a further control. For this, the participant conducted the conversation away from the vehicle without involvement of any driving task, seated alongside the experimenter on normal easy chairs with no other distractions.

All drivers were familiarised fully with the simulator vehicle and given time to drive and get used to the handling characteristics and all aspects of the synthetic environment before the main trial commenced.

Conversation task: the topic for each conversation condition consisted of monologues, repeating sentences and verbal puzzles prompted by the experimenter at set points along the route. Questions were used from the Rosenbaum ‘Verbal Cognitive Test Battery’ (RVCB), which measures judgement, flexible thinking and response times (Waugh et al., 2000). The battery is composed of remembering sentence and verbal puzzle tasks with five levels of difficulty. These questions were balanced across the conditions and also included short monologues on familiar topics (e.g. 40 seconds describing a recent holiday).
Subjective workload measures were taken using the ‘Rating Scale for Mental Effort’ (RSME) at the end of each of the conditions (Zijlstra and Van Doorn, 1985). Upon completing the experiment, the drivers were debriefed on the exact aims of the study, and any questions they might have about the study were answered.

*Route and traffic scenarios:* participants drove a 17 km route that was composed of four different segments. The route started with a car-following task on a motorway.

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**Figure 1** View of lead vehicle in car-following task on motorway

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**Figure 2** View of warning symbol in choice reaction task on dual carriageway
(3.5 km). After this, drivers were instructed to drive as they would normally on a motorway. The three-lane motorway had a moderate amount of traffic and the speed limit was 70 mph (113 km/h), the standard speed for UK motorways. The traffic varied in speed and could overtake or be overtaken depending on how the subject drove. The motorway continued for 4.7 km. A section of curved road was used to measure the driver’s ability to control the vehicle on a more demanding type of rural road (3.6 km). The curves were followed by a 5.3 km section of dual carriageway (two lane road). During this section, drivers had to respond selectively to 24 warning signs at various points along the dual carriageway. They were instructed to flash their headlights whenever a particular target sign appeared. There were four different warning signs in this choice reaction time task: elderly pedestrians, pedestrian crossing, cyclists and roadwork. Each sign appeared six times. Examples of the road scene for car-following tasks and choice reaction tasks are given in Figures 1 and 2.

Results

Driving performance

There were significant differences in driving performance between the baseline drive and the three driving task conditions. Driving performance was significantly better during the baseline drive for standard deviation of lane position, standard deviation of following time-headway, standard deviation of speed and mean speed. There were no consistent significant differences across the passenger, in-vehicle and hands-free conditions for these same measures. Each of the tasks resulted in decreased performance.

A one-way repeated measures’ ANOVA was calculated for the median reaction time ratings across the four conditions (see Figure 3). The mean reaction time data was significantly skewed so median reaction times for the six events were used. This median

![Figure 3 Median reaction time to warning signs](image-url)
data was normally distributed. There was a significant main effect by condition for median reaction time \[F(2.4, 84) = 24.39, p < 0.001\]. There was a significant problem of sphericity with the data, so a Huynh-Feldt correction was used. Post hoc tests were run to compare the reaction times. Reaction time was significantly slowest for the hands-free phone condition in comparison to the in-vehicle tasks \((p = 0.046, \text{one-tailed})\), talking with a passenger \((p = 0.03, \text{one-tailed})\) and the baseline drives \((p < 0.001)\). Reaction times in the baseline drive were also significantly faster than during the in-vehicle task \((p < 0.001)\) and passenger drives \((p < 0.001)\).

The highest number of missed targets was in the hands-free drive \((n = 31)\) followed by the in-vehicle task drive \((n = 27)\) and passenger conversation drive \((n = 22)\). Only one target was missed in the baseline drive. This data was significantly skewed so a nonparametric Friedman’s test was used. The number of misses differed significantly across the four conditions \([\text{chi-square} = 21.6, p < 0.001]\). Post-hoc comparisons showed significant differences between the control drive and other drives. There were no significant differences among the other conditions and there were no significant differences in the number of false alarms.

### Subjective workload

A one-way repeated measures’ ANOVA was calculated for RSME across the conditions (see Figure 4). There was a significant main effect by condition for mental effort \([F(3, 84) = 23.49, p < 0.001]\).

Post hoc tests were run to compare the mean mental effort ratings by condition. Mental effort was rated highest for the hands-free drive and lowest for the baseline drive. The baseline drive required significantly less mental effort than hands-free \((p < 0.001)\), passenger conversation \((p = 0.001)\) or in-vehicle task drives \((p < 0.001)\).

Hands-free was significantly more demanding than either the passenger conversation \((p < 0.001)\) or in-vehicle task drives \((p < 0.001)\).
There was no significant difference in the mental effort ratings between the passenger conversation and in-vehicle task drives.

**Conversation measures**

For each of the following results there are three scores. The **control** condition refers to the conversation conducted away from the simulator vehicle where there was no concurrent driving task, the **passenger** condition refers to the conversation conducted with the front seat passenger while driving, and the **hands-free** condition refers to the same level of conversation conducted while driving but talking to the experimenter through the on-board carphone.

![Figure 5 Rate of talking during monologue](image)

Rate of talking was measured during the monologue part of the conversation task. This measure is associated with the difficulty of the task, yet it should be remembered that equivalent monologues were delivered in each of the three conditions. It was found that drivers in the control condition spoke consistently quicker than either of the driving conditions {\( F(2, 56) = 48.28, p < 0.001, n^2 = 0.63 \)}. It was also clear that drivers in the hands-free condition spoke slower than when talking to the passenger.

There was a similar pattern displayed when the number of correct answers to verbal puzzles was analysed.

These two figures show interesting patterns. There is a clear main effect for the number of correct responses to verbal puzzles {\( F(1, 93.8) = 3.74, p < 0.05, n^2 = 0.12 \)} showing not only that performance is worse when driving, but also that
there is a trend for a decrease in performance when talking to the experimenter through the hands-free carphone rather than when they are a front seat passenger. The pattern for the number of sentences repeated correctly is somewhat different. There is a clear main effect showing a difference between conditions \( F(1, 95.3) = 68.14, p < 0.001, \eta^2 = 0.71 \). In this case however, there is no substantial difference between the control and the passenger condition, and the noteworthy decrease is in the hands-free condition. This is not believed to be an artefact of the particular...
hands-free system in use. Although an independent intelligibility test was not conducted in this study, there was a consensus among the experimenters that the clarity and volume of the hands-free link did not place it at a disadvantage when compared to instructions given from the front seat passenger.

Discussion

The general pattern of results from the driving measures indicates that performance suffers when the driver is performing a simultaneous task. The deterioration of performance can be interpreted as an indicator of additional workload. In the baseline task the participant’s attention was focused fully on driving the vehicle. In the passenger, in-vehicle and hands-free conditions a portion of their attention was focused on completing the secondary task. From these results alone there is no basis for the conclusion that hands-free phones are worse for driving. However, reaction times are more seriously affected by talking on a hands-free phone than performing other tasks.

Reaction times to selected road signs were faster in the baseline condition than the other task conditions. Reaction times in the hands-free condition were slowest and there was no difference in reaction times between the passenger and in-vehicle conditions. In general, reactions are slower while driving and performing a simultaneous task, and talking on a hands-free phone has the largest effect on performance.

It can be argued that reactions govern most aspects of driving. Reaction has an even greater role to play in more complex road situations such as navigating junctions and responding to hazards. In these situations the performance deficit caused by hands-free conversations is likely to be further emphasised.

The subjective workload measures are consistent with the driving performance results. Participants rated the baseline drive condition as requiring the least mental effort and the hands-free condition as requiring the most. There was no difference in ratings for the passenger and in-vehicle conditions. The ratings for mental effort support the explanation for the driving results that using a hands-free system requires more attention than talking to a passenger or adjusting in-vehicle systems. Performance is affected to a greater extent in more difficult situations.

The relationship between the passenger and the hands-free conditions is interesting. Both allow drivers to retain full physical control of the vehicle, unlike with hand-held phones, and the conversations were equivalent. Therefore, it must be some aspect of the situation, apart from the driving and verbal task, which affects conversation performance.

There are several differences between conversations with passengers and conversations over a mobile phone that might help to explain why phone conversations are more distracting. Firstly, it may be easier to hear a passenger because of the imperfect quality of the speakers on the phone/vehicle and because of the occasionally poor reception of the mobile phone signal. This however, was not the reason in this particular experiment, the sound was always clear and adequate. It must be remembered that the passenger can adjust their loudness and enunciation to
improve communication as the situation demands and in response to immediate circumstances. Thus there may be subtle changes in volume or pacing that aid comprehension when driving task demands are high.

The intimacy model of Argyle and Dean (1965) assumes that a conversation may be influenced by the medium in which it is conducted. Though alternatives have developed, notably the formality model (Morley and Stephenson, 1969), the social presence model (Short et al., 1976) and the cuelessness model (Rutter et al., 1981). These models make similar assumptions about the way that a conversation may be influenced by the level of interaction of the participants. The thrust of the argument being that a lack of natural cues when the participants are separated visually, leads to a more impersonal style of conversation. Social impact theory states that the magnitude of social influence is a function of the strength, immediacy and number of sources of influence (Latané, 1981). According to this theory the passenger would exert more social influence than the phone conversation and this would impact the demand characteristics of the task. Another difference is that passengers may be aware of the traffic situation and can adjust their talking to the demands of the traffic, for example in real traffic, they might hold a question until after the driver has negotiated a roundabout. Similarly, passengers can serve as another pair of eyes to warn the driver of potential hazards (e.g. Stewart, 2000). These effects are likely to be minimal in the simulator setting given that the experimenter attempted to keep a level pace to the instructions in a similar fashion to the hands-free condition. Any differences observed here are likely to be magnified in a real world setting.

Several constraints were placed on the conversations in this experiment to ensure a fair comparison between the conditions. In reality, there are other factors that could make passenger conversations less distracting than phone conversations. Phone conversations may be more intense because someone has intentionally made the call; so they are more purposeful or goal directed. Since the passenger and driver are a captive audience, the conversation can be less urgent and the exchange of information slower.

The results would appear to indicate a relative increase in risk associated with a decrease in driver performance when drivers talk on hands-free carphones. Other recent research (Burns et al., 2002) has shown that decrements in performance when engaged in hands-free conversations can in some instances be equivalent to those seen when drivers are performing at the legal limit for alcohol. If it is clear that hand-held systems are likely to increase accident risk to unacceptable levels, then this and other recent research, would appear to indicate that there is potential for hands-free systems to do the same. Whilst banning the use of such systems might be viewed impractical because of the extreme difficulty in enforcing compliance, there appears a strong case for making the driving public aware of the potential dangers.

Conclusions

Driving performance clearly suffers when the driver is performing a simultaneous task. The results of most driving measures showed similar fall off in performance for each of the three driving conditions. However, there was an interesting and important difference in reaction time results that showed the worst performance scores in the
hands-free condition. This result was complemented by the subjective workload scores that showed hands-free conversation rated higher than in-vehicle tasks or talking to a passenger. By looking at the conversation itself, we have shown a distinct difference between talking over the carphone and talking to a passenger. There is an important difference between communicating with a passenger who is directly involved in the concurrent drive, and with one that is remote and uninvolved.

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References


Introduction

The European HASTE (Human Machine Interface And the Safety of Traffic in Europe) project has been carrying out a systematic set of studies examining the effect of distraction on driving performance. These studies have been carried out on a variety of driving simulators and instrumented cars, and have looked at driving on motorways, rural roads and urban roads. Two kinds of distraction have been considered, visual load and cognitive load, and both the amount of load in the secondary task and the difficulty of the primary driving task have been varied. This paper considers some of the broader implications of the findings, both from a practical point of view, i.e. what has been learned about the impact of distraction on driving, and from a methodological point of view, i.e. did the HASTE approach work and does it suggest the need for further development of assessment tools.

The aim of HASTE is to develop methodologies and guidelines for the assessment of In-Vehicle Information Systems (IVIS). The intention is to devise an assessment regime that is independent of the design of an IVIS and that is based on an evaluation of driving performance while using the system, as compared with driving performance when not using the system (baseline driving). The ambition is to provide an assessment regime which:

- is technology-independent;
- has safety-related criteria;
- is cost-effective;
- is appropriate for any system design; and
- is validated through real-world testing.
The theoretical schema behind the HASTE approach is illustrated in Figure 1. In-vehicle information systems can impose visual and/or cognitive loads on drivers. Such loads can be measured by glance behaviour and by various indicators of workload. The effects of load can be manifested by changes in driving performance (e.g. reduced speed, greater lateral variability, decreased time-to-collision) and interference of perception and judgement of the traffic situation (i.e. reduced situation awareness). Reduced performance has a negative impact on safety, which could be measured, for example, by the increased risk of a conflict. All of this is influenced in turn by the traffic environment and the current situation, which in a test environment becomes the scenario.

Figure 1  The HASTE approach

A further important theoretical underpinning of HASTE is the notion that load on a secondary task is an impairment in terms of driving and that most impairment-safety relationships are exponential in form. This hypothetical relationship is shown in Figure 2. It has been hypothesised in HASTE that driving performance will deteriorate as secondary task load increases, and that while drivers may be able to compensate for secondary task load when the primary task load from driving is relatively easy, they will have far less capacity to do so in more complex and more demanding driving situations. As a consequence, the project identified a need to vary both secondary and primary task load in a systematic manner. This led to the development and use of a ‘Surrogate IVIS’ (in fact two surrogate IVIS or S-IVIS, one for visual load and one for cognitive load) to create controlled distraction. These two S-IVIS were used in all the experiments described here. Subsequent work in HASTE will examine how assessments of real IVIS map on to the results obtained with the surrogate IVIS. In carrying out the experiments, safety was assured by limiting IVIS task load in the real-road drives. In fact three levels of each S-IVIS were tested in the simulator and laboratory environments, but the maximum level tested in the real-road drives was in most cases a level ‘2.5’. This needs to be borne in mind when making comparisons between the effects of the most demanding IVIS in the different test environments.
Method

The approach adopted to examine driver behaviour was to require drivers to interact with a specially created or ‘surrogate’ IVIS (S-IVIS) at various points in their driving. Two different S-IVIS were used, one visual in the form of an arrows’ search task, and one cognitive in the form of an auditory memory task. Each task had three levels of difficulty, although for the on-road driving the hardest level of the visual task, level 3, was less difficult than it was in the simulator driving. This was because of concerns about maintaining safe driving. S-IVIS level was a within-subject factor, but S-IVIS type was a between-subject factor. Timing and pacing of the S-IVIS was fixed, i.e. the tasks were system-paced rather than driver-paced. This was so that the ‘dose’ of IVIS would always be known.

In addition to ‘average’ drivers, aged 25 to 50, older drivers, aged 60 and above, were used in some of the experiments. The minimum driver group was 24 participants (where older drivers were studied, there were at least 24 average and 24 older drivers).

For the simulator experiments, three different road layouts were created: an urban road, a rural road and a motorway. Within each of these roads and within a single drive, there were two levels of difficulty for the urban and motorway roads (level 1 without and level 2 with scripted events). In the rural road there were three levels of difficulty: straight sections (level 1), curved sections (level 2) and sections with events such as the car in front braking (level 3). All the three S-IVIS levels were encountered in each road level. In addition to driving with an S-IVIS, subjects also drove the road in baseline condition, without an S-IVIS. The S-IVIS drives and baseline drives were counterbalanced. Road type was a within-subject factor. The simulator experiments were conducted at six sites, as shown in Table 1. Each site studied both the visual and the cognitive S-IVIS. Elderly drivers as well as average

![Hypothetical IVIS task load and risk](image)
Implications of the first set of HASTE results on driver distraction

Drivers were studied in Leeds, but it proved impossible, because of simulator sickness, to investigate elderly drivers’ performance with the visual task.

The simulators at Leeds, Transport Canada and VTI are of comparable performance, being fairly sophisticated static simulators. The TNO simulator has a small moving base, while the VTI simulator has a large moving base. The Minho simulator has a set-up that is more like a simple laboratory setting, with the car being replaced by a seat and games-type vehicle controls and the projection by a video monitor. One dimension of the study was therefore simulator sophistication.

There was a concern that the Portuguese drivers might behave in a more risky manner, thus interfering in the attempt to investigate whether the Minho laboratory set-up was as usable as the more sophisticated simulators. Therefore an extra study was carried out, using UK drivers recruited in Portugal who drove on the Minho simulator. Their performance could then be compared with that of the Portuguese drivers to ascertain whether we were observing a simulator sophistication effect or a Portuguese driving style effect.

Overall there were a total of 14 simulator experiments. There were 12 basic experiments (the six simulators across the two types of S-IVIS) plus the additional studies of the UK drivers in Portugal (one study for each S-IVIS).

In the field (on road) studies, both types of S-IVIS could be investigated for each participant, but this was only done at some sites as shown in Table 2. Where more than one road type was studied, this was done in a single drive. Thus there were a total of four separate field experiments, making 18 separate experiments in total.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Simulator experiments</th>
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<td><strong>Site</strong></td>
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<td>Volvo, Sweden</td>
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<table>
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<th>Table 2</th>
<th>Field experiments</th>
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<tr>
<td><strong>S-IVIS</strong></td>
<td><strong>Site</strong></td>
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<td>Visual</td>
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The data collected included a large number of indicators of driving performance as well as performance on the S-IVIS task. Performance on the relevant S-IVIS was also observed statically, i.e. not while driving to see whether, as has been suggested,
static performance can be used as a predictor of the safety of IVIS use while driving. The definition and format of all the variables was agreed in advance of the studies.

The major dimensions of the study were therefore:

- **S-IVIS type**
  - within S-IVIS type, S-IVIS level; and
  - within S-IVIS type, static S-IVIS performance vs. dynamic performance.
- **Simulator vs. Field**
  - simulator type
- **Road category (urban, rural, motorway)**
  - road level
- **‘Average’ vs. elderly drivers**
- **UK drivers vs. Portuguese drivers**

**Overview of results**

It is impossible in a short space to cover all the findings of such a large number of experiments. It can be argued that the project has investigated the relationship between distraction and driving performance more fully and more systematically than any previous investigation. The full report on the studies will shortly be available as *HASTE Deliverable 2*. Instead, we will now present a brief overview of some of the major findings along most of the major dimensions of the investigation.

**S-IVIS type**

The visual task led to degradation of steering behaviour and lateral control of the vehicle. This is illustrated in Figure 3, which shows the effect of S-IVIS use on steering reversal rate from the Leeds simulator.

For the cognitive task, by contrast, the major negative effect is more on longitudinal control, particularly in car following, rather than on lateral control. This is illustrated in Figure 4, again from the Leeds simulator study, which shows a tendency for minimum time headway to decrease as the cognitive task becomes more difficult. The effect is more pronounced for the older drivers, whereas there are indications that the ‘average’ drivers surrender on the secondary task at its most difficult level. In terms of a reliable measure of deteriorating driving performance as secondary task load increased, the drivers’ self-rating of their driving was the best indicator.
There is also the strange phenomenon of an apparent ‘improvement’ in steering behaviour with increased cognitive task load, as shown, for example, in steering patterns: reversal rates decreased with S-IVIS level indicating ‘better’ lateral control. Eye movement analysis, carried out in some of the studies provides a possible explanation of this. With increased task load there was greater concentration of glances on the road straight ahead as opposed to the periphery, i.e. greater visual funnelling. This is illustrated in the spectral density plot of gaze angle in Figure 5. This concentration of gaze may account for the improved tracking in that the drivers are then subconsciously aiming for the point at which they are gazing.
The important question is whether there is a ceiling effect for the negative effects of distraction as the secondary task becomes more difficult. If so, this would be an indication that drivers are aware of the risk and seek to manage or limit their distraction. They could do this by switching off from interaction with the secondary task when they felt it was requiring too much attention. There are indeed some signs of just this strategy: driving performance was not always worst at S-IVIS level 3 and drivers generally performed worse in terms of percentage of correct responses at S-IVIS level 3 when driving, as compared with static task performance. However, drivers were by no means always able to manage the trade-off between primary and secondary task performance. This can be seen from Figure 6, which shows lateral position variation with the visual task on the VTI simulator. Drivers were able to manage their secondary task interaction on the straight and curved sections, but in the most difficult road section, those with events such as the lead car braking, did not successfully drop the S-IVIS when it became most difficult and the greatest interference in their lateral control was at S-IVIS level 3.

Comparison of static and dynamic S-IVIS performance

Generally, the studies here found that there was an interaction between S-IVIS performance across the baseline (static) and three levels of dynamic situation (i.e. the three levels of road difficulty). This confirms the HASTE approach of requiring driving context to be considered in assessing IVIS. Static performance did not reliably predict dynamic performance. Figure 7 illustrates this. As already stated, drivers generally performed worse in terms of percentage of correct responses at S-IVIS level 3 when driving as compared with static task performance.
Simulator vs. field

The field studies tended to pick up somewhat different effects of the systems to those of the simulator studies. One set of field drives, carried out by VTT in Helsinki, captured interaction with pedestrians at a zebra crossing (see Figure 8). With the visual task, there are some signs of poorer interaction, but with the cognitive task there is a striking deterioration. Drivers seem to be losing situation awareness, i.e. their understanding and prediction of pedestrian behaviour is affected. We do not know, since glance behaviour was not measured in this study, whether the gaze concentration effect of the cognitive task that has been noted above provides a partial explanation.

Additionally, it has not proved possible to test elderly drivers with the arrows task in the Leeds simulator, because of simulator sickness. This shows the value of the field tests. The problems observed in interaction with pedestrians suggest that the incorporation of some additional scenarios or tests in the simulator roads should be
considered. These could perhaps take the form of detecting objects in the periphery or detecting changes in the peripheral scene.

**Simulator type**

The broad conclusion is that the type of simulator or laboratory used in the assessment did not have an effect. If confirmed in the later work of the project, this may mean that a low-cost simulator is just as effective as a more elaborate one for IVIS evaluation.

**Road category**

In the simulator studies, the rural road was the most diagnostic and the motorway the least diagnostic, i.e. the effect sizes from the rural road were generally larger. The urban road did not pick up any additional information that was not provided by the rural road. This means that, for simulator and laboratory assessments, the rural road can be used as the sole road category in the later work of HASTE assessing real IVIS systems as well as in the final HASTE test procedure. In the field studies with the ACMT, the motorway produced the only indicator with a consistent effect, namely the drivers’ self-rating. Thus for the moment, the project is continuing to use real drives on motorways as part of the procedure for evaluating IVIS systems.

‘Average’ vs. elderly drivers

The findings have confirmed the hypothesis, advanced in deliverable 1 of the project, that there would be severe problems for elderly drivers in using IVIS while driving, particularly at higher levels of task demand. This can be illustrated by Figure 9, which shows lane discipline when driving with the visual task on real roads in Helsinki. The average drivers are able to manage the problem to some extent, but for the elderly drivers there is a severe impact of the secondary task and the negative effect increases by S-IVIS level. The results point to the fact that resources are needed for the task of resource management. With elderly drivers these ‘management’ resources may not be available, so that they are not able to close off the secondary task when required.
UK vs. Portugal

The controlled comparison of the British and Portuguese showed the expected effect: the Portuguese drivers exhibited riskier driving behaviours, such as shorter headways and higher speeds. But, reassuringly, the ANOVA analysis revealed there was no interaction effect of the ‘country’ factor. In other words, in a future test regime results obtained with Portuguese drivers should be as reliable as those obtained with drivers from northern Europe.

Conclusions

The effect of the S-IVIS visual task on driving is very clear and direct: increased distraction leads to problems in lateral control. However, the effect of cognitive task is more complex, in that some driving parameters, particularly related to steering control and lateral position appear to improve. However, this improvement seems to be an artefact of greater concentration on the road straight ahead at the expense of information acquired from the periphery. Since we know that information acquisition from the periphery is vital for detecting threats and hence for safe driving, this effect can be considered to be negative in terms of safety. Thought needs to be given to tasks or tests that, as part of an evaluation protocol, might capture this loss of information acquisition from the periphery.

Motorway driving in the various simulators and the laboratory was generally less diagnostic and urban driving did not provide any additional test. Thus the simulator testing regime can seemingly be based just on rural driving. The same was not true of the real-road evaluation, where the motorway driving produced the only reliable indicator. In general, the field studies provided some information that was not provided by the simulator assessments. The subsequent work in the project will have to consider whether real-road drives need to be retained as part of an evaluation regime, or whether some additional simulator tasks can provide analogous information.
Interactions between sleepiness and low blood alcohol levels — an update on the Loughborough findings

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Executive summary

Both alcohol and sleepiness are known to be major contributors to road traffic accidents in the UK. There has been much debate on whether the current legal blood alcohol concentration (BAC) limit for driving (0.08%) should be lowered to 0.05% like several other countries in the European Union. The present limit may be satisfactory when a driver is fully alert, however the pressures of today’s society mean that an increasing number of people may be sleep-deprived. The consequences of a sleepy person driving after drinking a current legally acceptable amount of alcohol have not been fully investigated. This report summarises the results of a three year study into the interaction of sleepiness and moderate alcohol intake.

An initial literature review identified specific areas that needed to be investigated. Our research takes a ‘lifelike’ scenario, with only moderate sleep restriction (5h in bed at night) and moderate alcohol consumption, producing BACs of approximately half the UK legal driving limit. The drive, on a simulated dual carriageway, lasted for 2h and was very monotonous.

The research programme was split into four main areas:

1. young men (the most at risk group of drivers for sleep-related crashes) driving in the afternoon (a time when the number of sleep-related crashes are known to increase), under a $2 \times 2$ experimental design (with and without alcohol at lunchtime) and (with and without the prior night’s sleep restricted to 5h);

2. an identical gender comparison using young women;
3. a time of day comparison using young men, but with the drive and alcohol consumption taking place in the early evening (a time of day when we are naturally more alert); and

4. a near-zero BAC, when young men have the same alcohol intake as in (1) but earlier, such that their BACs have reduced to nearly zero before starting the afternoon drive.

During the afternoon circadian trough the driving performance of both men and women is severely impaired when moderate sleep restriction and alcohol consumption are combined. Of particular concern, is that men seem to be unable to perceive this greater impairment. Women generally appear to have better perception of alcohol impairment, even without sleep loss. Unlike men, women’s driving is less impaired by modest amounts of alcohol when they are alert, which seems to be because they know their performance is affected and thus apply more compensatory effort. On the other hand, their impairment after alcohol when combined with sleep loss is well in excess of any compensatory effort.

Time of day also affects impairment after alcohol and/or sleep loss. Driving performance is generally better during the early evening hours, when we are naturally more alert, compared with the afternoon, and for all conditions. Moderate alcohol intake does not impair driving performance during the early evening, unlike during the afternoon. However, if combined with sleepiness, increased driving impairment does become apparent during the early evening, although, not to the extent that it is during the afternoon.

BACs are not a good indicator of alcohol-related driving impairment, especially when combined with sleepiness. During the afternoon, even when BACs fall almost to zero at the start of a drive, sleepy drivers are still more impaired for the first hour of the drive if they have consumed this modest amount of alcohol at lunchtime. An unexpected rebound improvement in driving performance is seen in the second hour of the drive. In non-sleep deprived, alert drivers, these same near zero BAC levels did not affect driving performance or significantly increase subjective sleepiness.

Our overall results indicate that, combined with modest sleepiness, the current legal drink-drive limit (0.08%) is too high. This outcome supports recent and extensive findings with fatal and serious road crashes in France (Philip et al. 2001). During the afternoon, a time of day when people are naturally less alert BACs of less than half this UK limit will impair driving even in non-sleep deprived people. If drivers are also sleepy, this combination produces dangerous levels of impairment during the afternoon; the combination also leads to impairment (but to a lesser extent) in the early evening. All these driving impairments would be greater if the sleep loss was greater and/or BACs were higher, but just under the legal limit. Greater public awareness is required in knowing the danger of driving after consuming any alcohol when tired or sleepy.

**Introduction**

**Background**

In the UK the legal limit for driving is a blood alcohol concentration (BAC) of 0.08% (80mg of alcohol per 100ml of blood; ‘80mg%’). This BAC has an
equivalent breath alcohol concentration (BrAC) of 35 μg alcohol/100ml breath. Throughout the European Union there are three principle alcohol limits in force for drivers: 0.08% (as in the UK), a lower limit of 0.05% (e.g. Germany), and 0.005% (effectively zero) as in Sweden, for example. In the USA, drink-driving limits vary between states, but many have a limit of 0.10% for drivers over 21 years’ old, and a limit of only 0.02% for those under 21. A zero limit does create a greater workload for police forces, more arrests, and would be unacceptable to the UK public (Dunbar et al. 1987). In 1998 the government consulted on whether to lower the UK drink-drive limit to 0.05%, however no action was taken due to a European Commission review on a possible Europe-wide drink-drive limit. If the UK was to adjust its own limit, we may need to adjust to European regulations soon afterwards, causing confusion.

In recent years, public awareness on the dangers of drink-driving has increased and as a result driving whilst over the limit has become socially unacceptable. More recently, public awareness has increased over the risks of driving whilst tired. It is likely that in the UK, alcohol and sleepiness cause similar numbers of road traffic accidents. However, sleepiness is more difficult to identify as a cause of a road crash. Drivers are unlikely to admit to having fallen asleep at the wheel, and unlike alcohol-related crashes there is no definitive proof. It is also possible that sleepiness is a contributing factor in many crashes where alcohol is involved, whether above or below the legal limit.

Little is known about the combined effects of alcohol and sleepiness on driving performance. Increasing pressures in today’s society are claimed to be causing people to reduce the time they spend asleep; 26% of Americans believe that a successful career and adequate sleep cannot be combined (Dement 1997). Combining reduced sleep time with a lunchtime alcoholic drink may have detrimental effects on a mid-afternoon drive when we naturally feel sleepier than at other times of day. A recent report looking at road crashes in France during 1994–1998, found that fatigue, especially when combined with alcohol, presented a high risk of being involved in a road crash resulting in death or serious injury, compared with alcohol or fatigue alone, even with BACs as low as 0.01% (Philip et al. 2001).

It is important to establish to what extent driving performance is affected by combining moderate alcohol consumption (at a legally accepted level for driving) and moderate sleep loss. The legal limit for driving at present may be reasonable for rested non-sleepy drivers, however, when low doses of alcohol below the legal limit are combined with sleepiness, performance impairment may increase well above the acceptable level for safe driving.

**Literature review — alcohol, sleepiness and performance, with reference to driving impairment**

An initial literature review, concentrated on the pharmacokinetic and pharmacodynamic properties of alcohol, as well as its effect on performance, with particular attention to simulated and real-car driving studies. Literature comparing alcohol-induced impairment with that of sleepiness was reviewed, followed by the limited number of studies that have investigated impairment caused by combining
the two factors. Of the key points identified from the review, the following were considered to be of most importance, and as a result the research programme was designed around these points:

- Monotonous tasks involving either passive concentration or, reasonably difficult discrimination (divided attention), are most sensitive to alcohol.

- There appears to be a lack of perception of performance impairment following alcohol combined with sleep loss. There is a need for subjective ratings during the drive to monitor this.

- Men and women show marked differences in the pharmacokinetic properties of alcohol and, therefore, should be treated as separate experimental groups.

- The majority of studies on the effects of alcohol on performance have been carried out in the morning. Lunchtime onwards would appear to be a more realistic time to administer alcohol, and simulating everyday life.

- Performance impairment on some tasks at low BACs, may only be evident during the two peaks (early morning and mid-afternoon) of circadian sleepiness, and in contrast to the circadian peak (acrophase) in alertness during the early evening.

- BACs are not a good indicator of performance impairment. Residual sedation and decrements in performance have been found long after BACs have reached zero. This has not been investigated with driving or in already sleepy people.

**Research phases**

Following the review, a research plan was formed which consisted of four main phases:

1. Combining moderate alcohol consumption and sleepiness in young men: the effect on driving performance in the afternoon.

2. Gender comparison — combining moderate alcohol consumption and sleepiness in young women: the effect on driving performance in the afternoon.

3. Time of day comparison — combining moderate alcohol consumption and sleepiness in young men: the effect on driving performance in the early evening.

4. Near-zero BrACs — combining moderate alcohol consumption and sleepiness in young men: the effect on driving performance in the afternoon when BrACs are approaching zero.

**Brief methods**

The methodology for each phase is very similar, specific methods are described in the appropriate appendices.
Participants for all four phases underwent four separate conditions in repeated measures, balanced design. The conditions were:

- normal sleep + no alcohol;
- 5h restricted sleep (02:00h–07:00h) + no alcohol;
- normal sleep + alcohol; and
- 5h restricted sleep (02:00h–07:00h) + alcohol.

Alcohol was consumed 30–45 minutes before the start of the drive (except in phase 4 [near-zero BrACs], when it was consumed 90–105 minutes before the start of the drive), diluted with 300ml orange juice. Men were given 75ml 37.5% proof vodka, and women 65ml (producing similar target BrACs). The participants were ‘blind’ to the presence of alcohol (in the non-alcohol conditions the rim of the glass was dipped in vodka).

Participants underwent a 2h simulated drive on a monotonous dual carriageway. The drive commenced at either 14:00h or 18:00h for the afternoon (phases 1, 2 & 4) and evening (phase 3) respectively. Driving performance (lane drifting), subjective sleepiness and the EEG were monitored throughout the drive.

Phase 1: combining moderate alcohol consumption and sleepiness in young men: effect on driving performance in the afternoon

Summary

The objective was to assess whether low BACs, around half the UK legal driving limit, and undetectable by police roadside breathalysers, further impair driving already affected by sleepiness, particularly in young men, who are the most ‘at risk’ group of drivers.

12 healthy young men drove for 2h in the afternoon (14:00h–16:00h), in an instrumented car on a simulated dual carriageway. In a 2\times2 repeated measures, balanced design, they were given: alcohol vs. placebo and normal sleep vs. prior sleep restriction. Measurements were: driving impairment (lane drifting), subjective sleepiness, and EEG measures of sleepiness.

Whereas sleep restriction and alcohol each caused a significant deterioration in all indices, the combined effect further and significantly worsened lane drifting (which typifies sleep-related crashes). This combined effect was also reflected to a significant extent in the EEG, but not with subjective sleepiness. That is, alcohol did not significantly increase subjective sleepiness in combination with sleep loss when compared with sleep loss alone. Modest, and apparently ‘safe’ levels of alcohol
intake exacerbated driving impairment due to sleepiness. Sleepy drivers seemed not to have realised that alcohol had increased their sleepiness to an extent that was clearly reflected by a greater driving impairment and in the EEG.

**Key points**

- Due to the natural circadian dip in the afternoon, drivers are more liable to be sleepy, especially after a night of disturbed sleep. Under these conditions alcohol may be particularly potent.

- Alcohol itself has a soporific effect that accentuates underlying sleepiness, even with BACs well within the legal limit.

- In young men, moderate sleep loss combined with low, legal BACs well within the ‘pass’ region of roadside breathalysers, produces a marked worsening of driving impairment compared with either sleep loss or alcohol alone. This added effect is mirrored by an increase in ‘sleepy’ characteristics in the EEG. However, this added effect was not reflected by any increase in their perception of sleepiness.

- Young men who are moderately sleepy seem unable to perceive a further increase in sleepiness due to alcohol intake, and may have a greater driving impairment than they realise.

**Phase 2: gender comparison — combining moderate alcohol consumption and sleepiness in young women: the effect on driving performance in the afternoon**

**Summary**

This study replicated that with men (phase 1), but recruited young women participants. There are distinct physiological gender differences in the absorption, metabolism and central nervous system (CNS) effects of alcohol. It is possible that these also differentially affect driving performance and sleepiness in women. The alcohol dose was reduced from 75ml (3 units), as in men, to 65ml in the women, to produce similar BACs.

12 healthy young women drove for 2h in the afternoon (14:00h–16:00h), in the instrumented car on a simulated dual carriageway. In a 2 × 2 repeated measures, balanced design, they were given: alcohol vs. placebo and normal sleep vs. prior sleep restriction. Measurements were: driving impairment (lane drifting), subjective sleepiness, and EEG measures of sleepiness.

Sleep restriction significantly worsened driving performance and subjective sleepiness, as with men. Surprisingly, unlike men, women showed no apparent...
adverse effects of the alcohol alone on these indices; seemingly, they compensated. However, alcohol’s effects were profound when combined with sleep restriction. Nevertheless, the women were aware of this enhanced sleepiness, unlike men. After alcohol the EEG showed increased beta activity, which was not seen in men, and indicated a differential pharmacokinetic effect of alcohol on the CNS and/or that the women were applying more compensatory effort. Debriefing questionnaires showed that the women were aware of the varying risks of driving under the different driving conditions. Legally ‘safe’ BACs markedly worsen sleepiness-impaired driving in women. However, women seem aware of their impaired driving, and able to judge the degree of risk entailed. Such an attitude may contribute to the lower incidence of sleep and/or alcohol-related road crashes in women compared with men.

Key points

- Low BACs in otherwise alert women drivers do not appear to impair driving to the extent it does in men, probably because women apply more compensatory effort.

- However, when combined with moderate sleepiness, this same BAC level has a profound effect on women’s ability to drive and their subjective sleepiness; to a greater extent than that seen in men.

- Women however, seem more aware of this sleepiness and are able to judge the comparative driving risks involved.

- The much lower sleepiness and/or sleepiness-related crash rates in women may be due to their particular cognisance of these driving impairments.

Phase 3: time of day comparison — combining moderate alcohol consumption and sleepiness in young men: the effect on driving performance in the early evening

Following the completion of all conditions by eight participants, during this evening driving phase, the findings were clear. Owing to resource limitations, it was decided to divert the remaining four intended participants to phase 4, which was running in parallel and revealing interesting findings that required extra participants.

Summary

This phase provided a time of day comparison for the afternoon findings (phase 1), with men. It examined whether low BACs, at around half the UK legal driving limit,
and in both alert and sleep restricted drivers, impair driving performance during the early evening, when circadian influences aid greater alertness.

Eight healthy young men drove for 2h in the early evening (18:00h–20:00h), in the instrumented car on a simulated dual carriageway. In a $2 \times 2$ repeated measures, balanced design, they were given: alcohol vs. placebo and normal sleep vs. prior sleep restriction. Measurements were: driving impairment (lane drifting), subjective sleepiness, and EEG measures of sleepiness.

Whereas sleep restriction produced significant impairments to driving and subjective sleepiness, alcohol alone did not. However, alcohol combined with sleep restriction significantly worsened all indices when compared with sleep restriction alone. The combination also significantly worsened driving and subjective sleepiness when compared with alcohol alone. The extent of these findings was less than those found for afternoon driving with identical interventions. Although low BACs may not affect driving in normally alert drivers in the early evening, the addition of moderate sleep restriction still produces a dangerous combination. Probably, there is no ‘safe’ level of alcohol intake for otherwise sleepy drivers, at any time of the day.

Key points

- In the early evening, low alcohol intake in alert drivers, did not significantly impair driving or cause any increase in subjective sleepiness or EEG.

- However, when combined with moderate sleepiness, low BACs produced greater driving impairment than the sum of the effects produced by sleepiness and alcohol alone. This worsening was mirrored by increases in subjective sleepiness and EEG indices of sleepiness.

- The outcome from combining sleep restriction with alcohol intake in the early evening was less than the combined effect seen in the afternoon (phase 1).

- However, even when people are usually most alert, during the circadian peak period, consumption of a ‘legally safe’ level of alcohol by a partially sleep-deprived person intending to drive, still produces a dangerous combination.

Phase 4: near-zero BrACs: the effect on driving performance in the afternoon when BrACs have fallen almost to zero

This phase evolved into two components, with the first taking the standard format with 12 participants. As a result of interesting trends, we switched some participants
intended for phase 3, to this phase 4 and added another eight participants, each undergoing just the two sleep-restricted conditions. Thus in total, phase 4 comprised 20 participants.

Summary

Epidemiological findings (Philip et al. 2001) point to very low BACs (less than 10mg/%) heightening the risk of sleep-related fatal road crashes. In phase 1, driving impairment was still present at the end of the drive even when BrACs had reached zero. The objective of phase 4 was further to assess these findings by advancing the near zero BrAC to the beginning of the drive.

12 healthy young men drove for 2h in the afternoon (14:00h–16:00h), in the simulator. In a 2 × 2 repeated measures, balanced design, they were given: alcohol vs. placebo and normal sleep vs. prior sleep restriction. Following this an additional eight young men underwent just the two sleep-restricted conditions. Three units of alcohol were consumed 90 minutes before the start of the drive (i.e. an hour earlier than was the case in phase 1), leading to near-zero BrACs on commencement of the drive. Measurements were: driving impairment (lane drifting), subjective sleepiness, and EEG measures of sleepiness.

During the drive, near-zero BrACs had little effect on driving performance and sleepiness levels in non-sleep-restricted, alert drivers. However, if they were already sleepy (having been sleep-restricted), near-zero BrACs produced interesting effects. First, and compared with nil alcohol, the alcohol condition increased sleepiness-related driving impairment for approximately the first hour of the drive. However, this was not mirrored by any increases in subjective sleepiness or in EEG changes indicative of sleepiness. An unexpected reversal (i.e. improvement) in driving impairment occurred in the second hour of the drive with the alcohol group. This was supported by a trend for improved subjective alertness. The worsened driving during the first hour, when alcohol was combined with sleep restriction, after BrACs had reached zero, together with the concurrent lack of any increase in perceived sleepiness, further points to the dangerous combination of sleepiness even with modest alcohol intake, and supports the epidemiological findings of Philip et al. (2001).

Key points

- Following modest alcohol intake by alert young men at lunchtime, leading to near-zero BrACs during afternoon driving, there is no increase in driving impairment or sleepiness.

- However, if they have been sleep-restricted, leading to increased afternoon sleepiness, then this near-zero BrAC will produce an initial driving impairment, which is not mirrored by any increase in subjective sleepiness. Thus, there again appears to be a lack of perception of the driving impairment.

- After this initial impairment under the combined alcohol and sleepiness condition, there is a rebound improvement in driving performance. This biphasic
effect may be due to an alcohol rebound and/or an advance in the circadian late afternoon rise in alertness.

- Consuming moderate quantities of alcohol when one is sleepy and planning to drive, is hazardous to driving even if BrACs have fallen to zero.

Conclusions

In alert (non-sleep-restricted) drivers, but during the afternoon when there is a natural dip in alertness, BrACs less than half the UK legal driving limit are more detrimental to driving performance in men compared with women. However, women believe that their driving performance is affected, and it seems that they apply more compensatory effort to counteract any effect that alcohol may be having. If sleep during the previous night is restricted by two to three hours, to five hours, then afternoon driving impairment in men is similar to that with the alcohol alone. Women’s driving was also impaired by this sleep restriction, and compensatory effort was not evident.

Combining moderate alcohol consumption with moderate sleepiness, however, produces altogether different results. Both men’s and women’s driving performance is severely impaired under these conditions, and during the afternoon, with women showing a greater detriment in driving ability. However, despite being more affected, women appear to perceive this impairment better than men. In men, the lack of a further increase in subjective sleepiness with alcohol, compared to when just sleepy, and despite increases in driving impairment and EEG measures of sleepiness, indicate that they are unable to perceive their worsened impairment.

Gender differences in perception of impairment after alcohol consumption, with women seemingly being more conscious of the effect that alcohol has on their driving appears to cause them to apply more compensatory effort to counteract its effect. When the women drivers are alert, their compensatory effort counteracts any impairment, however if they are sleepy, the impairment is greater than any compensatory effort.

Men account for 90% of drivers involved in sleep-related crashes on UK roads (Horne & Reyner, 1995), but the percentage of these drivers with legally safe alcohol levels is unknown. Although men have greater exposure to driving (Li et al. 1998) and are more likely to be on the roads at the time of day when sleep-related crashes occur (Horne & Reyner, 1995), it may be that women choose to avoid driving at these times, or are more likely to stop driving when they feel incapable of doing so.

Men account for 85% of UK drivers over the legal limit when breathalysed (DfT, 2002). If women are better at perceiving alcohol’s effects, then they may choose not to drive after consuming alcohol. In conversation, when having consumed alcohol under the two alcohol conditions, the majority of our female participants felt that they were over the legal drink-drive limit (despite their BrACs showing them to be approximately half that value). Men appear either to have a reduced ability to perceive this impairment, or they deny it, especially when sleepy.
In the alert driver, time of day is also a contributory factor to the extent to which performance is affected by alcohol. In men, greater impairment with alcohol was seen during the afternoon compared to an early evening drive, which is to be expected as the former coincides with the afternoon circadian dip in alertness, whilst the latter is when the circadian rhythm approaches a time of greatest alertness. Despite having little effect in alert drivers during the early evening hours, when sleepy, alcohol does impair driving performance at this time, although not to the same extent as during the afternoon.

BrACs are a poor indicator of driving impairment when drivers are already sleepy. Despite near-zero BrACs, drivers were still impaired and again there was an apparent lack of perception of this decrement in performance in the men. An unexpected rebound improvement in driving performance was seen later in the drive. The initial decrement in performance is a matter for concern. A sleepy individual who waits, after drinking alcohol, for his or her BrAC to return to zero before driving is still placing themselves, unknowingly, at risk. This message needs to be publicised widely, together with the fact that the only safe level of alcohol in the body if planning to drive is zero especially if one is sleepy.

References


Introduction

Conservative estimates suggest that driver tiredness contributes to at least 20% of fatal accidents on motorways and major UK roads and 10% of all accidents: this equates to approximately 350 fatalities each year. To combat the problem, the DfT has made significant efforts to improve public awareness of the issue, with the launch of the first TV campaign focusing on driver tiredness; radio adverts running during holiday periods, when drivers are more likely to undertake long distance journeys; together with motorway variable message signs displaying the phrase ‘Don’t Drive Tired’. Undoubtedly this campaign is beginning to have an effect, both on public perceptions of driver tiredness and of effective short-term countermeasures that drivers can employ to address the problem.

The government’s advice for tired drivers is based on research undertaken by Loughborough Sleep Research Centre, and is listed below:

- don’t start a journey if you are already tired;
- plan your journey to include 15 minute breaks every two hours;
- avoid making trips between midnight and 6am; and
- if you do feel tired, find a safe place to stop, then;
  - drink 1–2 cups of strong coffee;
  - caffeine takes 20–30 minutes to take effect so during this time have a short nap of between 15–20 minutes.
Professional drivers face additional problems

While the government advice is useful for ‘regular’ drivers, it may often be insufficient or difficult for professional (class II) drivers to comply with. Listed below are some of the difficulties experienced by professional drivers:

- **Don’t start a journey if you are already tired.** The transport industry is characterised by drivers working long hours to make a decent living wage. 12 hour shifts are the norm, with many drivers working up to 15 hours 1–2 times per week. Drivers often work five consecutive night shifts of 11–12 hours, and through weekends. This regime can leave the driver with insufficient time to commute to and from work, eat, wash, change, meet family and social obligations, and get adequate sleep essential to return to work in a refreshed state. Consequently, it is almost inevitable that drivers will frequently experience fatigue.

- **Plan your journey to include 15 minute breaks every two hours.** The trend within the haulage industry towards just-in-time delivery slots (often allowing for no more than a 30-minute delivery window), together with customer-imposed key performance indicators (KPIs) which penalise late deliveries, places time pressures on drivers. Consequently it may be difficult for the driver to take the recommended 15 minute break every two hours. Moreover, the EU Drivers’ hours regulations only require that a driver takes a 45 minute break for every 4.5 hours of driving.

- **Avoid making trips between midnight and 6am.** Vehicles making deliveries in town and city centres are often subject to curfew restrictions which require that deliveries are made during the very hours that ‘regular’ drivers are advised against making trips. Transport companies also tend to favour night deliveries as there is less traffic on the roads, making travel at this time quicker and more fuel-efficient.

- **If you do feel tired, find a safe place to stop.** It is a frequent complaint within the industry that there are insufficient places for LGVs to park safely, especially at night. Where safe areas do exist they quickly fill up with the consequence that truck drivers resort to parking in laybys and on side roads on the approach to major ports and interchanges.

- **Drink 1–2 cups of strong coffee.** The advice to drink coffee to temporarily alleviate tiredness for professional drivers should be considered an emergency countermeasure. It is inappropriate for professional drivers to regularly use stimulants to keep themselves awake because caffeine may interfere with the driver’s ability to get sleep of sufficient quantity and quality during their daily rest period.

Awake: tackling work-related driver tiredness

Professional drivers need long-term solutions in the form of education to raise awareness of the importance of sleep and the dangers of continuing to drive while
tired. In addition, we need to dispel the myths that many drivers have regarding effective countermeasures and the reasons why opening the window, turning on the radio etc. will not keep you awake. A key factor here is not simply knowing what to do when tired, but knowing when to do it: how to recognise the first signs of tiredness. Awake, linked to the Loughborough Sleep Research Centre (LSRC) was established to provide this training for professional drivers and others involved in safety-critical work. Awake aims to:

- help organisations minimise fatigue in the workforce;
- raise awareness of the importance of sleep and the dangers of working while fatigued;
- reduce accident risk;
- improve work performance; and
- improve quality of life.

We do this by addressing the reasons why drivers continue to drive while tired:

- driver tiredness is not taken seriously enough;
- drivers overestimate their own capabilities;
- drivers have poor knowledge on when to act on their sleepiness; and
- drivers have mixed knowledge of effective countermeasures.

The Awake ‘Tiredness Training Programme’ is used by multinationals and smaller companies alike, all of whom have a workforce of professional drivers. In December 2003 Awake and LSRC were awarded a Prince Michael of Kent International Road Safety Award in recognition of the contribution that the team has made to raising awareness of driver tiredness. This training programme has been shown to be a valuable way of reducing accident risk by raising awareness.

**Investigations of accidents involving tired drivers**

Another of our roles is the investigation of suspected tiredness-related accidents in the UK, Europe and the Middle East. Typically we are called in to provide an expert, impartial view on the contribution that driver tiredness may have played in the events leading up to an accident. Our investigations involve an in-depth analysis of the circumstances surrounding the accident. We typically analyse: police accident investigation reports; pathology reports where available; eyewitness accounts of the driver’s driving behaviour immediately preceding the accident; personnel records
Below are two cases with which we have recently been involved. For confidentiality reasons some of the detail has been removed, but hopefully the cases will provide readers with a flavour of our work.

**Case 1**

This case occurred in the UK and involved a male driver driving a 35-tonne semi-articulated road tanker. The accident occurred at 00.30hrs. An eyewitness travelling in a vehicle behind the tanker commented that the tanker ‘gently drifted to the left onto the hard shoulder. There was no indication or braking signals. In one movement the tanker continued to drift left moving onto the grass verge.’

The tanker rolled over and the driver died at the scene.

Our investigation began by comparing the circumstances of the accident with the criteria for identifying a sleep-related vehicle accident (SRVA) developed by Loughborough Sleep Research Centre, as a result of its work analysing police accident reports of fatal accidents (see Reyner, Flatley and Horne, 2001 for more information).

These criteria can be summarised as:

- good weather conditions, clear visibility;
- blood alcohol levels below legal limit;
- no mechanical defects to vehicle;
- no speeding or driving too close;
- no known medical disorders;
- vehicle ran off carriageway or into another vehicle that was clearly visible;
- no signs of emergency braking; and
- police officer at scene suspected ‘sleepiness’.

The police investigation and the company’s internal investigation indicated that the accident complied with all the LSRC criteria. Additional evidence for a SRVA included:

1. The accident occurred at 00.30 hours, a time when sleep-related accidents are particularly prevalent.
2. The driver was working night shifts and night shifts are known to promote sleep loss due to the difficulties associated with sleeping during the day time.
3. The driver was 7½ hours into his shift, hence mental and physical fatigue may also have contributed to the accident.

4. Further analysis revealed that the driver had been working regular overtime (approximately 2½ days per month) and had a history of rest break violations.

5. Upon investigating this driver’s activity patterns in the days leading up to the accident (he had just returned from three days of rest) it was apparent that he had not been using his time off to obtain sufficient sleep. One of the issues we frequently encounter with professional drivers is that they do not use their rest days effectively — often undertaking other work or being involved in recreational activities or hobbies when they should be sleeping.

These factors, together with other issues which, for confidentiality and privacy reasons are not discussed here, suggest that it was highly likely that the driver had fallen asleep at the wheel. However, there was one inconsistency. The vehicle travelled over bumpy terrain in the seconds before it crashed and if the driver was asleep one would have expected there to be some evidence of attempts to correct the situation, either by braking or by steering. However, there were no signs of either. We concluded that, while the driver was almost certainly driving without awareness at the time the vehicle left the road, we could not say whether he was asleep or unconscious, for example as the result of a seizure.

**Case 2**

This case occurred overseas and involved a particularly tragic set of circumstances. A 55-year-old driver (although he may have been older as birth date records were not kept until fairly recently in this country) died in a rollover accident while driving a 40-ton truck carrying over 20 tons of pipes. The vehicle gently veered off the carriageway instead of negotiating a bend, plunged down a 1.5 m embankment, jack-knifed and rolled over. The impact crushed the cabin and killed the driver.

Our investigation revealed a number of reasons to suspect a SRVA:

1. As in the previous case, time of day may have been a factor: the accident occurred at 17.15, a time of day when the driver would have been experiencing a dip in alertness and sleep-related accidents are more prevalent.

2. At the time of the accident the driver had been on duty for about nine hours, and had been awake for 12½ hours, having risen at 04.45 hrs to say prayers.

3. The driver had previously received warnings for poor compliance with journey management plans which dictate the routes that should be taken and the points on the journey where the driver is required to take a break and stop driving for the day.

4. On this occasion the journey management plan stated that the driver should stop and stay the night at a particular location. Despite contacting his scheduler and agreeing to make this stop, the driver continued to his destination. Our investigation revealed factors that may have contributed to the driver’s decision: (a) the journey manager (responsible for planning the driver’s schedule)
expected the driver to sleep either in a mosque or in his cab, neither of which would have been comfortable, as the weather was hot and (b) the driver may have decided that, as his destination was only two hours’ away, he would push on and sleep once he had completed his duties.

5. The case also revealed that the driver’s home circumstances may have contributed to his level of tiredness. The family was described as extremely poor. The driver had ten children and the family lived in a two bedroom house. Although it is not clear how many of the children still lived at home, it is likely that sleeping conditions were cramped and hardly conducive to the driver getting the adequate sleep required to be fit to drive.

In this case we concluded that driver tiredness was almost certainly the cause of the accident.

Raising awareness

Although these two cases are separated by geography, culture and circumstance, they share a number of common features. In both cases — although for very different reasons — the drivers probably did not get sufficient good quality sleep prior to beginning their shift. Second, both drivers failed either to recognise tiredness and its dangers, or to cope with the problem effectively.

Reasons for these failings (organisational, financial, etc.) are complex. The first step towards a solution is to raise manager and driver awareness of driver tiredness and provide practical strategies for combating the problem, such as how to get a good night’s sleep. Awake delivers a comprehensive training programme which aims to address such issues. Our approach is based upon the principle of shared responsibility: an acknowledgement that employers have a legal responsibility to provide a safe system of work, but drivers too have a legal responsibility to be fit to drive: this means ensuring they are adequately rested each time they get behind the wheel of their vehicle.

Reference

Symptoms of driver fatigue on long car journeys and recent collision involvement

SG Stradling, L Martin, C Rae, M Campbell
Transport Research Institute, Napier University, Edinburgh EH10 5BR

Introduction

Car accidents are a major cost to modern society through death, injury, physical and psychological trauma, road network disruption, emergency service deployment, and elevated personal insurance and inconvenience costs. Sleep-related vehicle accidents (SRVAs) are a common form of highway accidents (Horne and Reyner, 2001). Research from Loughborough Sleep Research Unit has indicated that at least 10% of all UK road accidents and one in five of accidents on motorways and trunk roads are caused by driver sleepiness (Horne and Reyner, 2000). Both drivers and passengers of cars become fatigued during long hours spent driving (El Falou et al., 2003). Referred to as ‘time-on-task’ effect, this is known to produce a deterioration of driving performance (Thiffault and Bergeron, 2003). Fatigue involves both physiological and psychological processes and Brown (1994) characterised fatigue on the road as a ‘disinclination to continue performing the task at hand and a progressive withdrawal of attention from road and traffic demands’.

SRVAs typically involve running off the road or into the back of another vehicle, with no braking beforehand. Sagberg (1999) reported that sleep or drowsiness was a contributing factor in 3.9% of all accidents reported by 9,200 Norwegian accident-involved drivers. This factor was strongly over-represented in night-time accidents (18.6%), in running-off-the-road accidents (8.3%), accidents after driving more than 150km on one trip (8.1%) and personal injury accidents (7.3%). Fatigue is often implicated in single-vehicle crashes, and on average these result in more severe injury than multi-vehicle crashes (Connor et al., 2001).

Driving while tired is one area where research has informed current UK road safety policy and practice. For example, the Local Authority Road Safety Officers Association website currently carries a story about road safety officers
targeting motorists at a motorway service station at Easter 2004 and dispensing information:

‘Instead of trying to fight off drowsiness by opening a window or turning up the radio – which have been proven not to work – drivers were advised to:

- plan their journey to include a 15-minute break every two hours;
- find a safe place to stop if they feel drowsy – not the hard shoulder;
- drink two cups of coffee or a high-caffeine drink, then take a short nap to allow the caffeine to kick in;
- don’t start a long trip if already tired;
- remember the risks of an unusually early start to a long drive; and
- try to avoid long trips between midnight and 6am.’

This paper reports data from a study of drivers in the Strathclyde region of Scotland (Campbell and Stradling, 2003a, b) who were questioned inter alia about the frequency with which they made long car journeys, the circumstances under which they did so, and the frequency of a number of behaviours identified in recent research as associated with elevating or reducing involvement in crashes while driving tired. While respondents were not asked about their involvement in sleep-related road traffic accidents, it was possible to make comparison between the fatigue-related behaviours on long car journeys of those who had and those who had not been involved in any RTA as a driver in the previous three years.

Survey sample

A quota sample of 1,121 drivers completed a 20-minute in-home interview conducted by NFO System Three Social Research in the 12 local authority areas within the region covered by Strathclyde police. This report focuses on the responses of 1,091 respondents who held current car driving licences and had driven within the previous year and did not also drive an HGV (21 respondents) or bus or coach (seven respondents). 52% of these respondents were male, 48% female. The age of respondents varied from 17 to 86. The survey over-sampled the number of 17 to 24 year-olds interviewed. Further information on sampling strategy and demographics is given in Campbell and Stradling (2003a).

Frequency of long car journeys

Respondents were asked to indicate how often they drove by car on journeys of more than two hours or of over 100 miles, as part of their work and for personal business. Table 1 cross-tabulates the responses showing total percentages.

6% made long journeys ‘most days’ on personal business, 4% as part of work, 2% did both. 79% ‘never’ made a long journey by car as part of their work, 31% never on personal business. Overall a quarter of the sample (28%) did neither and are omitted from subsequent analyses.
On a six-point scale from 1 ‘never’ to 6 ‘nearly all the time’, respondents rated how often they experienced 24 sleep-related driving behaviours when on long journeys. Items were drawn from recent research showing, for example, that SRVAs peak around 2–6am and 2–4pm, when daily sleepiness is naturally higher (Horne and Reyner, 2001). Thiffault and Bergeron (2003) discuss how the 24 physiological circadian rhythm, or time-of-day effect, is a major factor that accounts for fatigue. Driving patterns that run counter to circadian rhythms have been shown to result in falling asleep while driving and causing crashes (Morrow and Crum, 2004).

Table 2 reports the factor structure of a principal components’ analysis of responses to these 24 items (KMO .877; Bartlett’s Test of Sphericity significant at .000; display criterion 0.32; varimax rotation to three-factor solution accounting for 38.86% of variance).

Three factors passed the scree test and these were interpreted as symptoms of fatigued driving, contra-indicated conditions, and prophylaxes. Several items loaded on more than one factor, but the separation of the three factors suggests that levels of drowsiness (e.g. find your eyes closing or going out of focus by themselves on long journeys) and loss of vehicle control (e.g. find you have to keep jerking the vehicle back into lane on long journeys) which load on factor 1, ‘symptoms’, are statistically independent in this sample of Scottish car drivers of frequency of driving when fatigued (e.g. drive when you would normally be falling asleep at home on long journeys; start after a full day or a full shift on long journeys). These load on factor
Table 2  Rotated component matrix showing item weightings for 3 factor solution

...on long journeys

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find your eyes closing or going out of focus by themselves</td>
<td>.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have trouble keeping your head up</td>
<td>.66</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Find you have to keep jerking the vehicle back into lane</td>
<td>.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Find you cannot stop yawning</td>
<td>.56</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continue when close to your destination even though feeling drowsy</td>
<td>.56</td>
<td>.36</td>
<td></td>
</tr>
<tr>
<td>Have wandering, disconnected thoughts</td>
<td>.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open a window or turn up the air conditioning to combat drowsiness</td>
<td>.53</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turn up the volume on the radio/tape player/CD to combat drowsiness</td>
<td>.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Find that your journey schedule requires you to continue driving when feeling drowsy</td>
<td>.52</td>
<td>.52</td>
<td></td>
</tr>
<tr>
<td>Find you can’t remember driving the past few miles</td>
<td>.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wander between lanes, close follow the vehicle ahead or miss traffic signs</td>
<td>.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sing to yourself to combat drowsiness</td>
<td>.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drift off the road</td>
<td>.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive after taking medication that advises against operating machinery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive between 1am and 5am in the early morning</td>
<td>.74</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive when you would normally be falling asleep at home</td>
<td>.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Start after a full day or a full shift</td>
<td>.55</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Find that your journey schedule requires you to exceed the speed limit</td>
<td>.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive more than 400 miles without an overnight stop</td>
<td>.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take a break of at least 15 minutes</td>
<td>.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take a break every two hours or 100 miles</td>
<td>.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take a caffeine-based drink during breaks</td>
<td>.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take a brief nap during breaks</td>
<td>.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive between 2pm and 4pm in the afternoon</td>
<td>.33</td>
<td>.39</td>
<td></td>
</tr>
</tbody>
</table>

Table 3  Frequency of reporting symptoms of fatigue on long car journeys

<table>
<thead>
<tr>
<th>[as percentage of those who make long car journeys]</th>
<th>More often than never (%)</th>
<th>Quite often or more (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open a window or turn up the air conditioning to combat drowsiness</td>
<td>63</td>
<td>23</td>
</tr>
<tr>
<td>Have wandering, disconnected thoughts</td>
<td>48</td>
<td>9</td>
</tr>
<tr>
<td>Find you cannot stop yawning</td>
<td>45</td>
<td>7</td>
</tr>
<tr>
<td>Continue when close to your destination even though feeling drowsy</td>
<td>42</td>
<td>12</td>
</tr>
<tr>
<td>Find you can’t remember driving the past few miles</td>
<td>36</td>
<td>7</td>
</tr>
<tr>
<td>Turn up the volume on the radio/tape player/CD to combat drowsiness</td>
<td>32</td>
<td>10</td>
</tr>
<tr>
<td>Sing to yourself to combat drowsiness</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>Find your eyes closing or going out of focus by themselves</td>
<td>23</td>
<td>2</td>
</tr>
<tr>
<td>Wander between lanes, close follow the vehicle ahead or miss traffic signs</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>Have trouble keeping your head up</td>
<td>13</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Find you have to keep jerking the vehicle back into lane</td>
<td>11</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Drift off the road</td>
<td>8</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>
2, ‘contra-indicated conditions’, and both are statistically independent of the frequency of complying with recommended behaviours (e.g. *take a break every two hours or 100 miles on long journeys; take a caffeine-based drink during breaks on long journeys*) which load on factor 3, ‘prophylactic measures’.

Factor scores were saved for subsequent analysis.

Tables 3, 4 and 5 give an indication of the frequency with which each of these three types of behaviours were reported by all car-driving respondents, showing the percentage reporting each ‘quite often’, ‘frequently’ or ‘nearly all the time’ (scale points 4–6) and the percentage reporting it ever (more often than 1 ‘never’).

### Table 4 Frequency of reporting contra-indicated conditions for fatigue on long car journeys

<table>
<thead>
<tr>
<th>Contra-indicated conditions</th>
<th>More often than never (%)</th>
<th>Quite often or more (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drive between 2pm and 4pm in the afternoon</td>
<td>81</td>
<td>40</td>
</tr>
<tr>
<td>Find that your journey schedule requires you to continue driving when feeling drowsy</td>
<td>42</td>
<td>12</td>
</tr>
<tr>
<td>Find that your journey schedule requires you to exceed the speed limit</td>
<td>41</td>
<td>8</td>
</tr>
<tr>
<td>Drive when you would normally be falling asleep at home</td>
<td>38</td>
<td>6</td>
</tr>
<tr>
<td>Start after a full day or a full shift</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>Drive between 1am and 5am in the early morning</td>
<td>34</td>
<td>6</td>
</tr>
<tr>
<td>Drive more than 400 miles without an overnight stop</td>
<td>22</td>
<td>3</td>
</tr>
<tr>
<td>Drive after taking medication that advises against operating machinery</td>
<td>7</td>
<td>1</td>
</tr>
</tbody>
</table>

### Table 5 Frequency of reporting prophylactic measures to counter fatigue on long car journeys

<table>
<thead>
<tr>
<th>Prophylactic measures</th>
<th>More often than never (%)</th>
<th>Quite often or more (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Take a break of at least 15 minutes</td>
<td>84</td>
<td>57</td>
</tr>
<tr>
<td>Take a break every two hours or 100 miles</td>
<td>80</td>
<td>51</td>
</tr>
<tr>
<td>Take a caffeine-based drink during breaks</td>
<td>69</td>
<td>43</td>
</tr>
<tr>
<td>Take a brief nap during breaks</td>
<td>25</td>
<td>7</td>
</tr>
</tbody>
</table>

### Association with self-reported RTA involvement

While respondents were not asked directly about their involvement in sleep-related crashes, they did report the total number of road traffic accidents they had been involved in as a driver in the previous three years. 17% of the car drivers (19% of the males: 13% of the females) reported recent RTA involvement. General RTA
involvement was not related to reported frequency of undertaking long car journeys as part of work or on personal business (it was related, though, to whether or not drivers had been flashed by a speed camera in the previous three years (Campbell and Stradling, 2003b) with drivers who had been recently detected speeding, twice as likely to have also been RTA-involved).

Tables 6, 7 and 8 report comparisons between those drivers who had and those who had not been crash-involved in the previous three years of the mean scores on each of the symptoms of fatigue items (Table 6), contra-indicated conditions (Table 7) and prophylactic measures (Table 8). The tables show mean scores on the 1–6 scale for each group and the $p$ value of the associated t-test. Items are arranged in descending order of $p$ values.

### Table 6  Level of fatigued driving symptoms on long car journeys for drivers with and without recent RTA involvement

<table>
<thead>
<tr>
<th>Symptoms</th>
<th>RTAs last 3 y</th>
<th>$p$ for t</th>
<th>none</th>
<th>some</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find your eyes closing or going out of focus by themselves</td>
<td></td>
<td>.000</td>
<td>1.29</td>
<td>1.55</td>
</tr>
<tr>
<td>Find you can’t remember driving the past few miles</td>
<td></td>
<td>.000</td>
<td>1.63</td>
<td>2.00</td>
</tr>
<tr>
<td>Find you cannot stop yawning</td>
<td>.002</td>
<td>1.74</td>
<td>2.05</td>
<td></td>
</tr>
<tr>
<td>Continue when close to your destination even though feeling drowsy</td>
<td>.003</td>
<td>1.83</td>
<td>2.19</td>
<td></td>
</tr>
<tr>
<td>Open a window or turn up the air conditioning to combat drowsiness</td>
<td>.020</td>
<td>2.43</td>
<td>2.75</td>
<td></td>
</tr>
<tr>
<td>Have trouble keeping your head up</td>
<td>.025</td>
<td>1.16</td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>Have wandering, disconnected thoughts</td>
<td>.026</td>
<td>1.88</td>
<td>2.13</td>
<td></td>
</tr>
<tr>
<td>Wander between lanes, close follow the vehicle ahead or miss traffic signs</td>
<td>.031</td>
<td>1.27</td>
<td>1.40</td>
<td></td>
</tr>
<tr>
<td>Turn up the volume on the radio/tape player/CD to combat drowsiness</td>
<td>.035</td>
<td>1.62</td>
<td>1.86</td>
<td></td>
</tr>
<tr>
<td>Sing to yourself to combat drowsiness</td>
<td>(.067)</td>
<td>1.49</td>
<td>1.69</td>
<td></td>
</tr>
<tr>
<td>Drift off the road</td>
<td>(.099)</td>
<td>1.09</td>
<td>1.15</td>
<td></td>
</tr>
<tr>
<td>Find you have to keep jerking the vehicle back into lane</td>
<td>ns</td>
<td>1.13</td>
<td>1.20</td>
<td></td>
</tr>
</tbody>
</table>

1 ‘never’ — 6 ‘nearly all the time’

### Table 7  Level of contra-indicated conditions for fatigued driving on long car journeys for drivers with and without recent RTA involvement

<table>
<thead>
<tr>
<th>Contra-indicated</th>
<th>RTAs last 3 y</th>
<th>$p$ for t</th>
<th>none</th>
<th>some</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find that your journey schedule requires you to exceed the speed limit</td>
<td></td>
<td>.000</td>
<td>1.67</td>
<td>2.20</td>
</tr>
<tr>
<td>Find that your journey schedule requires you to continue driving when feeling drowsy</td>
<td></td>
<td>.001</td>
<td>1.39</td>
<td>1.67</td>
</tr>
<tr>
<td>Drive when you would normally be falling asleep at home</td>
<td>.008</td>
<td>1.60</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>Drive between 2pm and 4pm in the afternoon</td>
<td>ns</td>
<td>3.09</td>
<td>3.25</td>
<td></td>
</tr>
<tr>
<td>Start after a full day or a full shift</td>
<td>ns</td>
<td>1.67</td>
<td>1.80</td>
<td></td>
</tr>
<tr>
<td>Drive between 1am and 5am in the early morning</td>
<td>ns</td>
<td>1.56</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>Drive more than 400 miles without an overnight stop</td>
<td>ns</td>
<td>1.36</td>
<td>1.49</td>
<td></td>
</tr>
<tr>
<td>Drive after taking medication that advises against operating machinery</td>
<td>ns</td>
<td>1.11</td>
<td>1.13</td>
<td></td>
</tr>
</tbody>
</table>

1 ‘never’ — 6 ‘nearly all the time’
Drivers with a recent crash history show elevated symptom levels across all items, significantly so ($p < .05$) on nine of the twelve symptoms.

Drivers with a recent crash history showed elevated levels of commission across all items, but significantly so for only three of the eight conditions.

<table>
<thead>
<tr>
<th>Table 8</th>
<th>Level of prophylactic measures to counter fatigued driving on long car journeys for drivers with and without recent RTA involvements</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prophylactic</strong></td>
<td></td>
</tr>
<tr>
<td>Take a brief nap during breaks</td>
<td>(.086)</td>
</tr>
<tr>
<td>Take a break of at least 15 minutes</td>
<td>ns</td>
</tr>
<tr>
<td>Take a break every two hours or 100 miles</td>
<td>ns</td>
</tr>
<tr>
<td>Take a caffeine-based drink during breaks</td>
<td>ns</td>
</tr>
<tr>
<td>1 ‘never’ — 6 ‘nearly all the time’</td>
<td></td>
</tr>
</tbody>
</table>

Drivers with a recent crash history were no less likely to adopt fatigue counter-measures.

Table 9 shows the Pearson correlation coefficients between factor scores for the three fatigued-driving behaviour factors and RTA involvement, together with a number of other variables known to be associated with the latter: sex, age, years’ driving experience, annual mileage and whether the driver had recently been detected speeding.

<table>
<thead>
<tr>
<th>Table 9</th>
<th>Correlation of fatigued driving factor scores and other variables with RTA involvement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$r$</td>
</tr>
<tr>
<td>Sex</td>
<td>-.08</td>
</tr>
<tr>
<td>Age</td>
<td>-.14</td>
</tr>
<tr>
<td>Years’ driving experience</td>
<td>-.11</td>
</tr>
<tr>
<td>Annual mileage</td>
<td>.14</td>
</tr>
<tr>
<td>Stopped by police for speeding or flashed by speed camera last three years</td>
<td>.17</td>
</tr>
<tr>
<td>Symptoms factor score</td>
<td>.14</td>
</tr>
<tr>
<td>Contra-indicated factor score</td>
<td>.08</td>
</tr>
<tr>
<td>Prophylaxis factor score</td>
<td>.02</td>
</tr>
</tbody>
</table>

Subsequent inclusion of all variables in linear stepwise regression analysis selects four of the predictor variables, in the order: detected speeding; age; symptoms factor score; annual mileage.

**Conclusions**

Amongst a large sample of car drivers in the Strathclyde area of Scotland, 6% made long journeys ‘most days’ on personal business, 4% as part of work, 2% did both, and a quarter of the sample (28%) did neither.
Factor analysis of responses to a set of 24 drowsy-driving related items from those who did make long car journeys elicited three factors, labelled symptoms, contra-indicated conditions and prophylaxes.

Drivers who have a history of recent RTA involvement report significantly higher levels of drowsiness and loss of vehicle control on long car journeys, a higher likelihood of making long car journeys under some, but not all, contra-indicated conditions, and show no difference in frequency of use of recommended journey break procedures.

References


www.larsoa.org.uk/news_april04/news04_m1_fatigue.html
Safety culture and work-related road accidents

Introduction

The government has set challenging targets for reducing road fatalities by 2010 and research evidence has suggested that up to one third of current road traffic accidents involve people at work. Encouragingly, unlike private road users, occupational drivers work within organisational structures which may be able to help deliver improvements. There are also clear commercial benefits for organisations to adopt driver safety management systems, such as financial benefits linked to reduced accident rates and fulfilling legislative duty of care responsibilities. In order to explore some of the potential organisational mechanisms through which road risk may be managed, BOMEL was commissioned by the Department for Transport (DfT) to identify whether there is a relationship between an organisation’s safety culture and the attitudes of its drivers to safe driving behaviour and company accident liability. This has increased understanding of the elements of safety culture that have the greatest influence on driver attitudes and led to practical recommendations as to how safety culture could be improved in order to help reduce occupational road risk.

Scale of the problem

From DfT statistics, the current study has estimated that 19% of registered vehicles are used for work purposes. Of these vehicles identified as being involved with work, the largest groups are company cars (41%) which are likely to cover around three times’ the mileage of the average private car driver; ‘other private and light goods’ (45%); and HGVs (7%), the majority of which are made up of small haulage operators. Other DfT-commissioned research highlights that there are somewhere in the region of two and a quarter million company owned cars in Britain and that over half of all new cars sold each year are registered in a company’s name. This indicates that company car drivers are the largest group of working drivers. The current study has included HGVs, company cars and light goods’ vehicles within its remit, which reflects around 95% of vehicles that can be broadly classed as work-related.
There are no official statistics for casualties connected with work-related journeys as the STATS 19 accident data forms do not record journey purpose. Figure 1 shows the number of road accidents in 2001 in which buses/coaches, heavy goods’ vehicles and light goods’ vehicles were either the primary or secondary vehicle involved. This is broken down according to whether there was injury to the vehicle user or to a pedestrian.

Figure 1 highlights that accidents involving these work-related vehicles accounted for 898 fatalities in 2001, which is 26% of all road fatalities in that year, and for approximately 17% of all serious injury (SI) road accidents in this period. However, this is almost certainly an underestimation due to not accounting for company cars. The work-related road safety task group (WRSTG) estimated that 25% of road accidents involve someone at work.

**Underlying occupational road risk (ORR) factors**

In order to identify the areas where improvements would be most effective in the management of work-related driving risk, a review of the key contributory factors was undertaken which involved interviews with key DfT personnel, liaison with stakeholder groups and a review of the existing occupational road risk (ORR) research. Management of occupational road risk (MORR) featured heavily, with poor management systems blamed for increasing driver stress and failing to deliver incident reporting systems that will sufficiently inform driving risk assessment. Stresses caused by commercial pressures were thought to be worsened by other road users and fatigue was raised as a symptom of excessive work pressure. The importance of good planning to help reduce stress and fatigue was, therefore, also raised as a key factor in the management of MORR. Much debate existed on the
effectiveness of driver training for controlling ORR, with a belief that changing people’s attitudes towards safe driving will bring about a more lasting improvement compared with skills’ training. Finally, concern was raised about drivers’ general lack of appreciation of and compliance with the rules of the road.

A model of ORR was developed based on the ‘Influence Network’ technique (see Figure 2) to highlight the factors with the strongest influence on ORR in order to help focus improvement measures.

Direct level factors were identified as fatigue/alertness, individual attitudes, pressure/stress, compliance and suitable human resources. The organisational level factors deemed critical in influencing ORR were pay and conditions, training, procedures, planning, incident management/feedback and communications. At the policy level the key factors identified were contracting strategy, ownership and control, organisational structure, safety management and profitability. There were no factors at the environmental level identified as having a dominant influence. At the organisational level six out of the seven factors identified (excluding pay and conditions) were grouped as key components of organisational safety culture, which provided an early indication of the importance of safety culture in managing ORR.

The study

The current study was designed to investigate the relationship between organisational safety culture, worker driver attitudes and accident liability (risk) with
the aim of focusing on the potential benefits of organisational safety culture improvements. Seven companies participated in the survey, all of which varied in business type, size and vehicle fleet. The sample consisted of company car drivers (low and high mileage) and HGV drivers, a significant proportion of which were from the small haulage sector, in order to provide a representative cross section of working drivers.

The research involved three main phases:

1. measurement of organisational safety culture;
2. measurement of driver attitudes; and
3. collection of company and accident data.

Organisational safety culture was measured using the HSE’s health and safety climate tool (HSCST), chosen after considerable review of the available measurement tools. To gain a greater understanding of the additional influences on company drivers once they leave the confines of the organisation and its inherent safety culture, drivers were also interviewed.

The interviews were semi-structured in nature and addressed the contribution of individual factors (e.g. age, driving experience), attitudes to company driving rules and procedures, attitudes to specific driving violations, pressure and fatigue, and organisational driving safety management (including individual accident involvement, training, incident reporting and feedback).

The companies were also asked to provide available accident and company data. To ensure the survey approach covered all factors deemed critical to ORR, both the HSCST and interview questions were mapped to the influence network model of ORR (see Figure 2).

**Relationship between safety culture, driver attitudes and accident liability**

The key components of organisational safety culture (training, procedures, planning, incident feedback, management and communications) were represented within the HSCST and interview questions in order that results from both could be directly corroborated. In order to answer the original research question regarding the extent of the relationship between organisational safety culture, drivers’ attitudes and accident liability, survey results from each of the participating companies were pulled together. Findings generally revealed that the majority of companies exhibited more positive aspects of safety culture than negative and the majority of drivers displayed more positive attitudes than negative. In four of the participating companies there appeared to be a close relationship between safety culture and
drivers’ attitudes, but the relationship was found to be weaker in the other three companies. One of the companies was strong in all areas of safety culture, whilst for two companies areas requiring improvement were identified.

It is suggested that the findings should be thought of more in terms of the strength of the relationship in specific areas of safety culture. It is concluded that the strength of the relationship between safety culture and driver attitudes is at least moderate although varies between companies. Perhaps most importantly, the relationship appears to be strong enough to suggest that improvements to a company’s safety culture could be used to influence driver attitudes and help reduce ORR.

To further encourage companies to address safety culture as a way to reduce road accident risk, evidence was provided on the relationship between driver attitudes and accident liability (i.e. accident risk). Although caution was exercised interpreting company accident data due to its inherent limitations (in terms of breadth and depth), it was concluded that there is a moderate relationship between accident rate and driver attitudes. More specifically, low company accident rates corresponded with the highest percentage of drivers with positive attitudes and the lowest percentage of drivers with negative attitudes and vice versa (see Table 1).

### Cross sector issues

In order to understand the extent to which individual company issues and controls may be of help to other organisations and the DfT, the survey findings were assessed in the context of wider sector issues. In order to highlight these wider issues, the findings were considered according to company size (large and small companies) and road user type (HGV and cars).

Findings highlighted that tanker drivers carrying hazardous loads had most appreciation of rules/procedures; safety measures applied to HGV drivers were generally not applied to car drivers even within the same company and safety

<table>
<thead>
<tr>
<th>Company</th>
<th>Positive attitude drivers (%)</th>
<th>Negative attitude drivers (%)</th>
<th>Incident rate (per 1,000,000 vehicle km)</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>B - HGV</td>
<td>94</td>
<td>0</td>
<td>0.34</td>
<td>This is Company B Logistics UK</td>
</tr>
<tr>
<td>B - cars</td>
<td>80</td>
<td>7</td>
<td>1.9</td>
<td>This is only three business units within Company B UK Lubes</td>
</tr>
<tr>
<td>A - cars</td>
<td>67</td>
<td>33</td>
<td>5.4</td>
<td>This is Company A cars UK</td>
</tr>
<tr>
<td>A - HGV</td>
<td>83</td>
<td>8</td>
<td>7.7</td>
<td>This is only Company A South and North distribution sites</td>
</tr>
<tr>
<td>C - HGV</td>
<td>47</td>
<td>35</td>
<td>24.9</td>
<td>This is only the five Company C plants, sampled in the study</td>
</tr>
</tbody>
</table>

Note: This table should not be interpreted without reference to the full summary report (Department for Transport, 2004)
management systems were lacking in the smaller companies although big companies were not always better at addressing driver safety management. Overall, the cross sector analysis revealed that although larger hazardous operations were more likely to have good driving safety management systems in place, this was not always the case, suggesting there may be deeper reasons influencing the extent to which companies manage ORR.

Influence Network workshops

Influence Network workshops were hosted to focus on car and LGV driver ORR and were attended by key industry stakeholders and driving safety representatives from a selection of the participating companies. Attendees were invited to identify the key direct level factors that they felt showed most potential for reducing ORR. The workshops then took each of these factors in turn in order to assess which factors at the organisational, policy and environmental levels had most potential for reducing the negative impact this direct level factor had on ORR (termed a path of influence) and how improvements could be brought about. The paths of influence for each of the direct level factors were consolidated for both workshops in order that the overall key factors significant in managing ORR could be clearly identified.

In addition to the factors identified during workshops, the improvement measures suggested by drivers during the interviews were also consolidated and merged with the key workshop factors. On the basis of this consolidation exercise it was concluded that the most critical factors for management of car driver ORR are:

- fatigue;
- pressure;
- training;
- incident management; and
- communications.

The most critical factors for management of LGV ORR are:

- planning;
- fatigue; and
- management/supervision.

Of the factors identified, the organisational ones were all key components of safety culture, reinforcing the potential influence safety culture could have on work-related driving safety. To bring about improvements in these areas, a wide variety of work-related road risk control measures were generated from both the driver interviews and the influence network workshop sessions.
Case studies

To further illustrate measures for improving ORR, two case studies have been developed to highlight best practice and areas for improvement based on the research undertaken with each of the participating companies. The driving safety improvements described have been structured according to the key components of organisational safety culture, further demonstrating the potential safety culture has in the MORR. A series of key messages for companies looking to encourage a positive safety culture and reduce ORR are highlighted:

- appreciate the potential risk to car drivers and the ways in which they can be minimised;
- appoint someone to steer and have responsibility for safety initiatives to ensure they don’t lose momentum;
- encourage effective communications about driving safety through structured systems such as training, guidance and accident/incident reporting;
- apply best practice to minimise the inherent risks presented by occupational driving;
- ensure the importance of driving safely is always clearly underlined as implicit and explicit messages sent out by management play an important part in shaping employee attitudes to driving safety;
- bear in mind the cost benefits of safe driving such as from more fuel-efficient driving;
- involve the workforce in the ORR management process to add credence;
- educate employees about the usefulness of sharing accident/incident information;
- encourage accident and incident feedback;
- view training sessions and procedures/guidance as an opportunity to teach skills and imbue corporate safety messages and driving professionalism; and
- incorporate assessment needs and use evaluation findings to inform further training (if appropriate) so that the process is cyclical offering continuous improvement.

Recommendations

The following overall recommendations were made based on the findings of the current study:

1. DfT, companies and other stakeholders should consider aspects of safety culture when addressing work-related road safety issues, in particular, training,
procedures, planning, incident management/feedback, management/supervision and safety communications.

2. Companies should be aware that by improving safety culture they can improve the safety attitudes of drivers remote from the fixed workplace and that this in turn is likely to influence road accident involvement.

3. Companies should consider improving incident reporting and feedback as a way to learn from driving incidents and these systems should be tailored specifically for use with road incidents.

4. Companies should acknowledge that car driving carries risks as well as driving larger vehicles and that it may be of benefit to apply some LGV safety systems to the management of car driving safety.

5. There should be emphasis on persuading smaller companies of the significance of ORR and the benefits to be gained from addressing the issues while at the same time appreciating that large companies may share some of the weaknesses shown by smaller firms.

6. Although a range of factors may need to be assessed depending on individual companies, for LGV drivers, fatigue, planning and management/supervision should warrant consideration as should fatigue, pressure, training, incident management and communications for car drivers.

7. In terms of assessing ORR, companies should look at how component parts of culture (e.g. training, procedures, planning, incident management) apply to driving safety. They should assess their own areas of weakness and strength and develop improvement measures as appropriate. Drivers should be consulted on problem areas and solutions to ensure that risk management is likely to be effective.

8. In terms of how to improve safety culture and deciding which approaches to risk control might be suitable, the case studies, the influence network paths of influence and the risk control measures/approaches suggested by drivers outlined in the full summary report (Department for Transport, 2004) should be used as guidance. Based on the study findings an ORR ‘toolkit’ was also designed to help organisations assess and manage the risks for those who drive as part of their work (Department for Transport, 2004).

9. DfT could think about the following areas as offering potential to encourage companies to address ORR:

   - using good practice companies as a platform for raising industry standards in general;
   - initiatives to increase the value of driver professionalism;
   - clarity on how ORR should be incorporated into safety management, the responsibilities of senior managers and what the law requires in terms of driving safety;
• campaigns to increase public awareness of ORR;
• continued emphasis on the financial benefits of managing ORR;
• consideration of legislation that will help to reduce ORR;
• clear messages to companies that positive safety culture can benefit driver attitudes and accident levels; and
• dissemination of this report to industry to help demonstrate how cultural changes can be made to help manage work-related road safety.

10. The following areas should be considered for further investigation:

• An evaluation of the best way to measure organisational safety culture in relation to ORR (e.g. whether or not a questionnaire approach is appropriate and, if so, how it should be designed, what it should contain and how it should be disseminated).

• Further study of the work vehicle groups not covered in this project e.g. maintenance van drivers, delivery drivers, bus and coach drivers and wider coverage of small haulage companies.

• An evaluation of driver safety training to gauge the relative merits of skill and attitude-based training and measure training outcomes.

• Investigation into appropriate accident/near miss management systems tailored for on road incidents, to include reporting, recording, analysis and feedback. Particular emphasis should be on the feasibility of collecting reliable near miss data and the efficacy of such data in terms of learning from road incidents and effecting improvement.

• There should be further investigation of what motivates companies towards developing management systems and culture, the way these relate to address ORR and how to develop and disseminate key messages which come from this work.

• The research approach resulted in the collection and development of a rich data set, not all of which was explicitly used to address the original research question. This therefore provides a ready made occupational driving database available for further analysis and evaluation. Further work could potentially include interrogating the data based on demographic boundaries and correlating accident liability (risk) with likelihood of violating.

Acknowledgements

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References


Development of a psychometric measure of bus driver behaviour

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Abstract

In a factor analysis study, the original factor structure of the Driver Stress Inventory (DSI) was replicated for a sample of 543 bus drivers. This paper reports on the further development of a psychometric measure of bus driver behaviour (BDBI) incorporating some of the original DSI items found to be relevant to bus driving as well as newly constructed items based on transcripts of in-depth interviews with 45 bus drivers reported in study 1. For study 2, the pilot Bus Driver Behaviour Inventory (BDBI) was administered to 315 bus drivers and subjected to factor analysis. The solution revealed seven factors, four of which were similar to the original DSI factors and labelled fatigue proneness, hazard monitoring, anxious driving and thrill seeking and three new factors labelled patient driving, relaxed driving and incident inevitability were also identified. Factor analysis of bus driver coping responses revealed five coping factors labelled evaluative coping, emotion-focused coping, avoidance, risky coping and antagonistic coping. T-tests showed that bus drivers who had been involved in a blameworthy incident in the last three years scored significantly lower on hazard monitoring, patient driving and evaluative coping and significantly higher on antagonistic and avoidance coping compared with bus drivers who had not been involved in a blameworthy incident. Important distinctions between the BDBI and the DSI are revealed and further research on the reliability and validity of the BDBI to predict bus incidents is underway.

Introduction

It has been well documented that bus driving can be a highly stressful occupation resulting from high and conflicting demands and lack of control over work pace and driving situations at work. Factors intrinsic to the job, such as time pressure, long shifts, responsibility for passenger safety etc. can all contribute to bus driver stress.
There is also good reason to suppose that driver stress and fatigue may be underpinning increased accident risk amongst all occupational drivers. Hartley and Hassini (1994) compared car and truck drivers with either low or high traffic violation involvement and found that about a third of the truck drivers’ and about 40% of the car drivers’ accident and conviction rates were predicted by self-reported driver stress. Previous research has also shown that scores on the Driver Stress Inventory’s (DSIs) five dimensions of aggression, dislike of driving, hazard monitoring, thrill seeking and fatigue proneness are associated with different aspects of driving behaviour amongst car drivers (Matthews, Dorn, Hoyes, Davies, Glendon and Taylor, 1998). Whilst studies investigating broad personality measures and accident involvement have shown a somewhat small and sometimes inconsistent relationship, a more focused measure of personality-based emotional reactions to bus driving might be more predictive of accident involvement (Matthews, Dorn and Glendon, 1991). Such a measure may be useful for driver assessment, recruitment and training, not only for bus driving, but other occupational drivers as well. Hence, the rationale for the research reported here.

Garwood and Dorn (2003) describe an exploratory factor analysis of a slightly modified version of the DSI administered to 543 UK bus drivers. The purpose of the study was to investigate whether the original factor structure could be replicated for a bus driving population. Factor analysis indicated surprisingly minor differences for bus drivers, given that the original factor solution was based on non-professional drivers driving cars. All five factors were replicated for the bus driver sample with the factors of thrill seeking and dislike of driving reversed in their loadings but retaining the original items. Factor analysis of the driver coping component of the DSI also indicated considerable overlap with all five original factors being replicated. The study confirmed the robustness of the original DSI factor structure in defining bus driver behaviour with many of the items being relevant as a basis for the development of a bus driver behaviour inventory (BDBI). However, there are several issues pertinent to the demands of bus driving such as shift work and passenger problems that were not a feature of the original DSI and need to be included if the BDBI is to be representative of work-related aspects of bus driving.

The present study reports on the further development of the BDBI and the results of two studies. Firstly, in-depth interviews to generate items relevant to bus driving and secondly a factor analysis of the pilot version of the BDBI on a representative sample of bus drivers in order to define the factors that are characteristic of personality-based emotional reactions to bus driving.

Study 1

Method

PARTICIPANTS

45 (43 males and 2 females) bus drivers from around the UK, employed by Arriva, and aged between 24 and 66 (mean age = 43.5, SD = 10.5), volunteered to take part in this study. Length of service ranged from 0–36 years (mean length of service = 9.29, SD = 11.07)
MATERIALS AND PROCEDURE

Using information gathered from the literature and the results of a pilot questionnaire study, an interview schedule was developed. The interviews were semi-structured to enable an open discussion about the everyday driving and working experiences of bus drivers. The average length of each interview was approximately 20–30 minutes. All the interviews were recorded; transcribed in full and analysed to identify common themes amongst the transcriptions.

Results

The number of times the same issue occurred during interviews was monitored and led to the emergence of several themes. Table 1 describes the main themes and a sample item. To improve face validity of the BDBI, the wording of all items was taken, as much as possible, from the transcripts. Using the themes, 60 items were constructed and incorporated into the pilot version of the BDBI.

<table>
<thead>
<tr>
<th>Main themes</th>
<th>Sample item derived from theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggression (towards other road users and passengers)</td>
<td>‘I find myself cursing other drivers and passengers in my head when they do something stupid’</td>
</tr>
<tr>
<td>Autopilot (from fatigue and repetitive routes)</td>
<td>‘When I have been driving for several hours, with few or no breaks, I feel like I am running on autopilot’</td>
</tr>
<tr>
<td>Attentional capacity</td>
<td>‘When driving a bus I find it difficult to concentrate on lots of things at the same time’</td>
</tr>
<tr>
<td>Concentration issues</td>
<td>‘You can be concentrating so hard on driving the bus that you don’t see a hazard straight away’</td>
</tr>
<tr>
<td>Experience</td>
<td>‘I view driving as a continuous learning curve’</td>
</tr>
<tr>
<td>External influences</td>
<td>‘I get frustrated when I am late due to factors outside of my control’</td>
</tr>
<tr>
<td>Goal setting (alleviated boredom and allows pride in work)</td>
<td>‘I reduce boredom by setting personal goals, e.g. driving as smoothly as possible’</td>
</tr>
<tr>
<td>Inevitability of mistakes, near misses and accidents</td>
<td>‘When driving a bus everyone will make a mistake at some point’</td>
</tr>
<tr>
<td>Mentally tiring/stressful</td>
<td>‘When I have been driving for several hours, with few or no breaks, I feel mentally drained’</td>
</tr>
<tr>
<td>Need to relax/unwind at the end of a shift</td>
<td>‘It usually takes a few hours for me to fully relax after the end of my shift’</td>
</tr>
<tr>
<td>Other road users cause problems</td>
<td>‘Car drivers do not have as much experience on the road as bus drivers’</td>
</tr>
<tr>
<td>Passenger issues (difficult passengers, abuse and complaints)</td>
<td>‘When people verbally abuse me when I am at work, I take it personally even when it is not my fault’</td>
</tr>
</tbody>
</table>

(continued)
Table 1  Main themes from interview transcriptions (cont'd)

<table>
<thead>
<tr>
<th>Main themes</th>
<th>Sample item derived from theme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (from management, passengers and the job itself)</td>
<td>‘When I have to stick to a timetable I feel under pressure even if I know that I can do the job in the time allowed’</td>
</tr>
<tr>
<td>Responsibility for passengers when driving</td>
<td>‘Having to be responsible for other people on the bus places alot of pressure on me’</td>
</tr>
<tr>
<td>Running times/not enough time</td>
<td>‘It is better to be late than to have an accident’</td>
</tr>
<tr>
<td>Having to make quick decisions or not rushing even if late</td>
<td>‘When driving a bus it is important to be able to make quick decisions and act on them’</td>
</tr>
<tr>
<td>Shift issues</td>
<td>‘It upsets me when I get told at the last minute to do a shift or route that I was not expecting’</td>
</tr>
<tr>
<td>Stress/worry</td>
<td>‘When something bad happens at the start of the shift I know that the rest of the day will be bad’</td>
</tr>
<tr>
<td>Temperament</td>
<td>‘I am happy and cheerful when driving a bus’</td>
</tr>
</tbody>
</table>

Study 2

Method

PARTICIPANTS

For Study 2, a sample of 315 bus drivers (297 males and 18 females), employed by Arriva, and aged between 19 and 71 (mean age = 46.30, SD = 10.35) volunteered to complete the pilot version of the BDBI. Length of service ranged from 0–39 years (mean length of service = 9.09, SD = 8.98).

MATERIALS AND PROCEDURE

The pilot BDBI consisted of four sections: Section one covered background and demographic information. Section two included 45 items from the original driver stress inventory (DSI), as well as additional items constructed from interview data reported in study 1. Participants responded to a ten-point scale ranging from ‘never’ to ‘always’. Section three included 31 items from the Driver Coping Questionnaire (DCQ) responded to on a six-point scale from ‘never’ to ‘always’. In this section drivers were instructed to answer on the basis of how they usually deal with driving when it is difficult, stressful or upsetting. Section four incorporated the Driver Social Desirability Scale (DSDS: Lajunen, Corry, Summala and Hartley, 1997), which consists of 12 questions covering impression management and self-deception and responded by indicating which statements were ‘true’ or ‘false’. Incident data for each participant was obtained from the company’s database of incidents that occurred throughout the UK from December 2000 to the end of March 2004. Incident was defined as all incidents, including collisions with other vehicles, objects or pedestrians as well as passenger falls inside the bus.
Results and discussion

An exploratory principal component analysis of the bus driver stress items of the pilot BDBI was conducted. Factors with eigenvalues greater than two were extracted and this provided a nine-factor solution. Eight substantial factors were extracted and rotated using the varimax rotation with kaiser normalisation. The ninth factor was discarded due to low item loadings. Following the analysis, the eighth factor was found to contain only three items and was also discarded.

For each factor, item analysis enabled some items to be discarded due to their poor discrimination between respondents. The resulting alpha coefficient for each of the seven final factors is shown in Table 2 below.

Table 2: Factor labels and alpha coefficients

<table>
<thead>
<tr>
<th>Bus driver behaviour factors</th>
<th>Alpha coefficients</th>
<th>Bus driver coping factors</th>
<th>Alpha coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatigue proneness</td>
<td>.92</td>
<td>Evaluative Coping</td>
<td>.83</td>
</tr>
<tr>
<td>Hazard monitoring</td>
<td>.86</td>
<td>Emotion Focus Coping</td>
<td>.76</td>
</tr>
<tr>
<td>Relaxed driving</td>
<td>.85</td>
<td>Risky Coping</td>
<td>.69</td>
</tr>
<tr>
<td>Patient driving</td>
<td>.83</td>
<td>Antagonistic Coping</td>
<td>.68</td>
</tr>
<tr>
<td>Anxious driving</td>
<td>.78</td>
<td>Avoidance</td>
<td>.68</td>
</tr>
<tr>
<td>Thrill seeking</td>
<td>.65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incident inevitability</td>
<td>.51</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3 shows examples of the principal loadings on the seven factors, in the rotated component matrix and the origin of the sample item.

Table 3: Factor analysis of bus driver behaviour (BDBI) (loadings > 0.4 on the rotated factor matrix)

<table>
<thead>
<tr>
<th>Factor One: Fatigue Proneness (FP)</th>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less focused/aware of what is going on around me</td>
<td>-.757</td>
<td>Study 1</td>
</tr>
<tr>
<td>Reactions to other traffic increasingly slow</td>
<td>.700</td>
<td>DSI: FP</td>
</tr>
<tr>
<td>More drowsy or sleepy</td>
<td>-.695</td>
<td>DSI: FP</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor Two: Hazard Monitoring (HM)</th>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I usually make an effort to look for potential hazards when driving</td>
<td>.738</td>
<td>DSI: HM</td>
</tr>
<tr>
<td>I make an effort to see what’s happening on the road a long way ahead of me</td>
<td>.699</td>
<td>DSI: HM</td>
</tr>
<tr>
<td>I try and predict what other people on the road are going to do</td>
<td>-.673</td>
<td>Study 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Factor Three: Relaxed Driving (RD)</th>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find it easy to relax when I finish work</td>
<td>.744</td>
<td>Study 1</td>
</tr>
<tr>
<td>It does not usually take me a few hours to fully relax after the end of my shift</td>
<td>-.675</td>
<td>Study 1</td>
</tr>
<tr>
<td>I find it easy to relax at work</td>
<td>.667</td>
<td>Study 1</td>
</tr>
</tbody>
</table>

(continued)
Table 3  Factor analysis of bus driver behaviour (BDBI) (loadings > 0.4 on the rotated factor matrix) (cont’d)

<table>
<thead>
<tr>
<th>Factor Four: Patient Driving (PD)</th>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>It does not annoy me to drive behind a slow moving vehicle</td>
<td>.652</td>
<td>DSI: AGG</td>
</tr>
<tr>
<td>I am usually patient during the rush hour</td>
<td>.582</td>
<td>DSI: AGG</td>
</tr>
<tr>
<td>I do not get frustrated when I am running late due to factors outside of my control</td>
<td>.569</td>
<td>Study 1</td>
</tr>
</tbody>
</table>

**Factor Five: Anxious Driving (ANX)**

<table>
<thead>
<tr>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am disturbed by thoughts of having an accident</td>
<td>.605</td>
</tr>
<tr>
<td>It worries me to drive in bad weather</td>
<td>−.580</td>
</tr>
<tr>
<td>It worries me to drive a bus in the dark</td>
<td>−.578</td>
</tr>
</tbody>
</table>

**Factor Six: Thrill Seeking (TS)**

<table>
<thead>
<tr>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I enjoy the sensation of accelerating rapidly</td>
<td>.701</td>
</tr>
<tr>
<td>I get a thrill out of driving fast</td>
<td>−.698</td>
</tr>
<tr>
<td>I would enjoy driving a sports car on a road with no speed limit</td>
<td>−.605</td>
</tr>
</tbody>
</table>

**Factor Seven: Incident Inevitability**

<table>
<thead>
<tr>
<th>Loading</th>
<th>Origin of item</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am bound to have an accident some day so there is no point in worrying about it</td>
<td>.515</td>
</tr>
<tr>
<td>Other drivers are too impatient on the road</td>
<td>.503</td>
</tr>
<tr>
<td>Car drivers do not have as much experience on the road as bus drivers</td>
<td>.467</td>
</tr>
</tbody>
</table>

AGG = Aggression; FP = Fatigue Proneness; HM = Hazard Monitoring; TS = Thrill Seeking; DIS = Dislike of Driving

Factor one is labelled fatigue proneness as it includes seven of the original eight DSI fatigue proneness items and the remaining five items relate to how the driver feels when they have been driving for a long period without a break. Factor two is labelled hazard monitoring as seven of the 12 items were from the original DSI and the remaining five items relate to making quick decisions, planning ahead, looking ahead and being confident in your own ability. Factor three is called relaxed driving as the items relate to being relaxed at work, relaxing after work, being happy and cheerful and not taking things personally. Factor four is labelled patient driving as the items pertain to being patient, not being aggressive and not getting frustrated or annoyed. Factor five is called anxious driving, with five of the eight items being from the original DSI dislike of driving factor. The remaining three items are concerned with being worried about driving in the dark and about what might happen during the shift. Factor six is labelled thrill seeking, as all five of the items were originally from the DSI, thrill seeking factor. Factor seven is labelled incident inevitability as the items describe inevitability of having accidents or making a mistake and problems with other road users.

An exploratory principal component analysis of the 32 items of the bus driver coping section, of the pilot BDBI, was also conducted. Factors with eigenvalues greater than two were extracted and rotated using the varimax rotation with kaiser normalisation. Table 4 shows examples of the principal loadings on the five factors, in the rotated component matrix.

Factor identification was relatively straightforward as the new factors were similar to the original DSI factors. Factor one is labelled evaluative coping with the factor
being made up of items that previously loaded onto the reappraisal and task focus coping factors of the DSI. The nine items relate to changing behaviour, gaining something worthwhile from the drive, learning how to cope with stress etc. Factor two is labelled emotion focus coping with all seven of the DSI emotion focus coping items loading at >0.4. Factor three is labelled risky coping with the items relating to taking risks, driving aggressively and not changing behaviour when meeting difficult situations. Factor four is called antagonistic coping with the items relating to coping by getting angry with other drivers, swearing, flashing the lights and using the horn. Factor five is labelled avoidance with five of the original seven items from the DSI avoidance factor.

The results of both factor analyses enabled 43 items to be discarded and relevant items to be retained in the development of the final version of the BDBI.

An important consideration is to what extent the BDBI discriminates between bus drivers who have blameworthy and non-blameworthy incidents. A preliminary analysis showed that blameworthy incident-involved bus drivers scored significantly lower on hazard monitoring ($t = 2.05, p < 0.05$) and patient driving ($t = 2.03, p < 0.05$) compared with bus drivers who had not been involved in a blameworthy incident in the last three years. These findings are consistent with previous research on car drivers, particularly with regards to impatient driving and increased accident risk (Matthews, Dorn and Glendon, 1991). A significant difference was also found for evaluative coping ($t = 3.38, p < 0.01$) with blameworthy incident-involved

| Table 4 Factor analysis of bus driver coping (BDBI) |
| Loading | Original Scale |
| Factor One: Evaluative Coping (EVAL) |
| Looked on the drive as a useful experience | .812 | RE |
| Felt that I was becoming a more experienced driver | .705 | RE |
| Made an extra effort to drive safely | .624 | TF |
| Factor Two: Emotion Focus Coping (EF) |
| Worried about my shortcomings as a driver | .736 | EF |
| Blamed myself for getting too emotional or upset | .715 | EF |
| Criticised myself for not driving better | .705 | EF |
| Factor Three: Risky Coping (RC) |
| Tried to make others more aware of me by driving close behind them | .644 | CC |
| Relieved my feelings by taking risks or driving fast | .639 | CC |
| Drove too close to the vehicle in front | -.504 | TF |
| Factor Four: Antagonistic Coping (ANTAG) |
| Let other drivers know they were at fault | .731 | CC |
| Flashed the lights or used the horn in anger | .650 | CC |
| Showed other drivers what I thought of them | .643 | CC |
| Factor Five: Avoidance (AV) |
| Told myself there wasn’t really any problem | .770 | AV |
| Refused to believe anything unpleasant had happened | .725 | AV |
| Went on as if nothing had happened | .705 | AV |

RE = Reappraisal; TF = Task Focus Coping; EF = Emotion Focus Coping; CC = Confrontive Coping; AV = Avoidance
drivers scoring lower on task-oriented strategies to cope with bus driving demands. This finding confirms the results of a previous study showing that task-focused coping is linked to increased bus driver safety (Dorn, Garwood and Muncie, 2003). Blameworthy incident-involved drivers also scored significantly higher on antagonistic coping ($t = -1.98, p < 0.05$) suggesting that confrontation with other drivers as a coping strategy in dealing with bus driving demands is implicated in blameworthy incident involvement. Finally, a significant difference was found for avoidance ($t = -2.112, p < 0.05$) with blameworthy incident-involved bus drivers scoring higher on avoidance of difficult situations compared with bus drivers involved in a non-blameworthy incident. Further analysis will seek to understand the potentially mediating effects of age and experience on bus driver behaviour and incident involvement.

**Conclusion**

The factor analysis reported here reveals important differences between the BDBI and the DSI with the BDBI providing a more comprehensive measure of bus driver behaviour than the DSI. Based on the findings of Study 1 and 2 the final version of the BDBI is now available for reliability and validity analysis. Research is ongoing to determine the suitability of the BDBI to predict bus incident involvement to aid in its use as a bus driver risk assessment for recruitment and training purposes with the ultimate aim of improving work-related road risk for bus drivers.

**Acknowledgement**

We would like to thank the employees of Arriva Passenger Services Ltd for their contribution to this study.

**References**


Applications of the theory of planned behaviour to drivers’ speeding behaviour

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Abstract

The theory of planned behaviour (TPB; Ajzen, 1985, 1988, 1991) provides a potentially useful approach for investigating the links between drivers’ attitudes and behaviour and for informing road safety interventions that aim to promote ‘safe’ driving. This paper presents a review of previous research studies in which the TPB has been applied to drivers’ speeding behaviour. Some conceptual and methodological limitations of the studies are raised. We then summarise two studies that we have recently conducted to overcome these limitations and discuss the implications for road safety.

Introduction

It is well-known that excessive driving speed is one of the most important contributory factors in road traffic accidents. The relationship between driving speed and accident liability is complex (Taylor, 2001). However, research has demonstrated convincingly that fast driving will increase the likelihood of a driver being involved in an accident (Finch, Kompfner, Lockwood and Maycock, 1994; Taylor, Lynam and Baruya, 2000). Furthermore, when an accident does occur, its severity will tend to increase with vehicle speed. As well as the safety concerns of fast driving, Ward (1999) described a number of other disbenefits including: (1) increased exhaust emissions which leads to poor air quality, and the emission of carbon dioxide which contributes to global warming, (2) increased noise and vibration, (3) damage to property and death and injury to animals, and (4) reduced social interaction between members of the community and the severance of
communities from shops and facilities, and from other parts of the community. Excessive speed, however, which typically involves exceeding the speed limit, is not a rare occurrence (e.g. Corbett & Simon, 1992; Department for Transport, 2002). Considerable benefits to road safety and society in general are likely to be found by persuading drivers to comply with legal speed limits.

The effects of demographic variables on drivers’ behaviour are well documented (e.g. French, West, Elander and Wilding, 1993; Meadows and Stradling, 2000; Quimby, Maycock, Palmer and Buttress, 1999a; Stradling, 2000). Older drivers, female drivers and lower mileage drivers, for example, have been found to drive more slowly and to comply with speed limits more often than younger drivers, male drivers and higher mileage drivers. However, this information is of limited use when developing road safety interventions to promote compliance with speed limits. To develop effective interventions, what we need to know is: why do drivers of different ages, for example, behave differently? In other words, we need to identify variables that can explain the demographic — behaviour relationships. These variables also need to be predictive of behaviour and amenable to change via road safety interventions. A suitable approach for identifying such variables is found in the theory of planned behaviour (TPB; Ajzen, 1985, 1988, 1991).

The theory of planned behaviour

The TPB provides one of the most influential accounts of the relationship between attitudes and behaviour. The model (see Figure 1) postulates that behaviour is determined independently by two variables: intention, which is a summary of people’s motivation to perform a given behaviour, and perceived control, which is people’s perception of their ability to perform the behaviour. Intentions are, in turn, determined independently by three variables: attitude towards the behaviour (people’s positive or negative evaluations about their performing the behaviour), subjective norm (people’s perceptions of approval or disapproval from significant others for performing the behaviour) and perceived control. The effects on behaviour of variables external to the TPB (e.g. demographics) are held to be mediated by the components of the model.

Figure 1  Theory of Planned Behaviour
From an applied perspective, it is important to demonstrate the relationships posited by the TPB because if TPB variables cannot predict intentions and behaviour then, in the context of this paper, it would suggest that road safety interventions to alter drivers’ attitudes would be ineffective in promoting compliance with speed limits.

Numerous studies have provided support for the TPB as a general theory of social behaviour (for reviews see Ajzen, 1988, 1991; Armitage and Conner, 2001). In the domain of traffic psychology the theory has been used to investigate a number of driving behaviours (for a review see Manstead and Parker, 1995). Much of the research on applying the TPB to driving behaviour was conducted under Road Safety Division’s (RSDs) Behavioural Studies Programme and it led to a better understanding of why certain behaviours are carried out and how they might be changed to improve road safety. The following sections of this paper focus on previous applications of the TPB to speeding violations specifically.

Evidence for the TPB — intention relationship

The relationships between the TPB variables and drivers’ intentions to speed have been demonstrated convincingly. Parker, Manstead, Stradling, Reason and Baxter (1992) conducted one of the first studies in which the TPB was applied to drivers’ speeding behaviour. They conducted a survey of 881 drivers and investigated intentions to exceed the speed limit by 10mph in a 30mph zone. It was found that attitude, subjective norm and perceived control together accounted for 47% of the variance in intentions to speed and all three independent variables were statistically significant independent predictors of intention.

Parker (1997) later conducted a survey of 318 drivers and demonstrated that the results of the earlier study generalised to speeding intentions in three different contexts. Attitude, subjective norm and perceived control together accounted for between 47% and 56% of the variance in intentions to exceed the speed limit by 10mph in 30mph, 40mph and 60mph zones.

More recent studies have supported the previous findings of Parker and colleagues. For example, Stead, MacKintosh, Tagg and Eadie (2002) conducted four TPB surveys over a period of three years to monitor changes in drivers’ attitudes, intentions and self-reported speeding behaviour in 30mph zones due to the Scottish ‘Foolsspeed’ campaign (a campaign based on the TPB designed to change drivers’ attitudes and speeding behaviour). Across the four surveys, the TPB was found to account for between 47% and 53% of the variance in intentions to speed. In all but

The TPB is a causal model of behaviour in that attitudes, subjective norms and perceived control have a causal effect on intentions, and intentions have a causal effect on behaviour. These cause and effect relationships are essential to the idea that changes in behaviour can be brought about by changes in attitude. Establishing the causality of the relationships is difficult. However, it should be noted that previous studies using cross lag correlation analyses and variants of structural equation modelling provide some evidence for the posited cause and effect relationships, and they suggest that the effects of attitudes on behaviour are stronger than are the effects of behaviour on attitudes (e.g. Armitage and Conner, 1999; Bentler and Speckart, 1981; Kahie and Berman, 1979).
one survey, attitudes, subjective norms and perceived control were each significant predictors of intentions. In the other survey, subjective norm was not a significant predictor.

Evidence for the TPB — behaviour relationship

There have been few studies that have tested the ability of the TPB to predict speeding behaviour. In both the Parker (1997) and the Stead et al. (2002) studies referred to above, cross-sectional designs were used to obtain measures of TPB variables and self-reported behaviour. In both studies, the TPB was found to be a strong predictor of reported behaviour. The Parker (1997) study showed that, across 30mph, 40mph and 60mph roads, the TPB accounted for between 56% and 63% of the variance in self-reported speeding behaviour. In the Stead et al. (2002) study, the TPB accounted for between 33% and 40% of the variance in reported speeding on 30mph roads.

In addition to investigating the predictive validity of the TPB with respect to a self-reported measure of speeding behaviour, Parker (1997) tested the TPB’s ability to predict observed driving speeds using a retrospective design. The speeds of 726 drivers were recorded on one of four roads, each of which included sections with 30mph, 40mph and 60mph speed limits. Spot speeds of each driver were recorded on each of the three sections. The TPB measures were obtained from 318 of the drivers subsequently by conducting interviews in participants’ homes. Regression models showed that the TPB accounted for between 10 and 11% of the variance in observed driving speeds and intention to speed was the only statistically significant independent predictor of observed behaviour.

Limitations of previous research

Although the research we have reviewed provides results that are indicative of a relationship between the TPB variables and speeding behaviour, there are a number of conceptual and methodological limitations of prior research. These are briefly summarised below:

1. In both the Parker (1997) and Stead et al. (2002) studies, cross-sectional and/or retrospective designs were used. Cross-sectional and retrospective designs have potential limitations stemming from the fact that the behaviour measures obtained may only be regarded as measures of past behaviour. The use of past behaviour as a dependent variable is potentially problematic because it breaches the assumed causal ordering within the TPB (e.g. that the relationship between intention and behaviour is a cause and effect one) and past behaviour is known to affect subsequently reported attitudes (e.g. Bem, 1972; Salancik and Conway, 1975).
2. Cross-sectional designs also render the data vulnerable to consistency biases (see Budd, 1987), which are likely to artificially inflate the correspondence between components (e.g. intentions and behaviour). It is likely that consistency biases will pose a significant problem when behaviour is self-reported and measured within the same questionnaire as the TPB variables. Prospective designs with a time gap between the TPB and behaviour measures are less vulnerable to these criticisms.

3. Self-report is widely recognised as a valuable methodology in social research and reasonably strong correlations can be found between self-reported and more objective measures of behaviour (e.g. Aberg, Larsen, Glad and Beilinsson, 1997; De Waard and Rooijers, 1994; West, French, Kemp and Elander, 1993). However, self-reported measures of behaviour are vulnerable to social desirability and memory biases, both of which can lead to under — or over-estimates of how frequently behaviour is performed (see Corbett, 2001). Thus, drivers’ self-reports may not provide entirely accurate accounts of their speeding behaviour.

4. Although Parker (1997) used more objective measures of behaviour in addition to self-report, a potentially important limitation of the study was that drivers’ speeds were measured once at one specific location. A number of studies have found that ‘spot speed’ measures can have limited reliability (e.g. Haglund and Aberg, 2002; Ogawa, Fisher and Oppenlander, 1962; Quimby, Maycock, Palmer and Grayson, 1999b; Wasielewski, 1984). In the Parker (1997) study, the use of spot speed measures may therefore have limited the ability of the TPB to predict drivers’ speeding behaviour.

In order to provide an appropriate test of whether the TPB can predict drivers’ speeding behaviour, and thus determine whether interventions based on the model have the potential to be effective, it appears that there is a need for studies that: (1) are prospective in design, and (2) use more objective measures of behaviour than self-report — measures that are both reliable and valid indices of speeding behaviour. To address the first requirement, we have recently conducted a large scale prospective survey in which TPB variables, measured at time one, were used to predict a measure of self-reported compliance with speed limits, measured three months later. Since that study was still vulnerable to the criticisms of self-reported behaviour data, we conducted a second study in which the TPB was used to predict a more objective measure of speeding behaviour, which was obtained using a driving simulator. These two studies are summarised in the following sections of this report.

2 It should be noted that as well as testing the TPB’s relationships using a cross-sectional design, Stead et al. (2002) also tested whether TPB variables measured at time one (baseline) could predict self-reported speeding intentions and behaviour measured three years later (their fourth survey point). Together with demographic variables, the TPB accounted for a modest amount of variance only in subsequently measured intentions (27%) and behaviour (21%), and the effect of age appeared to be accounting for the majority of the variance. However, one could question whether this was a valid test of the TPB’s ability to predict prospectively measured behaviour because the main purpose of the Stead et al. (2002) study was to evaluate the effectiveness of a large scale campaign designed to change drivers’ attitudes (and subjective norms and perceived control), intentions and behaviour. This campaign ran during the period between the measurement of the TPB variables at baseline and the behaviour variables three years later. It might be unreasonable to suggest that the TPB can provide a strong account of behaviour when intervening steps are taken to change attitudes over a long period of time between the baseline and subsequent measures. Furthermore, the relationship between age and attitudes/behaviour is well documented (e.g. Parker, Manstead, Stradling and Reason, 1992; Quimby et al., 1999a) suggesting that attitudes and behaviour change over time. This is likely to affect the level of correspondence between TPB and behaviour variables when the time gap between the measures is as long as three years.
A prospective self-report survey of drivers’ speeding behaviour

In our first study, we used the TPB as a framework to investigate a number of issues regarding drivers’ compliance with speed limits while driving in built-up areas (Elliott, Armitage and Baughan, 2003). In this report we focus only on those aspects of the study that related to the prediction of intentions and behaviour from TPB variables, and the mediation of the effects of demographic variables. The study was a prospective self-completion postal survey. At time one, TPB variables with respect to complying with the speed limit over the next three months were measured using standard questionnaire items. The demographic variables of age, sex, mileage and socio-economic group (SEG) were also measured at time one. Three months later, follow up questionnaires were sent to respondents to measure their reported compliance with speed limits since their completion of the time one questionnaires. Almost 600 drivers completed questionnaires at both time intervals.

Using regression analysis we found further support for the TPB as a predictor of drivers’ speeding intentions. Attitude, subjective norm and perceived control accounted for 48% of unique variance in drivers’ intentions to comply with the speed limit and all three independent variables were significant predictors. More importantly we were able to demonstrate that the TPB was a powerful predictor of prospectively measured self-reported compliance with speed limits. A hierarchical regression analysis, in which the prospective measure of reported speeding behaviour was regressed on the demographic variables in step one and the TPB variables in step two, showed that the demographic variables accounted for 17% of the variance in behaviour ($p < .001$). When the TPB variables were added to the analysis they led to an increase in explained variance of 32 percentage points ($p < .001$). In line with the TPB, intention and perceived control were the significant independent predictors ($p < .001$ in each case). They were more powerful predictors of behaviour than were the demographic variables, as indicated by the final standardised beta weights from the analysis. After we took the TPB variables into account the predictive validity of the demographic variables decreased, suggesting that their effect on behaviour had been mediated by the TPB. Using the test for establishing mediator effects suggested by Edwards (1984), we were able to demonstrate that the predictive validity of age and sex decreased significantly ($p < .01$ and $p < .05$, respectively). However, we did not find that the predictive validity of SEG decreased by a statistically significant amount. Variables that are outside the scope of the TPB (e.g. moral norm or personal identity) have been found to predict drivers’ speeding behaviour (e.g. Manstead and Parker, 1996) and such variables may be required to explain the SEG-behaviour relationship.

In summary, the results provided by this first study demonstrated convincingly that the TPB was a strong predictor of self-reported speeding behaviour. The findings were particularly encouraging given that a prospective design rather than a cross-sectional or retrospective design was used. This meant that the conceptual limitations of previous research (see above) were overcome and the three month time gap between the TPB and behaviour measures being taken was likely to reduce any consistency bias in the data.
A study testing the predictive validity of the TPB using an observed measure of speeding behaviour

As we have described, a potential limitation of our first study was that the behaviour measure was self-reported. Therefore, in our second study (Elliott, Armitage and Baughan, forthcoming) we wanted to test whether the TPB could predict a more objective speeding behaviour measure, which we obtained using the TRL driving simulator. We used a driving simulator because it provided a safe and controlled environment in which to conduct the research (Kaptein, Theeuwes and van der Horst, 1996) and it offered a useful method for obtaining reliable measures of speeding behaviour.

The study used a prospective design. 74 participants completed questionnaires containing standard measures of TPB variables with respect to avoiding/exceeding the speed limit over the next week, and measures of the demographic variables age, sex and mileage. One week later, the participants drove in the TRL driving simulator. Speeding on a number of different road types was investigated in the study. For the purposes of this paper only those results relating to urban distributor roads will be discussed, although it should be noted that consistent results were obtained across all road types. The simulated urban distributor route was 5km in length with a 30mph speed limit. Driving speed data obtained from the simulator was used to calculate the proportion of the distance of the drive that each participant exceeded the speed limit by 10% (i.e. the proportion of the distance that they were driving in excess of 33mph).

In line with previous research, multiple regression showed that attitude, subjective norm and perceived control were each statistically significant independent predictors of intention to avoid exceeding the speed limit. For the purposes of this paper, we included demographic variables in the analysis where the TPB was used to predict behaviour (i.e. we replicated the analysis procedure used in study one whereby the behaviour variable was regressed on the demographic variables in step one and the TPB variables in step two). Remarkably similar results to those we obtained in our first study were found in this study. The demographic variables accounted for 19% of the variance in observed behaviour ($p < .01$). The TPB variables added a substantial amount to explained variance over and above that accounted for by the demographics (an increase of 24 percentage points, $p < .001$). Of the TPB variables, intention was the only statistically significant independent predictor of observed speeding behaviour ($p < .001$). This pattern of findings is consistent with Parker (1997). However, in our research the TPB was found to account for much more variance in observed behaviour than in the Parker (1997) study, possibly because the measure of speeding behaviour was more reliable as it was based on driving over a whole length of road rather than a ‘snapshot’ of behaviour at one point in time.

Age was the only demographic variable to have a statistically significant effect on observed speeding behaviour in step one of the analysis. After the TPB variables
were taken into account, its ability to predict behaviour decreased. Although this suggested that the TPB mediated the age-observed behaviour relationship, the decrease in predictive validity was not found to be statistically significant. However, intention to comply with the speed limit was a much stronger predictor of behaviour than age was.

Although the validity of this study could be criticised on the grounds that a driving simulator was used to measure speeding behaviour, we are confident in the validity of the findings for a number of reasons. One reason is that intention was the sole independent TPB predictor of behaviour, and this finding is consistent with Parker (1997). Another is that the mean speeds observed on the simulator in this study (not reported here) are comparable with mean speeds observed on urban roads in ‘real life’, which are reported in transport statistics (Department for Transport, 2002). This is supported by validation studies of the TRL driving simulator which have shown that the correspondence between mean speeds on the simulator and mean speeds in ‘real life’ are broadly comparable (see Lockwood, 1997). In addition, the finding that the TPB was a strong predictor of observed behaviour in the simulator supports both the TPB and the validity of the driving simulator. In effect, this is a form of construct validation in which the behaviour of a measured variable in accordance with theory is taken as simultaneously supporting both the theory and the validity of the variable as a measurement of the underlying construct (in this case, real-world speed behaviour) that it is aiming to tap.

Road safety implications

As we have outlined, the inherent usefulness of the TPB is that it can be used to identify variables to target in road safety interventions. The idea is that if attitudes (and subjective norms and perceived control) can predict drivers’ intentions to speed, and intentions can in turn predict speeding behaviour, then changing drivers’ attitudes, making them more desirable from a road safety perspective, is likely to bring about corresponding changes in intentions and behaviour. There is strong evidence for this argument. It has been demonstrated convincingly that attitudes (and subjective norms and perceived control) can predict drivers’ intentions to speed. Prior studies have produced findings that are indicative of a TPB-speeding behaviour relationship (e.g. Parker, 1997; Stead et al., 2002). Our research in which we have attempted to overcome some of the limitations of previous studies, lends further support to the TPB-speeding behaviour relationship. Thus, the accumulated research shows that there is strong support for the TPB’s application to drivers’ speeding behaviour.

Despite this, previous attempts to modify drivers’ attitudes have been found to produce little systematic change in intentions and behaviour (e.g. Parker et al., 1996; Meadows and Stradling, 1999; Stead et al., 2002). However, it should be noted that long-term attitude change is notoriously difficult to achieve (Cook and Flay, 1978). It might be the case that in previous empirical investigations, the techniques used to change drivers’ attitudes have been ineffective, producing only small changes over time which might not be sufficient to change driving behaviour. Indeed, some previous evaluations have taken place in laboratory situations (e.g. Parker et al., 1996), which may be regarded as artificial and not conducive to bringing about
changes in real world attitudes. Others have used extremely small sample sizes (e.g. Meadows and Stradling, 1999), which lead to low statistical power. In addition, the literature on attitude change has shown that repeated exposure to a persuasive argument will enhance its persuasive effect so long as a number of criteria are met such as having a high-quality argument (e.g. Cacioppo and Petty, 1979, 1985). However, in most studies of driver attitude change interventions, participants have been exposed to the intervention on one or two occasions only. There is also an abundance of studies in the attitude change literature showing that persuasion is likely to be enhanced when individuals have the ability and are motivated to engage in issue relevant thinking (see Eagly and Chaiken, 1993). This is likely to lead to changes in the cognitive structure underpinning attitudes, and in terms of Petty and Cacioppo’s (1986) ‘Elaboration Likelihood Model’ this is called ‘central route persuasion’. Attitude change that is not accompanied by a change in underlying cognitions (referred to as ‘peripheral route persuasion’) may only be temporary, is likely to be affected by peer group pressure and other influences, and is unlikely to be predictive of behaviour. Media advertising (Stead et al., 2002) or video interventions (e.g. Parker et al., 1996) may not be sufficient to bring about central route changes in attitudes; interventions that require more active involvement from the participants may be more effective in bringing about attitude change that is relatively enduring, resistant and predictive of behaviour. Though further research may be required to develop such countermeasures, it is possible that classroom-based interventions that allow a high level of interaction between ‘student’ and ‘teacher’, or interactive computer-based interventions, would have the required prerequisites.

In general, further research is required to investigate effective ways of changing drivers’ attitudes to speeding, their intentions to speed and ultimately their speeding behaviour. Studies in which interventions are administered in the real world (perhaps in the context of driver training) and evaluated using adequate sample sizes are required.

Conclusions

1. Excessive driving speed is a problem for road safety and effective interventions to promote compliance with speed limits are required. The theory of planned behaviour offers a useful approach for identifying variables that (a) predict drivers’ speeding behaviour, (b) can explain the relationships between demographic variables and behaviour and (c) are potentially amenable to change via road safety countermeasures.

2. Previous research has demonstrated convincingly that the TPB can predict intentions to speed. However, previous studies in which the link between TPB variables and speeding behaviour has been tested have used cross-sectional or retrospective designs, which are associated with a number of potential limitations stemming from the fact that the behaviour measures are past rather than future behaviour. Cross-sectional designs are also vulnerable to consistency biases that may artificially inflate the correspondence between TPB and behaviour measures. In addition, there are few studies in which speeding behaviour has been measured more objectively than self-report.
3. Our recent work, summarised in this report, has demonstrated that the TPB can predict speeding behaviour when using prospective designs, which are less vulnerable to the criticisms described above. We have also demonstrated that the TPB can provide a good account of measures of behaviour that are more objective than self-report (i.e. observed speeding behaviour as measured in a driving simulator). In both our studies, the TPB variables were more powerful predictors of speeding behaviour than were the demographic variables and we also found evidence to suggest that the effects of demographic variables on behaviour were mostly explained by the TPB.

4. The accumulated research evidence, therefore, supports the notion that it should be possible to promote compliance with speed limits by changing drivers’ attitudes and intentions to speed.

5. Previous studies have not convincingly demonstrated an impact of attitude change interventions on drivers’ attitudes to speed, their speeding intentions or their speeding behaviour. However, there are a number of limitations of previous evaluation studies that need to be borne in mind, including the use of small sample sizes and laboratory, as opposed to ‘real world’, situations.

6. Ideally, interventions are needed that require more active involvement from the participant than is required in traditional forms of media advertising (e.g. posters and television adverts). Classroom-based interventions that allow a high level of interaction between ‘student’ and ‘teacher’, or interactive computer-based interventions, may be successful in engineering attitudes that are long lasting, resistant to change and predictive of behaviour. It would be desirable to evaluate such interventions in the context of driver training programmes.

References


Elliott, MA, Armitage, CJ and Baughan, CJ (forthcoming). *Can the theory of planned behaviour predict observed speeding behaviour?*


The Thames Valley speeding awareness scheme: a comparison of high and low speed courses

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Introduction

For legislation to have its full effect, compliance is a key factor. For example, the effectiveness of a speed limit in reducing casualties will be a function of the proportion of the population who obey that limit. An important measure of the success of any legal requirement is then the extent to which people comply with the law.

It is quite clear that compliance with legal speed limits is one area that is characterised by massive disobedience. In one survey 69% of car drivers were breaking the 30mph speed limit (Department for the Environment, Transport and the Regions, 2000). An issue then arises as to how authorities should act when the majority of the people that they represent break the law. In cases of mass non-compliance, authorities could either adopt methods to increase compliance, or alternatively abandon the law. Given the empirical connection between speed and casualties, the latter option is one with a very clear negative outcome.

In considering methods that might increase compliance, one principle that can be considered is that of procedural justice. This refers to the perceived fairness of the legal processes. In other words, do the processes that are implemented coincide with what members of the public would judge as being fair? It has been argued that procedural justice is not only a key factor in determining whether people accept legal decisions, but also in whether they comply in their future behaviour (Tyler, 2003).

In the UK there are several factors that might be interpreted as manipulations of procedural justice in the domain of speed enforcement. One manipulation concerns the prominent display of safety cameras. Not only are they physically prominent, the distinctive yellow colour provides a conspicuous warning. Similarly, warning signs are provided along sites for mobile enforcement. These factors can be seen as manipulations of procedural justice in the sense that they are, in part, intended to
decrease the grounds of complaint that might be offered by those caught. In other words, having provided advance warning of enforcement, the only uncertainty in the case of the speed camera is whether the camera is currently in operation. In the case of the fixed speed camera there is no spatial uncertainty, the attentive driver knows exactly where the enforcement will take place. There is, however, temporal uncertainty in the sense that the driver does not know at any one time whether the camera is in operation.

In principle, for mobile enforcement there is both spatial and temporal uncertainty. However, with a move to a highly visible presence, some mobile enforcement has neither temporal nor spatial uncertainty. In other words, at some mobile sites, if members of the public can see a police presence then enforcement is taking place, and if they cannot then it is not. As a method of reducing potential complaints (and hence perceived procedural justice) this has much to commend it.

These methods are, however, not without some risks. As uncertainty surrounding enforcement decreases, it is possible that the public will be open to an erroneous but plausible heuristic: *If there is transparently obvious enforcement then legitimate speed detection can take place, and if there is not then legitimate speed detection cannot take place.* As evidence in favour of this heuristic one might cite the fact that some people plead not guilty to speeding offences, not on the basis that they were not speeding, but rather that they were not warned that enforcement may take place. A difficulty with the operation of this heuristic is that the public may learn that it is appropriate to obey the law in the presence of enforcement, and that it is acceptable to break the law in the absence of enforcement. In theory this heuristic would not provide a problem for public safety (though it might provide a problem for respect for the law) if it were possible to identify in time and space exactly when and where speed-related accidents had happened or might happen. The fact that we cannot completely identify when and where a speed-related accident might occur leads to problems. The operation of this heuristic might discourage generalisation of speed compliance beyond the specific time and place. The specificity of speed compliance is illustrated by Keenan (2002), who found that lower speeds occurred only at a very limited area surrounding the fixed camera. A challenge therefore exists in encouraging speed reduction beyond the enforcement time and place.

Another manipulation of procedural justice can be observed in the use of speed awareness programmes. These programmes offer those who have broken the speed limit the opportunity to avoid points on their licence if they attend and participate in a course. It is known that drivers are particularly concerned about points on their licence (McKenna, 2003). By exchanging participation on the course for points on one’s licence, one aim is to decrease the complaints surrounding speed enforcement. To the best of the author’s knowledge the first formal speed awareness programme in the UK was introduced in Lincolnshire by Greville Burgess in 1999. (An informal scheme was introduced in Thames Valley in the early 1990s.) The present chapter will consider the formal version of the Thames Valley Speed Awareness programme.

The Thames Valley speed awareness programme

The design of the programme was influenced by both criminological and psychological perspectives, each of which will be briefly described. From a
Criminological perspective there are two sources of influence on the design of the programme, these being procedural justice and restorative justice.

**PROCEDURAL JUSTICE**

As noted above, procedural justice is concerned with perceptions of fairness. In particular the proposal is that public compliance is dependent on perceived fairness of the enforcement procedures and their perceived legitimacy. Given that the majority of drivers break the speed limit and that people do not rate speeding as a severe offence, then it follows that enforcement is going to face some important challenges. By allowing drivers who participate on the course the option of avoiding points on their licence, one aim is to soften the enforcement blow and hence reduce one source of complaint.

Another important factor from the perspective of procedural justice is that of motive-based trust. The issue here is the extent to which people trust the motives of the authorities. There has, for example, been media criticism of safety cameras based on the proposal that the motivation of the authorities is primarily to raise money. Associated with this media coverage there has been a decline in support for safety cameras (Department for Transport report, 2004). As a consequence, one feature of the programme is to address explicitly the motivations of the authorities with reference to speed enforcement. An explicit aim of the course is to explain the safety motivations of the authorities and to boost the legitimacy of speed enforcement.

Another attack on the legitimacy of speed enforcement has come through the argument that ‘the police should be chasing real criminals rather than chasing speed offences’. Again, since this is a challenge to the legitimacy of speed enforcement, from a perspective of procedural justice this issue should be considered. The method that is used is to explore with the group the number of victims of serious crime and the number of victims of serious road crashes. The emerging argument is that the sheer magnitude of crash casualties compels action.

**RESTORATIVE JUSTICE**

The history of restorative justice is extensive and there are a number of different versions with a number of core ideas (for a review see Braithwaite, 1998). For the present purposes one important factor that will be considered is that of time perspective.

Traditional retributive punishment tends to look backwards in time, focusing on the crime and the conditions surrounding the crime. Restorative justice, by contrast, has a greater focus on the future and how amends can be made. Restorative justice brings together the various stakeholders including victims, offenders, families and communities.

The present approach differs in that the various stakeholders are not present. An important issue and challenge in dealing with speed awareness is that from the perspective of the offender there is no victim. From the offender’s perspective, the person was speeding but no one was harmed. For the vast majority of drivers who speed, and for all the drivers who attend the programme, there is no specific identified victim. This issue is specifically addressed on the programme, and with
the participants’ involvement they are shown that their personal speed choices would have produced a victim in different circumstances.

**PSYCHOLOGICAL PERSPECTIVE**

One aim of the course is to provide drivers with some insight into their personal driving attitudes, ability and risk. The majority of drivers have not been on any driving course since they passed their driving test. Of the 5,000 drivers who attended this programme, only 7% had been on any driving course and only 2.3% had been on a course that lasted for two days or more.

It has been known for some time that drivers have an overly optimistic perception of both their driving ability and their safety (McKenna, 1993; Svenson, 1981). With the absence of feedback, it is readily understandable how these perceptions of high ability might develop unchecked. The aim, therefore, is to provide drivers with feedback on their relative standing with respect to a number of driver attitudes and ability. Given that for the majority of drivers this will be the first opportunity for receiving feedback on their driving, the aim was to cover a broad range of driving issues. In other words, the assessment did not focus exclusively on speed choice.

At the end of the assessment period drivers were presented with a four page document outlining their personal risk profile. The document consisted of factual feedback providing drivers with their scores compared to other drivers. In addition, personally relevant safety messages were presented dependent on their scores.

As a delivery system for safety messages the current method is worthy of comment. Health communication in general faces many challenges. One major problem is targeting the appropriate audience. The advantage of the present system is that the drivers are self-selected on driving violations, so it known that the target population has been contacted. More specifically, the message is tailored to the attitudes and ability of the particular person. The system, therefore, allows the targeting of relevant people and the targeting of relevant attitudes and ability within a person.

An important ingredient in delivering personally relevant feedback and personally relevant safety messages is that the process is designed to be involving. Likewise, when engaged with the trainer the discussion was explicitly designed to be interactive to ensure that participants were actively involved. According to dual mode processing theories of attitude change (the heuristic/systematic model of Chaiken *et al*. 1996 and the elaboration likelihood model of Petty and Wegener, 1998) when people are more involved they are more likely to process the message in greater detail. When people are less involved they are more likely to be persuaded by less onerous routes, and hence persuasion relates to factors such as beliefs about the level of expertise of the source. While efforts were made to capitalise on the more peripheral routes to persuasion, the aim was to have participants engage with the message.

The message in each part of the programme was, of course, designed to be useful. At the end of the course the usefulness of each part of the course was anonymously assessed. As with many other persuasive campaigns, the aim was to change intentions. At the end of the course drivers’ intentions were anonymously assessed. The ability of the different parts of the course to predict speed intentions was also assessed. If the programme has no impact on drivers’ intentions, then we would predict no empirical connection between ratings of usefulness and speed intentions.
TWO COURSES — HIGH AND LOW SPEED

Two overlapping courses were designed, one for low-speed offenders and one for high-speed offenders.

The low-speed course consisted of drivers who had broken a speed limit at the low end of the violation scale, whereas the high-speed course consisted of drivers who were in considerable breach of the speed limit. The low-speed course was entirely based in a classroom setting and consisted of two sections. In the first section all participants completed an online battery of tests, at the end of which they received written feedback containing a) their relative position on a range of attitudes, personality and ability and b) safety messages related to their particular responses. Having examined their feedback they moved on to the second section, which consisted of an interactive discussion with the trainer.

The high-speed course consisted of the same two sections as the low-speed course, plus an on-the-road driving course was included. Another difference between the low-speed course and the high-speed course was that the high-speed course was more of a compromise with traditional retributive justice in the sense that all participants received points on their licence.

An interesting issue concerns whether there are any real differences between those on the low-speed course and those on the high-speed course. If the difference between those caught at low speeds versus those caught at high-speeds is due to random transient factors e.g. ‘on this particular occasion I was in a hurry’ then we should find that there are no stable differences between the two groups in terms of their general speed choices, attitudes and personality.

Method

Participants

A total of 4,678 drivers attended the low-speed programme while 410 attended the high-speed course. Of those attending the low-speed course 2,650 were men and 2,028 were women. Of those attending the high-speed course 306 were men and 104 were women. Age was determined in large part by participants responding in five-year ranges e.g. 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. To encourage interaction with the trainer the maximum size of any group was 24 participants.

Procedure

At the start of the session all participants sat at a workstation that could switch between having a flat screen monitor presented, or having the monitor folded into the desk.

The first section consisted of the computer-based assessment. The system was designed to be used by people who had little or no experience of computers. All participants were informed that their responses were anonymous and that no
The Thames Valley speeding awareness scheme: a comparison of high and low speed courses

questions would or could be used to identify an individual. They were informed that they would receive feedback and that the accuracy of the feedback was dependent on the accuracy of their answers.

The first section took between 40–50 minutes and covered a broad range of topics including demographics, self-report speed, driving violations, fatigue, driving experiences and personality, in this case, aggression. Digitised video tests were also included that assessed speed choice, close following and hazard perception.

On finishing the assessment they received a four page printout providing a) feedback on their attitudes and ability and b) safety messages tailored to their personal responses.

The next session was with a trainer who involved all participants in the discussion, which was designed to cover both perceived barriers to enforcement (e.g. should the police enforce the speed limit, and is this just a money making exercise?) and how speed is connected with accident involvement. The latter is illustrated through examining the personal speed choices of the participants.

At the end of the course the participants rated the usefulness of the digital video tests, the computer-based assessment with feedback, and the driver trainer discussion. Each was rated on a five-point scale with 1 anchored with the label ‘not at all’, 3 with the label ‘quite’ and 5 with the label ‘very’. They also indicated their future speed intentions.

Results

For the present purposes three issues were considered. The first determined whether there were any differences between those attending the high-speed course and those attending the low-speed course. The second was concerned with the participants’ ratings of the course and the third was concerned with drivers’ future speed intentions.

**High versus low speed**

In order to ensure comparability, the speed limit of 30mph was chosen for all participants. While this makes relatively little difference to the number attending the low-speed course (4,602) it does make a difference to the number attending the high-speed course (185). (A significant proportion of the high-speed group had broken the 70mph limit).

There was a significant difference in age \( t(4785) = 6.5, p < .0001 \) between the high and low speed groups. Although the mode for each group was in the age range 36–40, the high-speed participants had a higher proportion of younger and a lower proportion of older drivers than the low-speed course. On the low-speed course 57% were men whereas on the high-speed course 67% were men. There was no significant difference in mileage \( t(4785) = 1.2, p > .05 \). There was a significant difference in self-reported speed choice \( t(4785) = 6.7, p < .001 \), indicating that those on the high-speed course usually chose higher speeds than those on the
low-speed course. To illustrate this difference 46.4% of the low-speed course indicated that they would usually break the 30mph speed limit, whereas 58.4% of the high-speed course indicated that they would usually break the 30mph limit. There was a significant difference between the two groups in their digital video speed choices $t(4745) = 2.58, p < .01$ indicating that those attending the high-speed course chose higher speeds. There was no significant difference between the two groups in their digital close following choices ($t(4016) < 1, p > .05$) nor in their hazard perception scores ($t(4105) < 1, p > .05$). There was no overall difference in aggression ($t(4785) = 1.2, p > .05$). There was a significant difference in self-reported driving violations ($t(4785) = 4.7, p < .001$, indicating that those attending the high-speed course reported more driving violations. There was a significant difference in the number of times that the driver had been stopped by the police in the last three years, $t(188.9$ variance unequal) $= 2.2, p < .05$.

Of those attending the low-speed course 16.8% had experienced an accident in the last three years whereas the corresponding percentage in the high-speed course was 24.9%, a difference which is statistically significant $z = 2.87, p < .005$. When self-defined speed-related accidents are considered the difference is equally clear. Of those attending the low-speed course 6.8% had experienced an accident in which their speed had made a contribution, whereas the corresponding percentage in the high-speed course was 14.6%, a difference which is statistically significant $z = 4.05, p < .001$.

**Usefulness ratings**

It can be seen from Table 1 that the majority of the participants rated all aspects of the course as useful.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Percentage utility ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 not at all</td>
</tr>
<tr>
<td>Digital video</td>
<td>1.1</td>
</tr>
<tr>
<td>Risk profile</td>
<td>.6</td>
</tr>
<tr>
<td>Trainer discussion</td>
<td>.5</td>
</tr>
</tbody>
</table>

Given that the high-speed participants are more entrenched in their speeding habits, it is possible that they will be more resistant to the course. In comparing the course usefulness ratings (see Table 2) it was found that the high-speed participants were more resistant to the course message, rating the digital video as less useful $t(4644) = 2.7, p < .01$, and the trainer discussion as less useful $t(4644) = 2.1, p < .05$. However, there was no difference between the two groups in their ratings of the risk profile $t(4644) = 1.5, p > .05$.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Mean ratings of effectiveness (standard deviation in brackets)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low-speed</td>
</tr>
<tr>
<td>Digital video</td>
<td>4.1 (.96)</td>
</tr>
<tr>
<td>Risk profile</td>
<td>4.0 (.91)</td>
</tr>
<tr>
<td>Trainer discussion</td>
<td>4.2 (.88)</td>
</tr>
</tbody>
</table>
Where there are differences, the effect size is not great as is reflected in Cohen’s $d = .16$ and $.20$ for the trainer discussion and digital video respectively.

**Future speed intentions**

A key feature, of course, is whether at the end of the programme participants intend to change their speed. Figure 1 plots the speed intentions of the two groups separately.

![Figure 1 Percentage speed intentions](image)

In comparing the speed intentions of the two groups it was found that the high-speed participants intended to drive significantly slower than the low-speed participants $t(4647) = 3.9, p < .001$, Cohen’s $d = .30$.

To examine if the usefulness of the course was associated with drivers’ speed intentions, multiple regression was run using drivers’ ratings of the trainer and their ratings of the risk profile to predict speed intentions. (Given that the digital video ratings are a part of the risk profile, there is a conceptual overlap and a risk of multicollinearity so the digital video ratings were excluded.) The analysis was carried out separately for the low and high-speed participants.

It can be seen from Table 3 that age predicts drivers’ speed intentions, so that younger people intend to drive more slowly than older. Women intend to drive more slowly.

| Table 3 Regression to predict future speed intentions for the low-speed participants |
|-------------------------------------------------|----------------------------------|-------|----------|
| Age                                             | Standardised Beta | T     | Sig.     |
| Sex                                             | -.104               | -7.19 | .000     |
| Trainer discussion                              | -.138               | -8.11 | .000     |
| Risk profile                                    | -.184               | -10.84| .000     |
Those who rated the trainer discussion as more useful intend to drive more slowly, and those who rate the risk profile and feedback as more useful likewise intend to drive more slowly.

Table 4 shows that the direction of the predictors was the same for the high-speed participants, with the major difference being that age was not significant, perhaps because there was less variability in age and there were fewer older participants. In each group the risk profile was the most effective predictor of speed intentions.

<table>
<thead>
<tr>
<th></th>
<th>Standardised Beta</th>
<th>T</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.008</td>
<td>.159</td>
<td>.874</td>
</tr>
<tr>
<td>Sex</td>
<td>-.137</td>
<td>-2.84</td>
<td>.005</td>
</tr>
<tr>
<td>Trainer discussion</td>
<td>-.153</td>
<td>-2.38</td>
<td>.02</td>
</tr>
<tr>
<td>Risk profile</td>
<td>-.203</td>
<td>-3.19</td>
<td>.002</td>
</tr>
</tbody>
</table>

Discussion

As noted earlier, the sheer scale of traffic law violations presents authorities with very particular challenges. When the majority of the population breaks a law, the legitimacy of enforcement is readily challenged. While it is easy to exaggerate this challenge (surveys reveal that the public in general do accept the speed limits) it does remain a matter of some concern.

In the case of speed, the clear connection with accident involvement means that this challenge has to be faced. This means that issues of procedural justice become even more salient. Methods that increase compliance and that are perceived to be fair offer some important advantages.

Making enforcement very visible does have the considerable advantage that it renders accusations of unfairness untenable. After all, in conditions of high visibility, being caught for speeding becomes a voluntary exercise for the attentive driver. However, there is an important potential drawback. As the spatial and temporal specificity of enforcement increases, so also may the specificity of compliance. For the average driver there may be little incentive to generalise a decrease in speed beyond the enforcement time and place. While this would not eliminate the effect of enforcement, it would provide an important limitation. Other schemes such as education and speed awareness programmes would then have to provide the substantive arguments for generalising a decrease in speed choice.

It is of course quite likely that no single measure will be sufficient to deal with the speeding issue. At present there are a range of measures that are available. If these were to be arranged in terms of targeted persuasion and required compliance, we might consider speed education at one end of the continuum. Next we might consider speed indication devices, which have the merit of targeting the appropriate population, though the opportunity to provide a persuasive message is limited. Next we might consider enforcement, which targets the appropriate population and
offers a number of messages. The traditional punitive approach offers the powerful argument that compliance is better than points on one’s licence. Speed awareness schemes offer a variant that downplays the punitive aspect and emphasise the persuasive aspect. At the other end of the continuum, speed limiting devices and engineering bypass persuasion and aim for compliance.

It will take a judicious mix of all of these measures and others to provide real changes in speed choice. For the present, the aim has been to consider speed awareness programmes. A noted strength of these schemes is that they appeal to a combination of procedural and restorative justice. They target an appropriate audience in a non-punitive way, and in the present case attempt to boost the legitimacy of enforcement and to provide arguments for a change in speed intentions.

An argument in favour of speed awareness schemes is that they can operate at the level of public debate as well as at the individual level. At the level of public debate they provide an opportunity for explaining the significance and legitimacy of enforcement. At the individual level a number of issues are important. In the present case, full opportunity is taken of the fact that it is known that speed is associated with other high risk behaviours, and that for the majority of drivers, attendance at this course will be the first opportunity that they have had since passing their test to reflect on a core life skill. In the present case, drivers are provided with feedback on their personal risk attitudes and ability, and with safety advice tailored to their specific responses.

The anonymity provided by the course in general and the computer interaction in particular provides the participants with a good opportunity to reflect on their driving. The level of reported breaches would suggest that they take advantage of this opportunity and minimise impression management. For example, on the low-speed course 69% of participants report that they usually break the 70mph limit and in the high-speed course 81% report that they usually break the 70mph limit.

The overall aim of changing driver intentions was satisfied by the finding that at the end of both courses, the vast majority of drivers intended to slow down. The finding that those who attended the high-speed course reported significantly greater intentions to slow down might be tempered by the fact that they generally drive faster than those attending the low-speed course.

Although it is theoretically possible that the difference between the high and low speed groups is due to random transient factors, such as being in a hurry for a particular appointment, the results are not consistent with this position. From self-report and digital video assessment, those attending the high-speed course report that they usually choose faster speeds. Those attending the high-speed course were younger and contained a higher proportion of men. It is not uncommon for the proportion of males to increase as the severity of the offence increases. Those attending the high-speed course reported significantly more driving violations and, importantly, reported twice as many speed-related accidents as those attending the low-speed course.

Both groups rated each part of the course as useful, though the low-speed participants rated the trainer and the digital video assessment as more useful. There was no difference between the two groups on their ratings of the risk profile, which
was the most effective predictor of speed intentions. Interestingly, older drivers reported less intention to change their driving speed. This might be interpreted either in terms of the more fixed attitudes of older people (Visser & Krosnick, 1998) or perhaps in terms of the fact that since older people choose slower speeds to start with, they are less in need of change.

The high speed course presents an interesting mix of procedural, restorative and punitive justice in being a compromise of punishment (award of points) and the offer of a course that presents the opportunity for change. The fact that those attending the high-speed course rated the programme as slightly less useful might reflect their more entrenched position. However, their increased intention to change is not entirely consistent with this view nor is the fact that they rated the risk profile as equally useful. Given the fact that those attending the high speed course have a greater accident risk, any gains that could be achieved with this group have the opportunity of reaping considerable rewards. The high speed group presents an important challenge to authorities. To what extent should we look to punishment or persuasion or both?

In looking to the future we might seek a more flexible range of options. For example, the issue of the specificity of compliance matching the specificity of transparent enforcement will have to be addressed. If the public are learning that speed limits should be obeyed only in the presence of transparent enforcement then speed-related accidents will continue on a large scale. While education and speed awareness courses can play an important part in providing a rationale for generalising speed compliance it is likely that at some point in the future the highly transparent nature of enforcement will have to be addressed. This may provide a barrier to generalising speed compliance. One possibility would be to trade off the procedural acceptability of high visibility enforcement for the procedural acceptability of speed awareness courses. In other words those who are caught offending through a less highly visible enforcement strategy might be offered a speed awareness course.

One additional option might be to offer a speed awareness course with suspended points. If participants attending courses were not guilty of any subsequent offence in a specified period then the points would not be awarded. However, if participants were guilty of a subsequent offence in the specified period then not only would they receive the points for the current offence they would also resurrect their previous points. The idea being that the speed awareness course provides the knowledge of what to do and why and the suspended points provides an ever present motivation to ‘keep you honest’.

Conclusion

The frequency with which members of the public break the speed limits in combination with the clear connection between speed and accident involvement presents authorities with a challenge. In order to reduce speed-related accidents the public will have to be persuaded of the legitimacy of the speed limits and the legitimacy of speed enforcement. In the search for publicly acceptable methods of enforcement, speed awareness courses offer a new possibility. Their strength is that
they can target appropriate drivers, and as demonstrated in the present case, it is possible to deliver personally relevant messages tailored to the specific attitudes and ability of the person and to change drivers’ speed intentions.

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Introduction

It has long been known that young drivers are over-represented in accidents, and as a result have been a major focus of research and policy in traffic safety in the developed countries of the world for many years. More recently, research has shown that much of this problem is associated with inexperience, in that both younger and older new drivers have an elevated risk of accident involvement in the early stages of their driving careers (Maycock et al., 1991; Forsyth et al., 1995; Mayhew et al., 2000).

The first investigation into the new driver problem on a large scale in this country was started in 1988 in the Cohort I study (Forsyth, 1992a, b; Forsyth et al., 1995; Maycock and Forsyth, 1997). Every person who took a driving test on one of four days (two in November 1988 and two in July 1989) was sent a questionnaire two weeks after taking the test. Information on accidents and offences was collected at annual intervals for the first three years of driving. In addition, surveys of attitudes and opinions were carried out at intervals over two years.

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

The main objectives of the Cohort II study are:

• to look at performance in the driving test;
• to relate this to learning experiences;
The attitudes and reported behaviours of novice drivers: results from the Cohort II study

- to assess attitudes to safety;
- to collect information on accidents/offences in early driving; and
- to monitor effects of changes to the training/testing regime.

This paper looks at results relating to just one of these objectives, and examines changes in the attitudes and reported behaviours of new drivers over the first two years after passing the practical test.

Project design

The cohort study is a questionnaire survey of learner and newly-qualified drivers. The main part of the study contacts new drivers at the time they take their test and follows up those who pass their test for up to three years. Information about driving test performance (both for those who pass and who fail their test) is obtained from DSA and linked to the questionnaire data. A smaller supporting study looks at learner drivers at the time they take their theory test. The project is designed to run for four years, allowing 14 cohorts of novice drivers to be incorporated.

In summary, the project design is as follows:

- tracking drivers from time of test pass;
- a new cohort of drivers every three months;
- 8,000 test candidates in each cohort;
- follow-ups at six, 12, 24 and 36 months for those who pass their test; and
- a separate survey of theory test candidates.

Questionnaires

The study uses six different questionnaires:

- learning to drive questionnaire;
- driving experience questionnaire 1;
- driving experience questionnaire 2;
- driving experience questionnaire 3;
- driving experience questionnaire 4; and
- theory test questionnaire.

The first element of the project is to investigate methods used in learning to drive. The learning to drive questionnaire (LTDQ) is the first contact with respondents, and is a key part of the study. It includes questions about preparation for both the theory
and practical elements of the driving test, including time spent in different types of driving environment and whether this is with an instructor or with a friend/relation. It also includes some basic attitude questions.

The second element follows the experiences of new drivers in the early part of their driving careers. The driver behaviour questionnaires (DEQs) cover accidents, exposure and offences as well as attitudes and reported behaviour, and these are sent out as versions 1, 2, 3, and 4 at six, 12, 24 and 36 months after drivers pass the practical test. The repeated questionnaires allow an accident history to be built up which will track the changes in risk as drivers become more experienced. We are also able to track behavioural and attitudinal development.

A third element of the project involves the theory test questionnaire (TTQ), which collects information about preparation for the theory test, previous performance (if the subject has failed a previous test), and intentions for the future (if they have just failed the test).

As well as the questionnaire data we have access to the DL25 records from the practical driving test, which are linked for analysis purposes to the LTDQ data. The DL25 record includes data on all the driving faults committed by candidates. Subjects who passed their practical test are still likely to have a number of faults but these will not have been sufficient (in number or severity) to result in test failure.

Sample

The main cohort study sample consists of 14 cohorts, each of 8,000 candidates, taken at three-monthly intervals over the period of the project. Each cohort sample is selected from practical driving test booking data for a single week. Since about 24,000 candidates take a practical driving test each week, this represents approximately one third of candidates in our test weeks. The sample method makes use of the names and addresses within the DSA booking system which are held electronically, and are as up-to-date as possible. Making use of the booking system data therefore minimises the number not reached due to address errors. Information provided by DSA indicates that less than 5% of the sample taken at this point fail to attend their test. The cohort samples are selected using a randomised sample spread across each day of the week to ensure representativeness.

At the time of writing, data has been analysed from nine cohorts for the learning to drive questionnaire, seven cohorts for driving experience questionnaire 1 (six months), five cohorts for DEQ2 (12 months), and one cohort for DEQ3 (24 months).

Results

As can be imagined, the project is generating a wealth of data. This paper provides an example of the results that have been made possible by the project design, in that it looks at changes in attitudes and reported behaviour over time during the first two years of driving after passing the practical test.
A selection of data is presented for those respondents who have provided information at all four data points, i.e. two weeks after passing the test (LTDQ), six months, 12 months, and 24 months’ later (DEQs 1–3). The resulting sample of 242 respondents is small in relation to the study as a whole, but is still large enough to provide reliable results.

Three areas will be considered: self-assessments of confidence, self-reported behaviour as measured by the driver behaviour questionnaire (DBQ), and self-reported driving style based on what have become known as the ‘Guppy scales’.

The sample is predominantly made up of young people, with a mean age of 23.2 years, and with three out of four respondents being under 25. Females outnumber males in the sample by about two to one.

### Confidence

At all four time points of the study, respondents were asked to rate whether they felt ‘very confident’, ‘fairly confident’, ‘not very confident’, or ‘not at all confident’ in their driving ability (scored from 4 to 1). Mean confidence scores over time by age and gender are shown in Figure 1.

Figure 1 shows that males were more confident in their driving ability than females were at each time point of the study and, on the whole, that younger drivers claimed more confidence in their driving ability than older drivers. However, more interesting are the changes in drivers’ confidence levels over time. Shortly after passing the test, all respondents reported high levels of confidence in their driving ability. After six months, confidence in driving ability decreased by a statistically significant amount, and at one year after passing the driving test confidence levels
remained at the same level. Only at two years after passing the driving test does the confidence of new drivers in their driving ability increase, though not to the immediate post-test levels.

In the case of male drivers, confidence scores almost reached the levels they were two to three weeks after passing the practical driving test, but the confidence of older drivers (+25 years) did not increase at the two year point.

Overall, these findings suggest there is an over-estimation of driving ability immediately after passing the test. In the first year after passing, respondents develop more realistic perceptions of their driving abilities as they encounter a wider variety of driving situations than they would have experienced while learning to drive. For most drivers, it would appear that it takes a year of driving experience before confidence starts to increase again.

**Self-reported driving behaviour**

Self-reported driver behaviour was collected in each of the DEQ questionnaires using a 34-item version of the driver behaviour questionnaire (Reason *et al.*, 1990; Parker *et al.*, 1995; Åberg and Rimmo, 1998). The DBQ required respondents to rate on a six-point scale ranging from ‘never’ to ‘nearly all the time’ how often they carried out each of the 34 driving behaviours. Factor analysis confirmed a five-factor structure for the data, with the factors being labelled as slips/lapses (seven items), errors (eight items), inexperience errors (seven items), violations (six items), and aggressive violations (six items).

Figures 2a–2e show that the reported frequency of committing violations, errors, slips/lapses and aggressive violations increased over the first two years of driving,
whereas the reported commission of inexperience errors decreased. These findings were consistent across males and females and across older and younger respondents.

The age and sex differences shown in the figures are consistent with previous research showing that males report committing violations and aggressive violations more often than do females, and that younger drivers report committing these behaviours more often than do older drivers.
Self-reported driving style

Self-reported driving style was measured at each time point of the study using the measures developed by Guppy et al. (1990), which ask respondents to rate what kind of driver they think they are on 12 dimensions. These 12 items regularly reduce to
the three factors shown in Table 1. At each time point of the present study, factor analysis confirmed the three-factor structure shown in the table.

<table>
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<th>Table 1 Driving style scales</th>
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<td><strong>Factor 1</strong></td>
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<td>Inattentive/attentive</td>
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<td>Careless/careful</td>
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<td>Irresponsible/responsible</td>
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<td>Risky/safe</td>
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Figures 3a–3c show the changes in the factor scores over time from two weeks to 24 months after passing the test. The results show what might to a large extent be expected differences in age and sex across the factor scores, but with time differences being less predictable. Younger respondents reported a more unsafe driving style than did older respondents, and males reported a more unsafe driving style than did females. Compared with older respondents, younger drivers reported being less attentive, careful, responsible and safe, being less placid, patient, considerate and tolerant, and being more decisive, experienced, confident and fast. Compared with females, males reported being less attentive, careful, responsible and safe, being less placid, patient, considerate and tolerant, and being more decisive, experienced, confident and fast.

Across the whole sample, there were statistically significant differences in reported driving style over time. The results suggest that after the first six months of driving after passing the practical driving test, drivers became less attentive/careful/responsible/safe
and less placid/patient/considerate/tolerant, and that these driving styles then remain relatively stable over the subsequent one-and-a-half years of driving.

A different pattern of results was found for factor 3 driving style scores. These scores increased with each time interval (see Figure 3c). These findings can be readily accounted for by the fact that driving experience increases with time, and the items comprising this driving style scale were related to driving experience.
To examine these differences further it is revealing to look at the individual items in the Guppy scales, rather than just the factors. These are shown for the whole sample in Figures 4a–4c.

For items in factor 1, the picture that emerges is one of optimism being replaced by realism. Two weeks after passing the test, drivers rate themselves highly as being careful, responsible, and safe, and to a lesser extent, attentive. After six months, these ratings reduce markedly, and do not increase even after 24 months.
The factor 2 items shown in Figure 4b above present an all too predictable picture. Drivers who have just passed their test see themselves as being placid, patient, considerate, and tolerant road users, but in all cases the ratings on these items decrease over time, with the decrease in the “placid” rating being most marked.

Factor 3 items are perhaps even more predictable, in that drivers see themselves as growing in decisiveness, experience, confidence, and speediness as time passes in the driving population. There is, however, one item that merits further consideration. When drivers are asked to rate themselves as being confident or not confident on a seven point scale as part of a 12 item battery they provide (as shown in Figure 4c above) a rating that increases over time from two weeks to 24 months. However, when drivers are asked to assess how confident they feel as drivers by choosing one of the four alternatives of very confident, fairly confident, not very confident, or not at all confident, then the results are very different, in that they mostly show a U-shaped distribution of early confidence declining and only returning after 24 months of driving.

This result is intriguing, and has possible methodological implications for studies of this nature. However, these are still interim results, and this and many other questions will be addressed as the project continues.

References


New policy proposals for novice drivers in the Netherlands

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Introduction

As everywhere else in the industrialised world, in the Netherlands the number of accidents per kilometre driven for young novice drivers is exceptionally high. For young novice drivers between 18 and 25 years of age in the Netherlands, the accident risk is around 3.5 times higher than that of all other drivers of 25 years of age and older. During the past 18 years this difference in accident risk has not declined and has in fact gradually increased. Although the high accident risk of young novice drivers was known to policy makers, until a few years ago, no policy measures were taken. This was mainly due to conflicting interests of the driving school industry, the advocates of road safety and public opinion. Policy makers simply didn’t want to take unpopular measures although these measures would enhance road safety. Partly because of the role behavioural scientists managed to play, this deadlock could be overcome. In this paper first an overview will be presented of the scope of the problem, the causes and possible directions the countermeasures can take. This overview is based on a recent literature review. In the second part we will present a brief sketch about developments in the Netherlands and the role behavioural scientists played in the development of the new policy options.

The problem

In Figure 1 the number of severe accidents (death, severe injuries) per kilometre driven is presented as young novice drivers (18–24 years of age), female novice drivers (of the same age group) and all other drivers over the past 18 years.

As shown, young female drivers seem to profit from general road safety improvements over the years (safer cars, safer roads, etc.), but for young males there is hardly any decline of the accident risk.
Both experience mainly a lack of advanced skills and age-related aspects (high risk acceptance, over-estimation of one’s own skills, sensation seeking, etc.) seem to play an important role. In the Netherlands every two years a large survey is conducted. Each time the questionnaire is completed by approximately 10,000 road users. The first one was carried out in 1990. When the data from all the years is taken together, there is enough data to make an analysis of the effects experience has (kilometres driven) in the first year that a driver gets his or her driving licence. Figure 2 shows the results of these analyses.
Driving experience seems to play a very important role in accident risk. There seems to be some truth in the saying that one really starts learning to drive after taking the driving test. It is possible that the effect is biased by the fact that some novice drivers drive more than others immediately after the driving test. What also has to be kept in mind is that the data used for Figure 2 is based on self-reported accidents and self-reported distances driven.

The same data also offers an opportunity to estimate the effects of age. In Figure 3 the decrease in accident risk of drivers who passed the driving test at 18 in relation to the number of years they possess their driving licence is shown.

Not everyone gets their driving licence as soon as they have passed the age limit. From the data a similar trend line could be deduced from those who get their driving licence at 21 years of age, between 23 and 27 years of age and between 30 and 40 years of age. The results are shown in Figure 4.

The results resemble very much the model of Maycock et al. (1991). What is different is that drivers who start older will never become as good as drivers who learned at an early age. Again, one has to keep in mind that the results are based on self-reported accidents and self-reported exposure data. There will also undoubtedly be reasons why some people take driving lessons as soon as possible and others wait several years. This implies that what is shown in Figure 4 may not be caused by age and driving experience only, but can also be caused by personality differences between people who choose to drive at an early age and people who start to drive later. It is not possible to correct the diagram for this self-selection bias.

From the data and the results of very many studies in other countries, one thing is clear: both youth, and lack of experience are major contributors to the high accident risk of young novice drivers. There are more studies indicating that lack of experience is of slightly more importance than immaturity than the other way around.
Causes mentioned in the literature

Age and experience are very broad categories. Within each of these categories many specific elements have been subjects of study to find out why the accident risk of novice drivers is so high. In Figure 5 a scheme is presented that tries to structure the causes to some extent.

All the factors in Figure 5 help to explain the high accident risk of novice drivers, although some are more important than others. At the bottom of Figure 5 the task demands and the factors that influence the task demands are mentioned. All the other layers in Figure 5 are about competencies and capabilities. The first layer just above the task demands is about errors, mistakes and violations while performing the driving task. The layer above this layer describes the mental process when driving. Above this, the mental and physical conditions that lead to acute impairments when performing the driving task are presented. Above this, the ‘nurture’ aspects are presented and the top layer is about the ‘nature’ aspects.

Permanent (nature) traits

The influence of age is already mentioned. In a recent study with the driver behaviour questionnaire (DBQ) in the Netherlands (Verschuur, 2003), it appeared
that male novice drivers made significantly more deliberate violations and made more dangerous mistakes (e.g. misinterpreting speed and distances when overtaking) than young female novice drivers. Both violations and deliberate risks lead to a significant higher accident risk. On the other hand young female drivers made more attention errors and inexperience errors (e.g. using the wrong gear) than young male drivers. But these two factors didn’t lead to a higher accident risk. Sensation seeking is an often mentioned personality trait that is related to accident risk. The physical constitution of young drivers is no problem. A mental constitution that is rather typical for young people and related to a high accident risk is the Attention Deficit Hyperactivity Disorder (ADHD).

**Competencies/lifestyle**

Lack of formal knowledge of the rules of the road is not so much the problem, but lack of traffic insight (e.g. to make good judgements on what other road users will do). The same is true for skills. What is lacking is not so much the primary driving skills such as steering, braking and changing gear but the more advanced driving skills like hazard perception, situational awareness and the ability to assess one’s own capabilities. Several studies have revealed that young people from particular subgroups with a certain lifestyle (their attitudes, beliefs, norms and values) are more at risk than others (Gregersen & Berg, 1994, Fergusson *et al.*, 2001).
Mental and physical condition in traffic

Particular subgroups of young novice drivers tend to drive under the influence of illegal drugs. In a recent study in the Netherlands (Mathijssen, Koornstra & Commandeur, 2002) however it appeared that not all illegal drugs seem to have a negative effect on the accident risk. But in combination with only a slight amount of alcohol in the blood (and this is often the case) almost all illegal drugs lead to an increased accident risk. Novice drivers are not the most notorious concerning the habit of drinking and driving (older drivers between the age of 25 and 35 do it more often), but alcohol affects the driving capacities of young inexperienced drivers more profoundly than it affects the driving capabilities of older, more experienced drivers. Fatigue doesn’t seem to be of particular interest concerning the problem of novice drivers. There are however two aspects one has to keep in mind: for novice drivers the driving task is more exhausting because of lack of experience and some subgroups of young drivers tend to use their car late at night. Driving late at night leads to disturbances of the circadian rhythm. Stutts et al. (2001) after analysing about 30,000 accident reports concluded, that young drivers were more distracted than older drivers just before the accident. Young drivers were more distracted by operating devices like the radio or CD player and by passengers, than older drivers. In other studies it is proven that especially the presence of more passengers of the same young age as the driver leads to a higher accident risk. In the last couple of years more attention is being paid to the role of emotions in traffic, especially aggression. Unfortunately still little is known about the effects of emotions on the driving capabilities of young novice drivers. What we do know from developmental psychology is that adolescents have rather strong mood swings and are very sensitive to peer group influences.

Information processing in traffic

On all aspects of information processing while driving, it is well-established that novice drivers perform less than older, more experienced drivers. They scan the environment less systematically and pay too much attention to irrelevant aspects. Their eyes are fixed on a point close to the vehicle. When diagnosing the traffic situation they more often make wrong estimates about speed and distances of other vehicles. Concerning the ability to make good decisions Harrison (1998) states that novice drivers tend to drive in a deterministic way and experienced drivers in a more probabilistic way. This means they use fixed rules in all traffic situations (if this is the case, always first do this and then do that) and they don’t take into account that others might behave differently to textbook situations, so extra care is needed. As for risk acceptance it is well-known that especially young male novice drivers accept high risks, underestimate the risks and overestimate their own skills. Kuiken & Twisk (2001) describe the inability to adapt the competencies and capabilities to the task demands as a calibration problem.

Failures in the task performance

From studies with the DBQ (Parker, 1995, Verschuur, 2003) we know that novice drivers make more errors and mistakes on all cognitive control levels distinguished by Rasmussen. They especially make more knowledge-based mistakes. However
besides some dangerous knowledge-based mistakes, the relation with accident risk is rather weak. The best predictors for accident risk are violations. Young male novice drivers who tend to drive many kilometres, deliberately violate the rules of the road more often.

**Task demands/exposure**

If young drivers own a car, very often these are older cars that are more demanding to drive and offer less protection than new cars. Seatbelt use at least in the Netherlands among young drivers is not so much of a problem. In fact seatbelt use is a bit higher than among older drivers. In various studies it is revealed that young novice drivers drive relatively more at night (especially during the weekends) and with passengers of the same age (peer group pressure and distraction).

**Countermeasures**

There is no simple reason why the accident risk of young novice drivers is so high. The problem is complex and for all novice drivers, the causes are not the same. To tackle the novice driver problem efficiently, more than one measure has to be taken. In the literature the following directions in countermeasures can be distinguished:

- **Improvement of road safety education and driver training**
  This includes the initial driver training programme and the so-called second phase training some months after the driving licence is acquired. Countries in Europe with a second phase training are: Finland, Luxembourg and Austria. Some countries like Germany have special driver improvement courses for novice drivers who have been convicted. It is not only the training itself, but also improvements concerning the curriculum, the quality of the instructors, the training methods and the use of instructional devices like driving simulators.

- **Selection**
  These are mainly improvements (its validity and reliability) of the driving test.

- **Special rules of the road for novice drivers**
  Some countries have special demerit point systems and/or lower BAC-limits for novice drivers. In countries with a graduated licensing system, in the first period that unaccompanied driving is allowed, there are sometimes restrictions on driving in the dark and driving with passengers.

- **Extra control mechanisms for novice drivers**
  In some countries novice drivers have to make themselves visible as a novice driver for the other road users. This can be a plate with a ‘P’ for provisional licence holder on it. There have also been some experiments (e.g. in Germany) with novice drivers that could only drive in cars in which an accident data recorder (black box) was installed.

- **Information and public campaigns specially targeted at young novice drivers.**
• **Gaining commitment from relevant others of the young novice driver for his or her road safety performance.**

In the first place these are the parents. In some countries they have an active role in the driver education programme. Others can be schools, employers and places of entertainment. Landlords can take measures to prevent customers from drinking and driving.

• **First gaining driving experience in protected conditions**

The graduated driver licensing system is intended to let novice drivers gain experience first in circumstances where they cannot easily put themselves and others at risk. Gradually the restrictions get less and less. In the ‘learners phase’ only accompanied driving is allowed. In the ‘intermediate phase’ independent driving is allowed but not in all circumstances (e.g. no passengers, not in the dark, absolutely no alcohol). In the third phase, ‘the provisional phase’, one is allowed to drive without restrictions. However when convicted or after having caused an accident the novice driver is put back in a former phase.

Evaluating the effect of countermeasures is difficult. There are not very many methodological sound evaluation studies on the mentioned countermeasures available. However we do know that some measures are more effective than others. Graduated driving licensing systems seem to be effective, but improvements in basic formal driver training only, seem to have hardly any impact on the accident risk. It is also clear that there is not one single countermeasure that is the panacea for the whole problem. There always has to be a mixture of various countermeasures.

### Developments in the Netherlands

In the Netherlands, despite the fact that the high accident risk of novice drivers was known for decades, no real countermeasures were taken. The only aspect that received some attention was the driving test. The age limit in the Netherlands is 18. There is no national curriculum and driving lessons are not compulsory. However it is as good as impossible to pass the driving test without formal driver training. The average candidate needs 44 hours, driver training behind the wheel to pass the driving test. Only certified driving instructors can give driver training. To become a driver trainer one has to follow a course and to pass a test. Accompanied driving with a lay instructor before the driving test is not allowed.

For the past 25 years, until approximately four years ago, road safety advocates and behavioural scientists had no success in getting the novice driver problem on the political agenda. The main reason why nothing happened, was that all the stakeholders (the driving school industry, the ministry of transport, the driving test authority, the aspirant drivers themselves) were tangled up in a complex equilibrium of interests that made changes impossible. In 1998 this spell for the first time was broken by the project ‘Favourable measures for novice drivers’. In this project the behavioural scientist explained the causes of the high accident risk of novice drivers to all other participants (policy-makers, driving instructors, representatives of driver interest groups, the Dutch DSA, etc.) and also provided information about the effects of some countermeasures, but what they didn’t do was tell the others what they should do. The eventually proposed measures were not imposed by one group on the
other, but were jointly put on paper. Not only the estimated effect counted but also the feasibility and public support.

These proposals were:

- create legal conditions that make experiments for countermeasures possible;
- intensify road safety education in secondary schools;
- develop a kind of national curriculum (called ‘the training objectives document’) in order to improve the basic driver training. This document should not only contain detailed training objectives and a training programme, but should also provide suggestions on teaching methods.
- change the driving licence into a provisional licence for the first two years after passing the driving test. During this period the BAC-limit is zero and in order to obtain the full licence candidates have to follow a second phase training programme;
- develop a special driver improvement course on drinking and driving for novice drivers; and
- investigate the possibilities of accompanied driving as a way of gaining experience before the driving test.

Soon after the jointly-proposed countermeasures the national curriculum was developed, but then again nothing seemed to happen. The Ministry of Transport thought the curriculum was too detailed to give it a legislative status and on the contrary, for the training instructors the document was too general for practical use. Concerning the other proposals, a lower BAC-limit was proposed by the Ministry of Transport in 2002. Due to the fact that the police foresaw enforcement difficulties, the measure was postponed. In March 2004 the Minister of Transport made the announcement that the measure will come into effect in 2004. Also a provisional licence was introduced in 2002, but this measure had little in common with the original proposal. In fact it is a demerit point system for novice drivers. In the first five years, if a licence holder is convicted three times for a severe violation, the driving capabilities are assessed. If this assessment is negative, the driver has to do the standard driving test again. As the chance to get convicted is very low, so far no novice driver has lost his licence because of this demerit point system. Concerning the other proposed measures, nothing was undertaken.

The real public commitment to tackle the novice driver problem, came rather unexpectedly two years after the project ‘Favourable measures for novice drivers’ had ended. In the east of the Netherlands an employee of the local driver testing authority discovered the potentials of ‘the training objectives document’. In cooperation with the traffic research centre ‘Traffic Test’ on the basis of the mentioned document he managed to develop a new driver training programme. This was the so-called step-by-step driver education programme. The programme is very structured and a candidate can only pass from one module to another if all the training objectives of the former module are fully met. Because of the use of specified training objectives, both the instructor and the candidate have a good overview of what is achieved so far. As a didactic principle candidates first have to
learn so-called handling scripts (this is the traffic situation, I want to do this (e.g. turn to the left) so I first must do this (e.g. look in the mirror) and then do that). What is also different compared to the regular driver training is that a four hour training on a test course is included. This is not a short skid course. The intention is to let the candidate feel how easy it is to lose control and that it is better to avoid certain situations than to trust on your skills. It appeared that with the same amount of driving lessons taken, candidates who did the step-by-step programme had almost twice as much chance of passing the driving test in the first attempt than candidates who did the regular course. Because of this result the driving school industry got very interested in the step-by-step method and the policy-makers thought that by promoting the step-by-step method, road safety would improve. At the moment the number of driving schools that adopt the step-by-step method is rapidly growing. Although the step-by-step training programme is a success and it is intended to make novice drivers safer drivers, its effects on road safety are not yet known. From what is known of the effect of initial driver training programmes on the accident risk, one should not overestimate the expected effect.

What is even more important than the step-by-step method itself is that it changed the whole atmosphere around the novice driver problem. Partly due to the success of the step-by-step driver education programme, in 2002 the Ministry of Transport launched a new plan for driver education. This plan was called ‘the driver licence revolution’. In contrast with previous plans, behavioural scientists from SWOV and other institutes were consulted before the plans were made public. This caused some problems because the scientists were requested to make exact estimates of how many lives could be saved with a particular countermeasure. These estimates had to be delivered within only a few weeks’ time and without the possibility of doing experiments and field studies. The estimates were solely based on scarce evaluation studies on particular measures in other countries. For the policy makers remarks from the scientists about the doubtful reliability of most estimates, were not acceptable.

In ‘the driver licence revolution’ ultimately the following measures were proposed:

- If candidates choose a step-by-step like driver education programme that also incorporates an accompanied driving module, they can start their driving lessons as soon as they become 17 instead of 18. However the age limit for taking the driving test remains 18.
- A hazard perception or a situational awareness test will be included in the theoretical part of the driving test.
- If it appears from an evaluation study, at the moment carried out by the SWOV, that a second phase training programme is effective, such a second phase training programme will become compulsory for all novice drivers.

The first reactions in parliament were positive. If the plans are realised, then the traditional Dutch driving licence system with only emphasis on the driving test, will transform into a graduated driver licensing system. This will undoubtedly lead to a lower accident risk of young novice drivers. However the causes of the high accident risks given, countermeasures other than driver training and gaining experience in protected conditions, also have to be explored.
References


This is the fourteenth in a series reporting the findings of the annual behavioural research seminar in road safety. The seminar, organised by the Road Safety Division of the Department for Transport, provides a forum for the discussion of current research as well as the exchange of ideas in this area of behavioural research.