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**TRL Insight Report INS005** 

# How can we produce safer new drivers?

A review of the effects of experience, training and limiting exposure on the collision risk of new drivers

S Helman, G B Grayson and A M Parkes





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#### Abstract

New drivers, especially young new drivers, are over-represented in road collisions worldwide. This Insight Report reviews evidence for the effectiveness of post-licence driving experience, driver education and training, and limiting the exposure of new drivers to risk through graduated driver licensing (GDL) in lowering new-driver collisions. Increased post-licence driving experience is associated with considerable drops in collision risk, with the greatest benefits accruing in the earliest stages of post-licence driving. Driver education and training has little or no direct effect on the collision risk of new drivers. The exception to this is training that focuses on the cognitive skills involved in hazard perception or "reading the road". GDL has been shown to have considerable beneficial effects on the collision risk of new drivers, and the benefits are greatest for the youngest new drivers. It is recommended that all jurisdictions should consider some form of GDL, and a greater focus on the training of hazard-perception skills as part of driver licensing. Broader driver education and training should be relied upon to impart the basic vehicle-control skills required for access to the road system, and for encouraging safer attitudes to driving. However, it should not be expected to produce direct benefits in terms of lowering the collision risk of new drivers. Good-quality evaluation must form the basis of understanding what works, and what does not, in lowering the collision risk of new drivers.

#### **Executive summary**

New drivers, especially young new drivers, are at an elevated risk of having a road collision when they start their driving careers. In this Insight Report, we consider the factors that are associated with the collision risk of new drivers. Specifically, we review the literature for evidence relating to the effectiveness of three factors in lowering this risk: experience; driver education and training; and minimising new drivers' exposure to high-risk situations.

#### Experience

The evidence suggests that although there is an independent effect of age on collision risk – the youngest new drivers have on average the highest risk – the effect of post-licence experience is the dominant factor in lowering the collision risk of new drivers. The very early stages of post-licence driving experience show the greatest benefits. The first six months are associated with the greatest reduction in collision risk, and there is some evidence that, in terms of on-road experience, the main reduction accrues within the first 1000 miles. The fact that pre-licence driving experience does not seem to be associated with post-licence collision risk suggests that there is a mismatch in pre- and post-licence driving contexts.

#### Driver education and training

Much of the evidence on the effectiveness of driver education and training as a road-safety intervention comes from the US, although there are also evaluations of approaches to driver education and driver tuition to support licensure from a number of other countries. Traditional driver education and training supports the basic vehicle-control skills required for entry to the road system, and is a useful approach to encouraging safer attitudes towards driving. However, the weight of evidence from the literature as a whole is overwhelmingly in favour of the conclusion that driver education and training has little or no direct effect on the collision risk of new drivers; every major review carried out in the last two decades has come to the same conclusion. It is suggested that driver education and training as used in the past has failed to teach improvement in the skills that are actually associated with collision risk. Additionally, it has not generally been able to overcome the impact of other factors that determine driving style, such as peer influences and other social and cultural factors.

More recent approaches to driver training that treat driving as a cognitive skill show much more promise. Such approaches seek to maximise the relevance of driver training, and in doing so also seek to reduce the mismatch between training and real driving contexts. One method within this cognitive approach that shows considerable promise is the training of hazard-perception skills. The introduction of hazard-perception training in Great Britain has led to substantial reductions in the collision risk of new drivers for some types of collision.

#### Limiting exposure

Evidence relating to the effectiveness of minimising new drivers' exposure to high-risk situations for a period after they have become licensed is reviewed. This approach is usually referred to as graduated driver licensing (GDL). The weight of evidence supports the effectiveness of such an approach in lowering the number of new drivers involved in collisions. Considerable reductions in collision risk are seen in the best GDL systems, although the benefits overall are largest for the youngest new drivers. Evidence for the effectiveness of GDL extending beyond the restricted post-licence period is less conclusive, and an area where future evaluations need to be focused.

#### Recommendations

It is recommended that all jurisdictions trying to lower the collision risk of new drivers should consider adopting some form of GDL system. The precise make-up of such a system will probably vary according to the needs and practices in any particular jurisdiction. However, it seems likely that systems that set a minimum amount of time spent learning, that limit exposure to high-risk situations early in post-licence driving and that stimulate much greater amounts of on-road experience will have the greatest effects overall. The benefits in terms of lowering collision risk are likely to be greatest for the youngest new drivers.

It is also recommended that jurisdictions take an approach to lowering the collision risk of new drivers that is based on understanding driving as a cognitive skill. This should include the training of hazard-perception skills, and research effort is needed to establish how such training can be improved and optimised.

More traditional driver education and training should be seen as necessary to impart vehicle-control skills, and as a way to encourage safer attitudes to driving over the very long term. However, it should not be expected to produce any direct benefits in terms of lowering the collision risk of new drivers.

In short, the new-driver problem should be approached with a focus on reducing exposure to risk, increasing the amount of on-road driver experience and providing training in skills known to be beneficial in reducing collision risk, such as hazard perception.

Good-quality evaluation should be used to establish what works, and what does not, and the data from such evaluation should be used to guide policy.

#### **1** Introduction

An examination of road casualty trends over the last 30 years in developed countries shows that great progress has been made in terms of reducing the burden of road traffic fatalities. For example, the fatality rate per 100 000 people in the population in France. Australia and Canada has dropped from around 25 in 1978 to under 10 in 2006. Countries that started from a lower baseline in 1978, such as Sweden and Japan, have also achieved around a halving of their rates (World Health Organization, 2009). In Great Britain, the major 2010 targets for casualty reductions are likely to be met or exceeded (Broughton and Knowles, 2009). Compared with the 1994-1998 baseline figures, in 2008 the number of people killed or seriously injured in personal injury road accidents reported to the police was 40% lower, the slight casualty rate per 100 million vehicle kilometres was 36% lower and the number of children killed or seriously injured was 59% lower.

Despite these improvements, it is still the case that in absolute terms road traffic collisions<sup>\*</sup> continue to be a major problem even in countries with the better safety records. One group that has proved to be remarkably resistant to efforts to improve its safety is that of young drivers. Almost 40 years ago, Goldstein (1972) noted that it had been well known for several decades that young drivers were over-represented in accidents. Evidence that the problem is still ongoing comes from a recent international report (OECD, 2006) that identified traffic accidents as the greatest single cause of death to 15- to 24-year-olds in OECD countries, and noted that young drivers still have typically twice the fatality rate of older drivers.

For many years, there has been debate regarding the reasons that account for the young-driver problem, largely in terms of the relative contributions made by age and experience. While early investigators mostly concluded that age was the predominant factor, the wider use of more sophisticated statistical techniques has led to it now being generally accepted that it is experience, or rather inexperience, that plays the major role. Accordingly, it is now new drivers as a whole that are the focus of interest for both research and policy, though it should be borne in mind that it is still the case that the majority of inexperienced drivers are also young drivers.

Given that new drivers, and particularly young new drivers, are so over-represented in statistics for collisions on the road, it is not surprising that most jurisdictions have implemented procedures to influence drivers in the early stages of their careers, when it is easier for the authorities to manage those drivers' access to the road system. For example, education and training for learner drivers is mandatory in most developed countries (the most notable exception being Great Britain), and licensing systems that regulate in some detail the way in which candidates are allowed to enter the driving population are the norm. In addition, an increasing number of jurisdictions have now put into place procedures to supervise and restrict the exposure to risk of drivers both before and after they acquire a licence.



Figure 1.1 Road collisions are a major world health concern. New drivers (especially young new drivers) are much more likely to be involved in collisions than experienced drivers.

In this Insight Report, we review evidence for the effects of driving experience, different types of driver education and training, and the limitation of exposure on the road collision risk of new drivers. We then suggest the roles that might be played by these methods in future approaches to the newdriver problem.

#### 1.1 Report structure

This Insight Report begins by considering the role that postlicence driving experience plays in reducing collision risk. It is concluded that post-licence driving experience is associated with considerable reductions in road collision risk and that although the effect is largest for the youngest new drivers, it is still substantial for drivers of all ages. The fact that drivers appear to "learn safer driving by doing" suggests that driver education and training should have a role in accelerating or assisting this process. Evidence from the driver education and training literature is reviewed to assess how effective different approaches have been in reducing the collision risk of new drivers. The driving task is then defined as a skill within the cognitive psychology paradigm, and the role that hazardperception training has played in addressing the collision risk of new drivers in Great Britain is reviewed. The report then moves to a consideration of approaches to reducing the collision risk of new drivers that are based on limiting exposure to high-risk situations. Finally, suggestions are made for the various methods that should be considered by jurisdictions looking to lower the collision risk of new drivers, taking into account the evidence reviewed in this Insight Report. The importance of good-quality evaluation is highlighted.

<sup>\*</sup> In this Insight Report, we adopt the term "collision" rather than "accident" or "crash". The reason for this is that the term carries no implications of culpability or its absence, as does "accident", or seriousness of impact, as does "crash".

#### 2 Driving experience

In this section, we review the evidence that driving experience early in a driver's post-licence period is associated with a marked reduction in collision risk; that is, drivers "learn safer driving by doing". In essence, this is what defines the newdriver problem. New drivers – especially young new drivers – begin their driving career at their peak in terms of collision risk, all other things being equal. Understanding how drivers teach themselves to be safer through their early experience is crucial if we are to understand how we can accelerate or assist in this process.

# **2.1** Collision risk drops sharply during the first six months of licensure

Studies from a number of countries have shown that new drivers of all ages are at an elevated risk of having a road collision. Although there is an independent effect of age on collision risk - younger drivers have greater collision risk than older drivers - the acquisition of experience early in postlicence driving is accompanied by substantial reductions in collision liability for drivers of all ages (Forsyth et al., 1995; McCartt et al., 2003; Maycock, 2002; Maycock et al., 1991; Mayhew et al., 2003a; Sagberg, 1998; Wells et al., 2008; Williams, 1999), and experience has been shown to be the dominant variable when compared with age. As noted earlier, arriving at this conclusion has been made possible through the use of multivariate statistical techniques that were developed in the 1980s, which have made it possible to separate the independent effects of age and experience on collision liability.

A review of the literature by Maycock (2002) reports a number of these early studies showing that collision risk drops as post-licence driving experience is gained, that the effect of experience is most pronounced early on in post-licence driving and that the effect of experience is greater than the effect of age. Figures 2.1 and 2.2, produced in Maycock (2002) from original sources by Maycock *et al.* (1991) and Forsyth *et al.* (1995), illustrate the general pattern of data.

In figures 2.1 and 2.2, the modelled data are derived from self-reported collisions. Maycock *et al.* (1991) used data from approximately 13 500 participants split roughly equally between the sexes. Forsyth *et al.* (1995) obtained data from between 2000 and 3000 male new drivers and between 3000 and 4000 female new drivers, of different ages, for their first three years of driving. In both studies, these data were used to model the collision risk of drivers according to their age and experience.

In both figures, the dotted lines show the modelled collision risk for novice drivers at different ages. The solid lines show how collision risk changes for drivers who begin driving at 17, as they gain experience. Although there are some differences in the relative liabilities of males and females between the two studies – Maycock (2002) has a detailed discussion of the likely reasons for this – the general pattern is the same in both figures. As drivers become older, their first-year collision risk goes down, and as 17-year-old drivers gain experience their collision risk drops considerably, especially during the earliest portion of their driving experience.



Figure 2.1 The effects of age and experience on collision risk, from Maycock et al. (1991; figure reproduced from Maycock, 2002)



Figure 2.2 The effects of age and experience on collision risk, from Forsyth et al. (1995; figure reproduced from Maycock, 2002)

Another recent example comes from Mayhew et al. (2003a), who examined driver record data for 40 661 drivers who were licensed between 1990 and 1993 in Nova Scotia, Canada. They showed that the collision rate of new drivers dropped by 33% between the first and sixth months of postlicence driving. Although the magnitude of the effect was largest for drivers aged between 16 and 19, a still-substantial drop in collision rate of 27% was evident in drivers aged 20 and above. Rates of collisions for pre-licence drivers did not change with pre-licence experience even over a two-year period, which supports the observation that changes in collision risk associated with experience tend only to occur after licensing (although see Gregersen et al., 2000; and Sexton and Grayson, 2009). Consistent with previous findings in the literature (eq Williams et al., 1997), the rate of collisions for pre-licence drivers in the data from Mayhew et al. (2003a) was also very low compared with that for post-licence drivers. These latter two findings are both relevant to the debate on whether pre-licence driving experience is similar enough to the driving that new drivers encounter immediately postlicence. This point will be revisited in Section 4.

Numerous studies have shown that new drivers – especially young new drivers – have a slightly different mix of collision types than more experienced drivers. For example, the first major study of accident liability carried out in Great Britain (Maycock *et al.*, 1991) found that a high proportion of young-driver accidents in the first year did not involve another vehicle. Using different data sources, Clarke et al. (2002) and Clarke et al. (2006) examined age-related effects on collision characteristics by studying police injury accident reports in detail, and showed that some types of collision are more frequent in younger drivers. These included: collisions involving single vehicles and loss of control; those involving excess speed for conditions; those at night; those on singlecarriageway rural roads; and those involving cross-flow turns. Maycock (2002) reviewed a number of studies that examined the effects of age and experience on collision rates, and on types of collisions, and came to much the same conclusions: age and post-licence driving experience are both associated with collision risk and with differences in the types of collisions in which drivers are most likely to be involved (see also Wells et al., 2008). However, experience does have an "across the board" effect in lowering collision risk for all collision types (see also Mayhew et al., 2003a).

# **2.2** The first 1000 miles of post-licence driving may be the most important

Many studies examining the effects of experience on the collision risk of new drivers follow the ones reviewed above in using "time since licensing" as the measure of experience. McCartt et al. (2003) is another example of a study that does this. The authors examined self-reported collision rates (and other data such as miles driven and month of licensure) in 911 students in high schools in the US. They reported that the collision rate fell sharply during the first and second months of post-licence driving. Importantly, they also examined the effects of actual levels of driving experience - the number of post-licence miles driven - on collision risk. The number of collisions per 10 000 miles of driving was 3.2 for the first 250 miles of post-licence driving, and this rate dropped to 1.8 by the time 500 miles of driving had been completed, 1.3 by 750 miles and around 0.7 by the time 1000 miles had been driven, with male and female drivers showing a broadly equivalent pattern. Between 1000 and 3500 miles, the collision rate fluctuated around 0.5–1.0 for both sexes. These data suggest that the first 1000 miles of driving experience may be the most important for new drivers, at least very young new drivers, in terms of lowering collision risk.

Further data for the importance of the first 1000 miles of post-licence driving come from Kinnear *et al.* (2009). Rather than examining collision risk directly, they examined the impact of post-licence experience on the physiological responses to road hazards measured via skin conductance response. They showed that after novice drivers gain 1000 miles of post-licence experience, they begin to show similar physiological responses to developing road hazards in video-clips to those shown by experienced drivers who have three or more years of post-licence driving. These data are reproduced in Figure 2.3.

This finding hints at one mechanism by which postlicence experience may reduce the risk of collisions. The anticipation of road hazards or "hazard perception" is a key driving skill that has been shown to be related to collision risk across a number of studies; drivers who have better hazard-perception skills have lower numbers of collisions, presumably due to their ability to "read the road ahead" and anticipate potential hazards before they become imminent and require emergency responses (for reviews, see Grayson and Sexton, 2002; Horswill and McKenna, 2004). Much of the development work for hazard-perception training and testing was carried out by TRL and its collaborators during the 1980s and 1990s. This issue will be revisited in Section 4.2 when we consider the impact that hazard-perception testing (and training) has had on the collision risk of new drivers in Great Britain since its introduction into the driving theory test in November 2002.

#### 2.3 Summary

In this section, we have reviewed the literature looking at the effects of driver experience – in particular experience gained early in the post-licence period – on new drivers' collision risk. We have seen that there is evidence for the existence of independent effects of age and experience on collision risk, with experience being the dominant factor. New drivers of all ages show drops in collision risk across all collision types as they gain their early post-licence experience, although these effects are stronger for the youngest drivers, and for some collision types. In short, new drivers "learn safer driving by doing".



Figure 2.3 Graph of anticipatory score (proportion of hazards that elicited a skin conductance response during the hazard's development) by experience group with standard error bars (reproduced from data in Kinnear *et al.*, 2009)



Figure 3.1 Driving instruction prior to licensing is widely undertaken on a voluntary basis in Great Britain

#### 3 Driver education and training

In this section, we review the literature on driver education and training, concentrating on the evaluation of evidence for direct road safety benefits resulting from such an approach. Since new drivers clearly learn something that lowers their collision risk in their early driving experience, there is a presumption that pre-licence driver education and training should be able to accelerate this learning process so that when drivers begin driving after having gained their licence, they are at as low a risk as possible of being involved in a road traffic collision.

## 3.1 What do we mean by driver education and training?

The terms "driver education" and "driver training" have tended to be used synonymously in the literature, with "education" tending to be preferred in the North American literature and "training" predominating in the European literature. Christie (2001) suggests that most courses that have been termed "education" could actually be termed "training" since they tend to have a "specific, practical focus" (p. 4).

In this Insight Report, we use the term "driver education and training" in a broad sense. It is important to recognise that driver education and training varies greatly even among the most developed countries, both in terms of delivery and the legislative structure in which it takes place. Thus, in many US states, driver education forms part of the high school curriculum, while in Great Britain any form of education or training is undertaken on an entirely voluntary basis<sup>†</sup>. In order to quantify the effectiveness of different programmes on collision risk, the comparisons of interest are slightly different depending on which of these types is being evaluated. For example, in the case of basic driver training for licensing purposes, the treatment group consists of those who learn with professional instructors and the comparison or "control" group consists of those who have learned to drive informally (ie with parents and friends)<sup>‡</sup>. For courses that sit outside the basic licensing process, the treatment group consists of graduates of the course and the control group consists of those who have not been exposed to the course.

# 3.2 Evidence for the effectiveness of driver education and training in reducing collision risk in new drivers

Williams and Ferguson (2004) have noted that driver education and training has wide public appeal and acceptance as a road safety intervention. It is fair to say that among any large sample of lay-persons, the stock answer to the question "Is driver education and training effective at producing safer new drivers?" is likely to be "Yes". However, among a sample of road safety researchers who know the literature well, the stock answer is likely to be "No".

There have been a number of major reviews of evaluation studies conducted on this issue over the last two decades. All of these reviews have concluded that driver education and training has little or no reliable direct effect on road safety in terms of reductions in collision risk for new drivers (eg Brown *et al.*, 1987; Christie, 2001; Clinton and Lonero, 2006; Mayhew *et al.*, 1998; Mayhew *et al.*, 2002; Roberts and Kwan, 2001; Vernick *et al.*, 1999). Quoted conclusions from some of the above reviews are instructive in understanding how scarce the evidence is:

"The only acceptable verdict on the benefits of compulsory driver/rider training for road safety must ... be, for the moment, 'not proven'."

(Brown et al., 1987, p. 142)

"The review of the scientific evaluations performed to date provides little evidence for the claim that driver

<sup>†</sup> In Great Britain, the existence of a stringent practical test is intended to act as an incentive to candidate drivers to undergo training. The effectiveness of this approach can be seen in the recent study by Wells *et al.* (2008), which showed that over 99% of test candidates had taken some professional instruction.

t It is clear that there is a basic level of competence required so that access to the road system is facilitated, including basic control of the vehicle, and the understanding and execution of road laws and conventions such as driving on the correct side of the road and obeying flow controls such as traffic lights. We assume that all drivers who pass the test(s) necessary for licensure possess this basic level of competence. What is at issue is whether there are other measures that can be taken through driver education and training pre-licence that can add something in terms of a reduction in collision risk beyond the "baseline" condition, which is represented by drivers who enter the licensing system with no formal training.

instruction is an effective safety countermeasure – ie, the safety benefits of driver education/training programs remain unproven."

(Mayhew et al., 1998, p. 62)

"At the individual level, there is no convincing evidence that high school age students who complete a driver education course have fewer motor vehicle-related crashes or violations than those who do not."

(Vernick et al., 1999, p. 44)

"The research evidence suggests that driver training of a traditional and conventional nature contributes little to reductions in accident involvement or risk among drivers of all age and experience groups."

(Christie, 2001, p. 35)

"There is no evidence that driver education reduces teenage involvement in road traffic crashes." (Roberts and Kwan, 2001, p. 4)

"The international literature provides little support for the hypothesis that formal driver instruction is an effective safety measure."

(Mayhew et al., 2002, p. ii3)

That the research literature should reach such a negative conclusion does seem counter-intuitive, given the wide public acceptance that driver education and training seems to hold (Williams and Ferguson, 2004). It has been suggested that perhaps the complexity of the outcome variable (collision risk) demands that we re-think how we evaluate. For example, in the most recent review in this field, Clinton and Lonero (2006) have pointed out that the major reviews of driver education and training evaluations have tended to include only randomised control trials, in which treatment participants and control participants (ie those participants who are not exposed to the intervention being evaluated) are randomly assigned to groups, thus ensuring that possible confounding variables such as demographic differences and self-selection biases are likely to be balanced evenly across conditions. Although they are the "gold standard" in terms of maintaining experimental control, such designs are often difficult to use in applied fields such as the evaluation of driver education and training interventions. Another approach is to examine evaluations that have used less robust guasi-experimental designs<sup>§</sup>, to see if evidence of reduced collision risk is apparent. Clinton and Lonero (2006) reviewed a number of such studies. The study methodologies included: using preexisting data to model fatal collision rates in US states (Levy, 1988, 1990; Robertson and Zador, 1978); comparing collision rates in Connecticut school boards with and without driver

§ Quasi-experimental designs are defined by Coolican (2004) as those designs that are "almost" experiments but lacking one or more of the central features of a true experiment, the most important features being random assignment to treatment and control groups, and full experimenter control over the independent variable. A design in which pre-existing groups are compared – such as drivers in one jurisdiction that has driver education, and drivers in another jurisdiction that does not – is said to be quasi-experimental, in that attempts can be made to match the groups on important demographic variables, but groups can never be assumed to be equivalent in the same way that randomly allocated groups can be.

education (Robertson, 1980); and comparing collision rates after mandatory driver education was introduced in Quebec (Potvin *et al.*, 1988) and Denmark (Carstensen, 1994, 2002). These studies, at best, also provide equivocal evidence for the effectiveness of driver education and training. Robertson and Zador (1978) found no effect, Robertson (1980) and Potvin *et al.* (1988) both found negative effects, and Levy (1988, 1990) and Carstensen (1994, 2002) both found positive effects.

Clinton and Lonero point out that there are strengths and weaknesses in all of these studies, and that often the weaknesses prevent firm conclusions being drawn. For example, Robertson (1980) reported that in Connecticut, when nine school boards dropped driver education from their syllabus, the total collisions for 16- and 17-year-olds decreased by 10-15% in those areas. However, no data (and no statistical significance levels) were reported for how this compared to overall changes in rates of collisions in areas where school boards retained driver education classes. Carstensen (2002) did report reduced crashes in driver education graduates, but did not control for potential changes in demographic variables (especially age) between the two groups that might have resulted from other consequences of the new requirement to take driver education, such as the increased expense of becoming licensed.

Another example of positive evidence for the effectiveness of driver education and training given by Clinton and Lonero (2006) is a study run by Dreyer and Janke (1979). This study is a rare example of a trial with random group assignment to conditions that has shown some apparently positive effects on collision risk. Dreyer and Janke compared two types of prelicence driver training on post-licence collision risk, and found that a programme that included some off-road or "range" training resulted in a subsequent collision rate of around 30% lower than the group who had only participated in on-road training. However, possible differences in post-course exposure between the groups were not taken into account, and because no control group was included for people not trained, it is possible that both training groups actually showed an increase in collision rate relative to what would have happened without the training. This possibility cannot be ignored given the fact that there are numerous examples in the literature of driver education and training actually having negative effects on some measures of safety (eg Glad, 1988; Jones, 1993; Katila et al., 1996). The negative effects are usually presumed to be due to encouraging early licensure (and thus driving at a younger age) or through inflating the confidence of graduates such that they take more risks when they begin driving than they otherwise would have done without the training intervention (see Williams and Ferguson, 2004).

Clinton and Lonero (2006) conclude in their review that there is more to say than simply "driver education and training does not work". Specifically, they conclude that progress is likely to be made on the basis of the weight of evidence from different types of studies. TRL agrees with this conclusion. The weight of evidence as a whole will be crucial in determining the value of different approaches to obtaining safety benefits, especially given the complexity of the outcome variable (collision risk).

It is worth noting at this point that the weight of evidence is not spread equally across jurisdictions. For example, the majority of evaluations regarding classroom-based education come from the US, meaning that the degree to which the findings can be generalised needs to be considered. However, to the extent that driving can be seen as a broadly consistent task in all jurisdictions – ie it always involves controlling a vehicle using broadly standardised control inputs in a dynamic environment – we conclude, on the weight of evidence available, that driver education and training as used in the past has been shown not to work in reducing the collision risk of new drivers<sup>¶</sup>.

This does not mean that we think driver education and training has no value as part of a more comprehensive approach to making new drivers safer. The possible indirect effects of educational approaches are discussed in Section 3.3, and recent training approaches in Great Britain that use the cognitive psychology approach to define driving as a skill are discussed in Section 4.

#### 3.3 Driving skill versus driving style

Even those commentators who highlight the lack of evidence for the effectiveness of driver education and training in lowering collision risk suggest that it still has a role to play in more comprehensive approaches to improving the safety of new drivers, as well as providing the basic skills and knowledge required to enter the driving population. Williams and Ferguson (2004), for example, suggest that driver education should concentrate on involving parents more in the learningto-drive process than they are already, so that pre-licence and restricted-period experience within graduated driver licensing (GDL) approaches (see Section 5) can be maximised. They also suggest that parents might be given general tips about safer driving, so that these messages can be communicated to learner drivers consistently from family members, as well as from driving instructors and educationalists.

A useful distinction to draw here is that between driving skill and driving style. The conceptual difference between these two has been noted by a number of authors. Elander et al. (1993), for example, define driving skill as concerning the limits to performance of various aspects of the driving task, and driving style as concerning the way that people choose to drive. More recently, McKenna (2009) distinguishes between factors that are involved in the technical aspects of having the ability to control the vehicle and factors that influence whether this ability is employed. A large number of the behaviours associated with collision risk can be described as style variables rather than skill variables. There is an argument that this may be one reason why approaches to driver training that have tended to focus on vehicle-control skills rather than style variables have not yielded collision reductions; many skill variables have not been shown reliably to be linked to collision risk (although see Section 4.2 for one exception).

**1** Although in this report we have focused on approaches to improving the safety of new drivers, it is also worth considering traditional approaches to lowering collision rates in experienced drivers. Ker *et al.* (2003) reviewed randomised control trials of post-licence educational interventions (such as remedial training for violators of road laws) with a combined sample size of over 300 000 participants, and found no evidence that such interventions reduced the collision risk of those who take part. An earlier study by Lund and Williams (1985) evaluating defensive driving courses in the US also found no consistent effect on collisions, and Williams and O'Neill (1974) found that licensed race drivers had worse on-road safety records than regular drivers.

Examples of driving style variables associated or believed to be associated with collision risk include speed choice (eg Aarts and van Schagen, 2006; French et al., 1993; Horswill and McKenna, 1999; Quimby et al., 1999), close following of vehicles in front (eq Evans and Wasielewski, 1982; Rajalin et al., 1997), high-risk overtaking (eg Hegeman, 2004), violation of traffic laws (eq Parker et al., 1995) and engaging in distracting activities, such as speaking on hand-held or hands-free mobile phones while driving (eg Burns et al., 2002). There are also important variables that fall outside the driving domain altogether - so-called "lifestyle" factors. For example, Groeger (2006) and McKenna (2009) have argued that fatigue-related factors are associated with collision risk. Groeger (2006) points out that this is especially relevant for very young new drivers, since their lifestyle - often involving extensive weekend and evening socialising - does not support good sleep hygiene. Sleep hygiene refers to the behaviours people engage in to ensure that they get enough sleep, and of sufficient quality (Riedel, 2000). McKenna (2009) has shown in a sample of 7075 drivers attending a speed-awareness course that those with the worst sleep hygiene were nearly three times more likely than those with the best sleep hygiene to have been involved in a collision. The effect of sleep hygiene remained statistically significant even when age and speed choice (both known to be associated with collision risk) were controlled.

Hatakka et al. (2002) use a similar distinction between skill and style factors when they present the Goals for Driver Education (GDE) matrix of driving. The GDE matrix outlines several hierarchical levels of behaviour that are required for safe driving, with basic vehicle control at the lowest level. The next level is "mastery of traffic situations", which can be interpreted as including such higher skill variables as hazard perception (see Section 4.2). Next highest is "goals and the context of driving", which can be interpreted as including style variables such as the overall context of a particular driving journey (eg whether or not the driver is in a hurry to get somewhere). The highest level is "goals for life", which can be interpreted as including lifestyle factors such as sleep hygiene and substance abuse that may have an impact on collision risk. In addition to this hierarchy of behaviour levels, the GDE matrix also suggests that there are three types of knowledge that drivers require to operate safely at each level. Firstly, drivers need to have the basic knowledge and skills associated with each level of the hierarchy. Secondly, they need awareness of the risk-increasing factors at each level. Thirdly, they require an ability to self-evaluate themselves at each level, so as not to overestimate their abilities.

Within the skill/style distinction, and within the context of approaches such as the GDE matrix, it is still assumed by most authors that educational approaches must have a role to play in imparting the knowledge, attitudes and self-awareness that drivers require to make better decisions, particularly relating to their driving style, when they begin driving. A possible role for driver education and training then is in the promotion of these good attitudes towards driving in a desirable way, in the hope that these attitudes will lead to behavioural change. Theories that posit links between attitudes and behaviour such as the Theory of Planned Behaviour (Ajzen, 1991), suggest that future behaviours are underpinned by various attitudes and motivations that are related to the behaviours in guestion. Some authors have attempted to use this theoretical framework to find underlying attitudes to (and change behaviour in) a number of driving-related behaviours, including speeding, close following, overtaking, running red lights, drink-driving and seat-belt use. Elliott et al. (2003) point out that typically this work has shown that the various components of the theory can explain good proportions of variance in these driving behaviours (reported or observed). However, the same authors have also pointed out that longterm behavioural change has been shown to be notoriously difficult to achieve, and attempts to change behaviours in driving style, even when basing such efforts on a widely accepted model of attitudinal and behavioural change such as the Theory of Planned Behaviour, have not yet demonstrated any real success. Additionally, recent data from Great Britain suggest that some style factors may still be dominated by post-licence experience when it comes to determining new drivers' collision risk. For example, Wells et al. (2008) showed that new drivers, and in particular young new drivers, showed an increase in the self-reported frequency of traffic violations (eq running red lights, speeding) over the first three years of their post-licence driving. This is interesting in that such violations have been shown to be associated with collision risk to some degree (eq Parker et al., 1995). The fact that selfreported violations are increasing early in drivers' post-licence driving while collision risk (see Section 2) is decreasing again suggests that experience is the dominant factor underlying the collision risk of new drivers.

Another point is worthy of mention here. It can also be argued that educational approaches, while they struggle to create direct behavioural change in drivers, may still have indirect effects on road safety. McKenna (2007) makes this point when he argues that one potential end goal for driver educational courses is the changing of public attitudes towards driving behaviours that we know are associated with collision risk so that undesirable behaviours, over time, become socially unacceptable. The argument runs that even if changes in attitudes do not have a direct impact on whether people perform unsafe driving behaviours, attitudinal change may make the public more open to enforcement regarding those behaviours. An example that illustrates this line of reasoning is provided by seat-belt wearing in Great Britain. In the decade before legislation required drivers and front-seat passengers to wear seat-belts, there were extensive educational activities and publicity efforts regarding their safety benefit, and yet wearing rates stayed consistently at around 35-40%. When legislation was introduced in January 1983, wearing rates jumped to between 90% and 95% almost immediately and have remained at broadly this level ever since. One interpretation of this is that the combination of education and legislation was a key factor in achieving such high compliance with the legislation. It should be noted, however, that the high levels of compliance with seat-belt legislation in Great Britain have not been repeated everywhere across the world, despite similar attempts to educate and publicise their safety benefits. On this basis, it is safest to conclude that such indirect effects are not yet fully understood. As such, further evaluation should focus on gaining a detailed understanding of attitudinal shifts, including possible indirect effects that may ease public acceptance of legislative approaches to the new-driver problem (see, for example, Section 5). However, the fact that such hypothesised cultural shifts in attitudes seem to take a very long time (often decades) to occur should be borne in mind when designing approaches to lowering the collision risk of new drivers. To lower collision risk directly over shorter timeframes, other approaches (see sections 4 and 5) may have more value.

#### 3.4 Summary

In this section, we have reviewed the literature on driver education and training. The only direct benefits imparted by broad driver education and training would appear to be the basic vehicle-control skills and knowledge of road rules necessary for entering the driving population. According to the evidence, it has no measurable direct effect on collision risk, and its continued use should therefore be set against much lower expectations in terms of what it can contribute directly to the safety of new drivers. Driver education and training is still required to impart basic vehicle-control skills. and there is an argument that educational approaches may have an influence on attitudes to safe driving, even in the absence of a direct effect on behaviour. More evaluation is needed to assess the extent to which educational approaches can produce such attitudinal shifts, how such shifts may have an indirect effect on road safety and over what timeframes. We need to find other approaches to lowering the collision risk of new drivers directly.

### 4 A modern approach to driver training for new drivers – treating driving as a cognitive skill

In this section, we return to the consideration of driving as a skill-based activity. We consider the multi-faceted nature of the driving task within the cognitive psychology approach. Cognitive psychology is defined by Reber (1985) as a "... general approach to psychology emphasising ... internal, mental processes" (p. 129). In short, cognitive psychologists are interested in understanding mental faculties such as learning, memory, decision making, language and visual processing, with reference to the mental processes and representations that underpin them. Importantly for our purposes, cognitive psychologists have developed a good understanding of how people acquire, retain and use skills, and this knowledge can be used to understand why broad approaches to driver training have not succeeded in demonstrating direct safety benefits for new drivers.

#### 4.1 Avoiding collision risk as a cognitive skill

In Section 2, we argued that the evidence related to collision risk in drivers' early post-licence driving period is consistent with the interpretation that they "learn safer driving by doing". But what do they learn? Most commentators would agree that driving is a complex task involving almost every aspect of perception, cognition, motor skills and even emotion. Against this backdrop, it may not actually be a surprise that driver training has generally failed to produce safer new drivers. Williams and Ferguson (2004), for example, suggest that courses tend to be too short, tend to teach a limited set of skills that are not in themselves related to collision risk and tend to teach these skills in ways that fail to overcome the influence of other factors that lead people to drive in particular ways. In a similar vein, Evans (1991) noted that most learner drivers in developed countries already have a large body of information about rules of the road and how to behave in traffic, having been riding in motorised vehicles since infancy. He adds, "... a few weeks of driver education make but a modest increment to this large pool of knowledge" (p. 106). In considering the difficulty of achieving behavioural change in driving style variables (eg Elliot et al., 2003; see Section 3.3 of this report), we have already seen that the apparent disconnect between driver education and training on the one hand, and post-licence driving on the other, makes it difficult to imagine how broad educational and training approaches pre-licence can ever be relevant to "real driving".

Another approach to this issue is to consider the driving task as a cognitive skill. Groeger (2006) has discussed in more detail the precise nature of the learning effect apparent in the data on experience and collision risk. He discusses the fact that the relationship between driving experience and collision risk follows a power law, characterised by a rapid decrease in collision risk early in the learning period and a steadily reducing rate of decrease as more and more experience is gained. This pattern of learning is similar to that seen in a wide range of human activities involving skill acquisition. Groeger also discusses how such data can be explained quite readily by fundamental theories of skill acquisition (eg Anderson, 1983; Logan, 1988). Although different models posit slightly different mechanisms, there is broad agreement that experience with a task leads to an "experience bank" of memories related to the task, and this experience bank is used to move performance on the task from slow effortful processing that is flexible in terms of it being applicable to a wide range of situations, to faster processing that permits more skilled performance in specific contexts. As more experience is gained, the bank of experience becomes more comprehensive. This means that people are able to call upon previously experienced examples of situations (within the same context) to guide their behaviour and responses.

Groeger and Banks (2007) point out that if we accept that driving (and specifically avoiding collisions) is a skill within this general framework, it becomes clearer why driver education and training does not generally seem to help in reducing collision risk, while post-licence driving experience does. Over decades of research in the skill learning literature (almost all of it based on much simpler tasks than driving), researchers have come to the broad conclusion that transfer of training from one context to another, when those contexts do not match very closely, almost never occurs. Barnett and Ceci (2002) suggest a framework for thinking about how training and transfer contexts need to match on a number of dimensions if transfer of training is to occur. The dimensions include knowledge, memory demands, time since learning, physical features and social context. They are only able to point to a few examples in the entire skill learning literature where far transfer – ie transfer from a training context that has little overlap to the transfer context - occurs. None of these are in domains as complex as driving (Groeger and Banks, 2007).

There are major differences between the pre-licence and post-licence driving contexts in most developed countries. Not least is the fact that almost without exception during pre-licence driver training, drivers are accompanied by a supervising driver, whether a gualified driving instructor or a responsible family member or friend. We know that prelicence or "learner" drivers are sensitive to these differences in context, and that they find the change from supervised pre-licence driving to independent post-licence driving to be both challenging and stressful. The jump in collision risk between pre- and post-licence driving (eg Mayhew et al., 2003a) may be simply a corollary of this disconnect between the two modes. If driver training is to achieve a direct road safety benefit for new drivers, it will need to overcome this disconnect and enable pre-licence experience to show a transfer of training effect to post-licence collision risk (although see Gregersen et al., 2000).

Consideration of driving as a cognitive skill then suggests that to expect driver education and training pre-licence to have a safety benefit on post-licence collision risk is mistaken, because of the inevitable mismatch in training and transfer contexts on a number of dimensions. Groeger and Banks (2007) consider in detail the extent to which pre-licence driver training will fall foul of the far transfer problem due to lack of overlap in knowledge (eg different manoeuvres post-licence than pre-licence), in physical context (eg different car and locations post- and pre-licence versus driving tired and late at night in unknown situations post-licence) and in social context (driving with instructor pre-licence versus driving with noisy peers post-licence).

A seamless transition from pre-licence to post-licence driving in terms of collision risk should probably be seen as the ideal, and may not be achievable until there is an almost complete overlap in the context of pre-licence and postlicence driving experience. Recently, however, attempts have been made in Great Britain to go some way to addressing the problem. For example, changes are being made in 2010 to the practical driving test so that learner drivers are assessed in terms of their ability to drive independently. For a section of their driving test, learner drivers will be required to drive without any directional input from their examiner, eg while following road signs, to assess whether they are able to drive safely while "thinking for themselves". By ensuring that such abilities are tested as part of the practical driving test, it is intended that practice of these skills will become routine during driver training, and thus that there will be more chance for training pre-licence to show a transfer of training effect on post-licence collision risk. Data from Helman and Vandrevala (unpublished, 2009) and from work in The Netherlands by Vissers et al. (2007) have suggested that learner drivers find these "independent driving" tasks highly relevant to their postlicence driving. Although as yet there are no evaluation data regarding the direct effects of such changes on post-licence collision risk, such data should become available over the coming years.

Recent support for the importance of overlap in contexts between training and post-licence driving is available from Sexton and Grayson (2009). By using data from Wells et al. (2008), the authors assessed how much time or how many miles driven elapse before new drivers have their first collision, and also analysed which factors impacted on this. They found that drivers who did more pre-licence driving in busy town centres "survive longer" before having their first collision, whether on the basis of time or miles driven. When considering only pre-licence experience with professional instructors, more experience driving in the rain was associated with a longer survival time. These data are compatible with the interpretation that by encouraging a more diverse set of circumstances (in this case driving in busy town centres, and in the rain) pre-licence, a transfer of training effect is encouraged through the greater overlap in pre- and postlicence driving contexts.

The fact that post-licence experience does work in reducing collision risk also makes sense within this framework; post-licence, drivers are driving "for real" in all of the contexts in which they need to acquire an experience bank to draw upon to show the benefits of this experience in avoiding collisions. As people progress through their post-licence experience and gain more and more experience in a wider variety of situations, the chances for them to be able to apply this knowledge become higher. In post-licence driving, the training context is effectively identical to the transfer context, and thus transfer of training occurs. It is this reasoning that underpins the Pass Plus scheme in Great Britain, which was introduced in November 1995. Pass Plus seeks to give postlicence new drivers experience in several contexts that may not have been covered extensively in their pre-licence training. For example, new drivers gain on-road experience in night driving, motorway driving and driving in different weather conditions. The scheme is voluntary, and Wells *et al.* (2008) showed that 18% of new drivers took part in the scheme within their first year of post-licence driving. Unfortunately, there has not yet been any full evaluation of the impact of Pass Plus on collision rates, mainly because of the difficulties in disentangling the effects of self-selection bias and course participation.

#### 4.2 Evidence for the effectiveness of hazardperception training in reducing the collision risk of new drivers

Another approach that shows promise as a pre-licence training intervention to reduce the collision risk of new drivers is hazard-perception training. Hazard perception refers to the ability to identify potentially dangerous traffic situations (eg Grayson and Sexton, 2002; McKenna and Crick, 1991; Quimby et al., 1986). It is usually measured by having participants view a video of traffic scenes filmed from the perspective of a driver in a car. Participants are required to respond to developing hazards by pressing a button, or clicking on the relevant area of the screen with a mouse pointer. The usual measure of hazard-perception ability is the anticipation time for these specified hazards. Larger anticipation time equates to better hazard-perception skill, since it reflects that participants are seeing and responding to hazards earlier in their development. Although the measure of hazard perception requires time-critical responses, it is the ability to anticipate hazards that is important, rather than "having fast reactions".

Figure 4.1 shows stills from the kind of video-based clip that is used to test hazard-perception skill in the GB driving theory test. In the top picture, a cyclist (circled) is just coming into view around the left-hand bend, beyond the parked car. At this point, the combination of the oncoming cyclist and the parked car could be considered as constituting a potential hazard, since there is a chance that the driver of the car represented by the camera will not be able to pass the parked car safely without violating the path of the cyclist. In the second picture, an oncoming car is now also visible. It is now clear that a hazard is developing, since the oncoming car will need to pass the cyclist, and this will take the oncoming car into the path of the camera car at about the time that the parked car is reached. The third picture represents the point at which the hazard is imminent. Experienced drivers would be expected to respond to early stages in a hazard's development, possibly as early as the situation represented by the first picture in Figure 4.1, because of their ability to anticipate the development of the hazard. Simply responding quickly when the hazard is imminent (as in the final picture) does not represent good hazard perception, as it would be too late for the driver's car to take action to avoid the hazard.



Figure 4.1 In Great Britain, learner drivers need to pass a video-based hazard-perception test as part of their driving theory test. Hazard perception refers to the ability to anticipate road hazards and respond to them early in their development.

Hazard-perception skill is related to experience (eq McKenna and Crick, 1994; McKenna and Horswill, 1999), and has been shown to be related to accident risk across a number of studies (eq Hull and Christie, 1993; McKenna and Horswill, 1999; Quimby et al., 1986; Wells et al., 2008). It is also a skill that is trainable. For example, Sexton (2000) and McKenna and Crick (1993) have shown that when drivers are trained using video-based stimuli, and are asked to predict what might happen next in those scenes when they are frozen, later on such drivers are better at hazard perception in validated tests (not involving the same road scenes). In addition, road-based training has been shown to enhance hazardperception ability in video-based tests (Crick and McKenna, 1991), and more recently Pradhan et al. (2009) have shown using eye-tracking technology that learner drivers can transfer their training from video-based hazard-perception stimuli to on-road driving.

More importantly for the current review, the introduction of hazard-perception training into the GB driving theory test has been shown to have a beneficial impact on the collision risk of new drivers. Its introduction has been shown to have led to an estimated 17.4% reduction in the collision risk of drivers in their first year of driving - when non-lowspeed collisions on a public road, and in which the driver accepted some blame (ie those collisions in which failures of hazard perception seem likely as a contributory factor), are considered (Wells et al., 2008; see Table 4.1 of this report). The presumed mechanism by which the introduction of hazard-perception testing has had this beneficial effect is through stimulation of training with video-based training packages available from the Driving Standards Agency, from various commercial training companies or training on-road from driving instructors or other supervising drivers.

Another analysis from Wells *et al*. (2008) was run on data comparing the collision risk of new drivers in the lowest-scoring group on the hazard-perception test with that of the highest-scoring group. These data are shown in Table 4.2.

## Table 4.1 Estimated effects of introducing the hazard-perception component of the driving theory test in Great Britain on first-year reported accidents (table reproduced from data in Wells *et al.*, 2008, with permission)

		Non-low-speed public road accidents	Non-low-speed public road accidents where some blame	
Percentage reduction in collision	Central estimate	11.3%	17.4%	
of hazard-perception testing	95% confidence value*	0.3%	3%	
* One can be 95% confident that the true values are at least as great as this.				

# Table 4.2 Estimated reduction in collision liability from those in the lowest-scoring group (score taken to be 41) to those who scored 63 or more on the hazard-perception test (table reproduced from data in Wells *et al.*, 2008, with permission)

		Non-low-speed public road accidents	Non-low-speed public road accidents where some blame	
Percentage reduction in collision liability from lowest-scoring group	Central estimate	9.4%	15.6%	
on hazard-perception test to highest-scoring group	95% confidence value*	0.9%	4.5%	
* One can be 95% confident that the true values are at least as great as this.				



Figure 4.2 Future research is needed to assess how to maximise the effectiveness of hazard-perception training. For example, can such training be carried out in high-fidelity driving simulators?

Hazard-perception training, on the basis of these data, shows considerable promise as a driver training approach that works directly in reducing the collision risk of new drivers. It is a major success story for driver training in Great Britain. Importantly, unlike with some other driver training and educational approaches, there is a theoretically plausible reason why we might expect hazard-perception training to work, within the context of driving as a skill as described in this section. By taking a driving skill that is known to be associated with collision risk, and providing new drivers with multiple examples of hazards in a learning context that has a close enough match to the transfer context (ie using externally valid video stimuli with real-world hazards), or by stimulating on-road practice of this important skill, we are able to show a transfer of training effect.

Given this promise, an obvious priority is to examine the ways in which hazard-perception training can be improved and extended, so that any transfer of training effects is maximised. A number of questions need to be answered. Would it be beneficial to utilise hazard-perception training stimuli that cover high-risk post-licence driving scenarios such as driving in the dark? To what extent can hazard-perception training be done within immersive simulated environments, or by using 3D computer animation? Which are the most effective ways of training hazard-perception skill on the road during practical driving lessons? Future research to answer these questions should enable the effectiveness of hazard-perception training as an intervention to reduce the collision risk of new drivers to be maximised.

#### 4.3 Summary

In this section, we have considered the driving task as a skill within the cognitive psychology approach. The evidence regarding post-licence experience and collision risk fits this interpretation. Defining driving as a skill in this way helps to explain why previous driver education and training approaches have been shown not to work in bringing about direct reductions in the collision risk of new drivers. There has not been a focus on those aspects of driving skill that relate to collision risk, and there is a lack of overlap in the training (pre-licence) and transfer (post-licence) contexts. It also helps to explain why approaches such as hazard-perception training do seem to show promise in lowering collision risk. Such approaches concentrate on skills that are known to be related to collision risk, and on training them in a way that encourages such training to transfer effectively to post-licence driving. Further research should focus on finding ways to build on and improve the contribution of the cognitive approach to reducing the collision risk of new drivers.

# 5 Limiting exposure to high-risk situations

In this section, we review another approach to making new drivers safer. GDL seeks to manage experience and exposure to high-risk driving situations in the post-licence period.

#### 5.1 Graduated driver licensing

Although they vary across the world, the key feature of typical GDL systems is that they have a pre-licence period like any other licensing approach, but then also have a period post-licence (lasting months or years) during which time drivers are only allowed to drive unsupervised under the conditions of lowest risk. Figure 5.1 shows this general framework, using "driving at night" and "driving with teenage passengers" as two examples of the kinds of high-risk activities that have been restricted in several GDL systems.

GDL systems hope to achieve three things. Firstly, delaying exposure to the highest risk situations (and to driving postlicence at all through the use of minimum learning periods) should reduce collisions in the short term. Secondly, some maturational changes will occur in very young new drivers, and this will lower their collision risk somewhat by the time they become licensed. Thirdly, by allowing new drivers to gain experience under low-risk conditions, it is hoped that the benefits of this experience will carry over to higher risk situations such as night driving and carrying teenage passengers when the final unrestricted period is reached (eg Hedlund, 2007; Williams, 2007). In short, GDL seeks to utilise management of two things that we know are related to collision risk: exposure and post-licence experience.

# 5.2 Evidence for the effectiveness of graduated driver licensing in reducing new-driver collisions in the restricted exposure period

In the same way that there have been several major reviews of driver education and training evaluations, there have also been major reviews of the effectiveness of GDL systems in bringing about direct road safety benefits.

There is overwhelming evidence that GDL systems do bring about direct road safety benefits, in many cases for all ages of drivers studied, but especially for the youngest teenage drivers. Hartling *et al.* (2004) reviewed 13 studies evaluating 12 GDL systems from four countries (the US, Canada, Australia and New Zealand), and found impressive collision reductions in almost all studies, for all kinds of collisions, for all ages of driver studied (from 15 to 19 years old) in the first year after GDL implementation. Hartling *et al.* (2004) also reported reductions for years beyond the first year postimplementation, where data were available, and similar large reductions were generally observed, although they tended to be smaller in magnitude than first-year reductions.

The weight of this evidence led Hartling *et al.* (2004) to conclude that although the magnitude of benefits varied across jurisdictions, GDL is effective in reducing collision rates for all ages of teenage drivers, and for all types of collisions. They admit that causal associations cannot be proved through the kinds of observational designs reviewed, but they make the case that the support for the effectiveness of GDL is substantial given that there are almost entirely consistent positive results across and within studies, a clear temporal relationship between GDL implementation and observed benefits and a highly plausible mechanism by which GDL obtains these benefits (reducing exposure to high-risk situations).

Hartling *et al.* (2004) were unable to make an assessment of which elements of GDL systems (eg night-time restrictions, passenger restrictions) are most effective. However, according to the quality criteria for GDL systems put forward by the Insurance Institute for Highway Safety (IIHS), of the 12 GDL systems assessed six were rated "acceptable", five were rated "marginal" and one "poor". Despite this variability (and the fact that none of the systems were rated as "good" by the IIHS criteria), there was an almost universal beneficial effect on collision risk across GDL systems.

Since the review by Hartling *et al.* (2004), a number of researchers have been working on quantifying the contribution of the different components of GDL systems. Williams (2007) suggests that there is evidence regarding the effectiveness of extended learner periods, night-time restrictions during the restricted period and restrictions on the number of passengers allowed. Chen *et al.* (2006) studied the effect of differing levels of GDL by characterising the number (and type) of components included in each US state included in their analysis, from none (no GDL system) to seven (GDL system including all seven components, ie minimum age for

## Time from gaining learner permit

Pre-licence period	Restricted period	Unrestricted period
<ul> <li>Examples of limitations:</li> <li>Minimum learning period</li> <li>Minimum hours of supervised driving</li> </ul>	<ul> <li>Examples of limitations:</li> <li>No unaccompanied driving at night</li> <li>No driving with teenage passengers</li> </ul>	No restrictions – full licence

Figure 5.1 GDL systems have varying mixes of restrictions in pre-licence, and a post-licence restricted period, before an unrestricted post-licence period is reached.

learner permit, mandatory waiting period, minimum hours of supervised driving in the learning period, minimum age for the intermediate stage, minimum age for full licensing, night-time restrictions and passenger restrictions). The results showed that, compared with states with no GDL systems, the only states showing significant reductions (16–21%) in fatal collisions involving 16-year-old drivers were those with GDL systems including a minimum waiting period of  $\geq$ 3 months after obtaining a learner permit, plus night-time restrictions, plus either passenger restrictions, 30 hours of supervised driving in the learning period or both.

Further evidence for the effectiveness of GDL systems being dependent on the components they include comes from Morrisey *et al.* (2006). These authors defined GDL systems as "good" if they contained both a mandatory learner's period of at least six months and a restricted period lasting until age 17 that either restricts night-time driving (starting at 10 p.m.) or allows no more than one teen passenger. Systems were graded as "poor" if they only contained a mandatory learner's period of less than six months. Systems were graded as "fair" and "moderate" for various combinations of restrictions and learning periods in between these two extremes. They found that only "good" systems reduced the numbers of fatalities among 15- to 17year-old drivers overall (by 19.4%).

Something that earlier reviews of GDL have not been able to achieve is a meta-analysis to assess the magnitude of the beneficial effects of GDL across all studies, due to the different populations, methods, outcome measures and types of programme used across different jurisdictions. However, recently, Vanlaar et al. (2009) carried out a meta-analysis using fatality data from the Fatality Analysis Reporting System (FARS) in the US, and from the Traffic Accident Information Database (TRAID) in Canada. By using a population fatality rate as a standard metric across all GDL implementations in the US and Canada (ie not just the studies covered in previous reviews of evaluations), Vanlaar et al. (2009) have shown that GDL systems do have an overall beneficial effect (19.1% reduction) on the fatality rates of 16-year-old drivers. However, no overall effects were found on 17-, 18- or 19-year-old drivers, although for 18- and 19-year-old drivers some elements of GDL did seem to provide beneficial effects. Interestingly, mandatory driver education in the learner stage had a significant beneficial effect on the fatality risk of 18-year-old drivers, something which is at odds with the results reported in the literature as a whole (see Section 3.2). Mandatory driver education during the intermediate stage for 19-yearold drivers had a negative effect (ie it increased fatality risk). Thus, overall, Vanlaar et al. (2009) show that the evidence on the effectiveness of driver education within GDL seems to be equivocal.

Vanlaar *et al.* (2009) do report that their analysis suffers from a number of serious limitations. For example, 25- to 54-year-old drivers were used as a comparison group that in theory had not been affected by GDL implementation. However, in all Canadian jurisdictions, and a few US states, these older drivers would also be affected by GDL restrictions, and therefore cannot be used as a true control group. Also, using age as a grouping variable does not allow the effects of GDL on collision risk in different stages of licensure to be established. To achieve this, a grouping variable based on licensing stage is needed. The authors report that the difficulty of obtaining licence status data makes it very challenging to address this problem. Finally, no account was taken of exposure.

Overall, although the evidence for GDL being effective is strong when the weight of evidence from the literature is assessed, there needs to be a considered approach to moving forward with GDL implementation more widely. Understanding what the ideal GDL system should look like, in terms of the length of the learning period and restricted period, and in terms of the restrictions used, is essential if the obvious promise of the approach is to be realised in full. Further evaluations and meta-analyses that overcome the methodological problems of recent work (Vanlaar *et al.*, 2009) are essential.

# 5.3 Evidence for the transfer of benefits to the unrestricted period in graduated driver licensing

The weight of evidence for the effectiveness of GDL comes from the restricted period of driving post-licence, and these effects are likely to be largely related to exposure. Because people are simply not being exposed, on their own, to the higher risk situations in the restricted period, they are much less likely to have collisions in this period. In addition, some benefits will accrue due to the effects of maturation.

Another key question regarding the effectiveness of GDL is whether the benefits carry over to the unrestricted period. In allowing new drivers to build up their experience bank in the very lowest risk situations, how can we ensure that this experience still protects them in later, novel highrisk situations? Do drivers revert to being high risk for those specific situations when they enter the unrestricted period? Worse still, do they become even higher risk than they would have been because we have not allowed them enough exposure early in their learning to these situations? Consideration of this issue is crucial to ensure two things. Firstly, that GDL systems do not have unintended negative effects as some driver education and training courses have had (eg Glad, 1988; Jones, 1993; Katila et al., 1996; see also Williams and Ferguson, 2004, for a discussion of possible early licensure effects of driver education). Secondly, that GDL systems are as effective as they can be beyond their obvious positive impact on collision risk, especially for the youngest new drivers, through limiting exposure to high-risk situations. Groeger (2006) suggests that even within GDL systems there may be a need for more intensive training and practice in the restricted period to further prepare new drivers for those highrisk situations they will later encounter. In other words, even within GDL we still face the issue of how to optimise transfer of training.

Williams (2007) reports two studies showing that there are either neutral or positive effects in terms of carry over of benefits from the restricted period to the unrestricted period. Mayhew *et al.* (2003b) showed that in Nova Scotia there were no significant differences in collision rates of 16- to 17-yearold drivers in the year after graduation to the full licence, compared with pre-GDL drivers. Foss (2006), however, has shown that in North Carolina, the positive effects on collision rates for GDL drivers while in their restricted period have persisted after they acquired their full licence. Much more work is needed to establish the magnitude of any transfer effects of GDL systems. As with understanding the overall effects of GDL systems, the key will be further evaluation work.

#### 5.4 Summary

In summary, the evidence for the effectiveness of some GDL systems in bringing about direct road safety benefits in terms of a reduction in the numbers of new drivers (especially the youngest new drivers) being involved in road collisions is robust. Knowledge is beginning to accumulate as to the effectiveness of individual components that are most effective within the GDL approach. Although evidence for the effects of GDL systems carrying over into the post-restriction period is scarce, some early results are encouraging and further evaluations should give a clearer picture of how such transfer of training can be achieved. The most recent reviews, and a recent meta-analysis, suggest that GDL is a very promising approach, but that like any intervention, GDL systems need to be designed and implemented well to be effective.

### 6 Future approaches to the new-driver problem

The title of this Insight Report is in the form of a question: how can we produce safer new drivers? We have reviewed evidence for the effectiveness of early driver experience, various approaches to driver training and the limitation of exposure through GDL in terms of reducing the collision risk of new drivers.

The evidence reviewed has led us to conclude that postlicence driver experience is associated with large reductions in the collision risk of new drivers. Driver education and training has been shown to have little or no direct effect on collision risk, but cognitive-based interventions such as hazardperception training that focus on skills known to be associated with collision risk have been shown to hold considerably more promise. Limiting exposure through GDL has also been shown to lower the numbers of collisions involving new drivers, especially the youngest new drivers, although there is a great deal more to be learned in terms of which elements of GDL are most effective.

It is unlikely that there is a "one size fits all" approach to solving the new-driver problem. Different jurisdictions have their own priorities and have different populations of new drivers. For example, in the US the minimum new-driver age is generally lower than it is in Great Britain, and thus although on the balance of the evidence GDL systems might be expected to have a beneficial effect in both jurisdictions if designed and implemented optimally, on the basis of current evidence they would be expected to have a greater beneficial effect in the US, with its younger new-driver population, than in Great Britain.

We believe that the weight of evidence reviewed in this Insight Report supports the conclusion that the most effective approach to producing safer new drivers will include measures that seek to manage two things: the on-road driving experience of new drivers, including the overlap between any training and post-licence driving, such that transfer of training can be maximised; and exposure to risk. Traditional "broad" approaches to driver education and training have a crucial supporting role to play, but should not be expected to have any direct effect on collision risk on the basis of the extensive evaluation work that has already been completed.

All jurisdictions should consider some form of GDL. Although effectiveness will probably vary with jurisdiction, especially with differences in licensing age, it is likely that the optimal GDL systems will be those that set a minimum amount of time spent learning, that limit exposure to high-risk situations early in post-licence driving and that stimulate much greater amounts of on-road experience either post-licence or pre-licence if it can be shown that such pre-licence experience can transfer and have an impact on post-licence collision risk. Jurisdictions should also consider a more cognitive approach to training to encourage transfer. Hazard perception is a skill that has been shown to be related to collision risk, and the evidence from Great Britain suggests that training in hazard-perception skill leads to considerable reductions in the collision risk of new drivers for some types of collision. Therefore, all jurisdictions should consider adopting this method, and research effort should be directed at establishing how hazard-perception training can be improved and optimised.

Broader driver education and training should not be relied upon to have any direct impact on collision risk, and should not be offered as a route to early licensure or as a substitute to post-licence experience, as this may have an adverse effect on collision risk. Educational interventions and training for driver licensing should be seen as the primary methods by which basic vehicle-control skills can be taught, and safer attitudes to driving can be promoted. There should be no expectation of any beneficial effects on collision risk in new drivers from these methods, except maybe indirectly and over the very long timeframes associated with "culture shifts" in attitudes. It is entirely possible that, in some jurisdictions, publicity and educational work may be required as a prelude to the adoption of any more stringent legislative changes such as GDL, given the considerable public support that will be required for such approaches.

The actual mix of sub-components and elements used in future approaches to the new-driver problem should be based on good-quality evaluation work. It is only through goodquality evaluation work that we can quantify the measurable effects on collision risk of whatever approach is taken in a given jurisdiction. Robust evidence on what works and what does not work, and why, must form the basis of approaches to lowering the collision risk of new drivers.

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## How can we produce safer new drivers? A review of the effects of experience, training and limiting exposure on the collision risk of new drivers



New drivers, especially young new drivers, are over-represented in road collisions worldwide. This Insight Report reviews evidence for the effectiveness of post-licence driving experience, driver education and training and limiting the exposure of new drivers to risk through graduated driver licensing (GDL) in lowering new-driver collisions. Increased post-licence driving experience is associated with considerable drops in collision risk, with the greatest benefits accruing in the earliest stages of post-licence driving. Driver education and training has little or no direct effect on the collision risk of new drivers. The exception to this is training that focuses on the cognitive skills involved in hazard perception or "reading the road". GDL has been shown to have considerable beneficial effects on the collision risk of new drivers, and the benefits are greatest in magnitude for the youngest new drivers. It is recommended that all jurisdictions should consider some form of GDL, and a greater focus on the training of hazard-perception skills as part of driver licensing. Broader driver education and training should be relied upon to impart the basic vehicle-control skills required for access to the road system, and for encouraging safer attitudes to driving. However, it should not be expected to produce direct benefits in terms of lowering the collision risk of new drivers. Good-quality evaluation must form the basis of understanding what works, and what does not, in lowering the collision risk of new drivers.

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