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THE EFFICACY OF ADVANCED DRIVER TRAINING: A TARGETED LITERATURE REVIEW

by

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The Efficacy of Advanced Driver Training: A Targeted Literature Review

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Abstract:

Advanced driver training programs are currently popular; however, the degree to which they reduce young driver crash involvement remains ambiguous. This report presents the findings from a review of the literature, the aim of which was to determine how effective advanced driver training has been in reducing young drivers' crash involvement, and to identify key research gaps and limitations. The review indicates that various forms of pre-licence training have been found to be effective for skill acquisition. Some post-licence advanced driver training programs have been found to enhance either driving performance or drivers' higher-order cognitive skills such as hazard perception; programs usually target these two skill domains separately. The evidence suggests, however, that traditional advanced driver training programs have not been effective at reducing crash risk for young drivers. Caution is urged when interpreting this finding, however, since the review identified major methodological flaws associated with the majority of studies used to evaluate driver training programs. It is concluded that these flaws raise questions over the validity of the findings derived. In addition, the use of crash rates as an outcome measure for advanced driver training programs is questioned. In closing, recommendations are provided for best practice when evaluating advanced driver training programs and suggestions are made regarding ways in which to enhance the efficacy of advanced driver training programs for young drivers.

Key Words:

driver training; driver education; crash rates; young drivers; novice drivers

Disclaimer

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Preface

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Ethics Statement

Ethics approval was not required for this project.

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EXECUTIVE SUMMARY

Background and research question

Young drivers are overrepresented in road crashes and fatalities (Western Australia Police, 2010). One approach to enhancing driver behaviour and safety is the provision of advanced driver training; however, the efficacy of advanced driver training programs remains ambiguous. This report presents the findings from a review of the literature on the efficacy of advanced driver training. The aim of the review was to assess whether advanced driver training is, or could become, an effective means of reducing young driver crash involvement.

Research tasks and scope

A literature review was undertaken focusing on studies evaluating the efficacy of driver training programs. The review utilised a range of sources, including electronic research databases, peer-reviewed academic journals, government reports and consultant reports judged to be of high scientific quality. A previous review of driver training literature was conducted for the Royal Automobile Club of Victoria (RACV) in 2001 (Christie, 2001). As such, the current review focused primarily on research published in the last 10 years, although some earlier seminal research is included and has been re-evaluated.

Both pre- and post-licence training programs were considered. Pre-licence training programs aim to develop the skills that are required to obtain a driver's licence and drive safely on the road, such as basic vehicle control and traffic assessment. Post-licence training programs aim to enhance skills that are considered relevant to the prevention of accidents, such as skid control, hazard perception and advanced vehicle control skills.

The efficacy of driver training programs was evaluated from two perspectives. Firstly, does the training improve the targeted skills? Secondly, does training result in an improvement in road safety? While previous reviews focused primarily on the impact of driver training on crash rates (e.g., Christie, 2001), the current review also considers evidence such as traffic violations and safe driving behaviours, which contribute to road safety outcomes.

What was found?

Pre-licence driver training

There is clear evidence that some forms of pre-licence driver training, such as professional driving instruction and resilience training, are effective. Professional driving instruction improves driving performance (Nyberg et al., 2007) and learner drivers experience less frequent and less serious crashes during professional driving instruction compared to lay instruction (Berg et al., 2004; Gregersen et al., 2003). Resilience training supports the development of safer attitudes towards risky behaviours and results in fewer traffic violations (Grifffin et al., 2004), increased safe driving behaviours (King et al., 2008; Senserrick et al., 2009) and lower crash risk (Senserrick et al., 2009).

While compulsory driver training programs appear to be effective at improving road safety outcomes, such as drink driving and crash risk (Cartensen, 2002), the success of voluntary driver training programs can depend on drivers' motivations for undertaking training. If drivers are motivated to learn safe driving skills, then training is associated with reductions in crash involvement and traffic violations. If drivers are solely motivated by the opportunity to receive insurance discounts or accelerate their licensure, road safety outcomes may be poor (Hirsch et al., 2006). In general, training programs that result in accelerated licensure are associated with increased crash risk for young drivers (Boase & Tasca, 1998; Lewis-Evans, 2010; Lund et al., 1986; Mayhew et al., 2003). Thus although pre-licence driver training has the potential to improve road safety outcomes for young drivers, it should not be considered a substitute for extensive on-road experience and must be delivered with safety goals in mind.

Post-licence advanced driver training

The efficacy of post-licence training appears to depend on the type of skill to be trained. Training that focuses on the development of procedural skills (i.e., manoeuvring, braking, skid control, defensive driving techniques) can improve driving performance (Isler et al., 2011; Petersen et al., 2006, 2008; Petersen & Barrett, 2009). Worryingly, the evidence suggests that procedural skills training, especially skid training, can negatively impact road safety outcomes for young drivers; for example, skid training does not improve skid handling ability and can inflate drivers' confidence in their ability to handle dangerous situations that they might otherwise avoid, leading to higher crash rates (Gregersen, 1996; Katila et al., 1996).

Conversely, training that focuses on the development of higher-order skills has the potential to improve road safety, although the research is in its infancy. Expert drivers are superior to novices in terms of hazard perception, situation awareness and self-assessment of driving skills, all of which are thought to influence safe driving, and training can improve the development of these skills in young drivers (Chapman et al., 2002; Crundall et al., 2010; Fisher et al., 2002, 2006; Isler et al., 2009; McKenna et al., 2006; Pollatsek et al., 2006; Pradhan et al., 2005; Regan et al., 2000; Soliman & Mathna, 2009). However, while these results provide support for the idea that higher-order cognitive skills training can potentially reduce crash involvement, the direct effect of training on road safety outcomes is yet to be examined.

Research limitations

The review highlighted a range of limitations associated with previous evaluations of advanced driver training programs. The major flaws identified included: lack of a control group; non-random assignment to training groups; failure to measure variables that may influence the efficacy of training; and poor program design. Another primary limitation is that little attention has been paid to whether training programs yield measureable improvements in on-road safety. This may be at least partly due to the difficulty of accessing such data in the past, which is less problematic following the advent of electronic databases containing detailed road accident and violation records. It is notable that more recent research, especially in the area of higher-order skills training, tends to be of higher quality, although it is worth noting that most studies that avoid these limitations use small sample sizes.

Recent technological developments in road safety research methods, such as vehicle instrumentation, may also allow researchers to better determine the impact of training on driver behaviour. The installation of unobtrusive cameras in participants' own vehicles allows researchers to observe driving behaviour on road over long periods of time (e.g., Dingus et al., 2006). For shorter-term assessments, instrumented vehicles make it possible to record a range of driver behaviours, including vehicle manoeuvres and drivers' eye-movements.

Main conclusions and recommendations

There are three main conclusions to this review. First, in the case of pre-licence training, it is concluded that a range of training methods are effective. Further, not only is it clear which methods work, it is also known under what circumstances they work. Second, in the case of post-licence advanced driver training, it is clear that there is much further research required. The literature suggests that although some forms of advanced driver training, such as those training higher-order skills, are effective at increasing safe driving behaviours, other forms focusing on procedural skills may not be. Further, although existing results are promising, the effect of such training on road safety outcomes is unknown. Third and finally, the review clearly highlighted that the majority of studies used previously to evaluate advanced driver training programs are subject to various flaws which limit the validity and utility of their findings. It is therefore recommended that further, more robust, research focusing on the evaluation of advanced driver training programs be undertaken. This research should utilise recent advances in the study of driver behaviour, such as advanced vehicle instrumentation.

CHAPTER 1. OVERVIEW

1.1. INTRODUCTION

A long-standing challenge for road safety research is that young novice drivers have disproportionately high crash involvement (Elvik, 2010). Although people aged 17-24 comprise less than 12% of the Western Australia (WA) population (Australian Bureau of Statistics, 2010), they account for approximately 20% of WA road fatalities (Western Australia Police, 2010) and similar patterns are evident in other countries (Toroyan & Peden, 2007). The elevated crash risk of young drivers is due to both their age and their inexperience; during the first six months of unsupervised driving, novice drivers of all ages have a higher crash risk but the problem is greatest for teenage drivers (Mayhew et al., 2003). Involvement in crashes and near-crashes is highest immediately after licensing and declines significantly after the first six months, but remains high; even after 18 months of licensure teenagers' crash involvement is approximately three times that of their parents (Lee et al., 2011; Simons-Morton et al., in press). Although overall crash rates have declined in recent decades, young driver crash rates remain high (Elvik, 2010).

Various strategies have been attempted to reduce young drivers' crash involvement, including limiting their exposure to high-risk situations such as night-time driving or driving with teenaged passengers. Currently many jurisdictions, including WA, use a Graduated Driver Licensing System (GDLS) in which drivers first gain supervised driving experience on a learner's permit, then progress to unsupervised but restricted driving on a provisional licence, and finally attain a full unrestricted driver's licence. The introduction of GDLS was associated with significant reductions in young driver crash rates in most jurisdictions (Begg & Stephenson, 2003; Boase & Tasca, 1998; Ferguson et al., 2007; Vanlaar et al., 2009; Williams, 2007); however, crash rates remain disproportionately high and research indicates that strengthening GDLS restrictions does not lead to further crash rate reductions (Masten & Hagge, 2004). Therefore it is necessary to explore other means for reducing young driver crash rates, such as advanced driver training programs.

Advanced driver training programs are currently popular, both in Australia and across the world (Engesbak & Tønseth, 2010; Lonero, 2008; Mayhew, 2007; Williams & Ferguson, 2004). Although various studies have explored the efficacy of these programs, questions remain over their effectiveness with regard to enhancing driver behaviour and safety. The Royal Automobile Club (RAC) of WA asked the Curtin–Monash Accident Research Centre (C-MARC) to critically review the literature on the efficacy of advanced driver training in reducing the crash involvement of young drivers and to highlight the research gaps in this area. This report presents the findings from the review and addresses the question as to whether advanced driver training is, or could become, an effective means of reducing young driver crash involvement.

1.2. RESEARCH UNDERTAKEN

A literature review was undertaken focusing on studies evaluating the efficacy of driver training programs. The review utilised a range of sources, including electronic research databases, peer-reviewed academic journals, government reports and consultant reports judged to be of high scientific quality. A previous review of driver training literature was conducted by Ron Christie in 2001 (Christie, 2001) for the Royal Automobile Club of Victoria (RACV). As such, the current review focused primarily on research published in the last 10 years, although some earlier seminal research is included and has been re-evaluated.

1.3. STRUCTURE OF REPORT

This report presents the findings derived from the literature review. In Chapter 2, a brief overview of driver training programs is given. Chapter 3 presents a summary of pre-licence training programs and their effectiveness, followed by Chapter 4 which presents a summary of post-licensing training programs and their effectiveness. Issues associated with driver training evaluation studies are discussed in Chapter 5. The conclusions to the review, along with recommendations for future advanced driver training program evaluation studies, are presented in Chapter 6.

CHAPTER 2. OVERVIEW OF DRIVER TRAINING

2.1. DRIVER TRAINING VS. DRIVER EDUCATION

Driver training involves an individual receiving instruction that aims to develop their driving skills. The implicit assumption is that making people *better* drivers will make them *safer* drivers and consequently driver training has been viewed as a road safety measure. Although the term “driver training” is often used interchangeably with “driver education”, they have distinct definitions. *Driver training* focuses on the development of specific skill sets; initially it focused exclusively on procedural skills such as vehicle manoeuvring and handling (Horneman, 1993), but more recently has been expanded to higher-order cognitive skills (e.g., Isler et al., 2011) including hazard perception and situation awareness. *Driver education* is broader, often involving long-term processes, and typically focuses on the acquisition of knowledge about driving and road safety (Christie, 2001). Driver education can include driver training, as in North American school-based driver education programs that incorporate on-road training. The current review focuses on driver training, including driver education programs that incorporate driver training.

2.2. PRE- AND POST-LICENCE DRIVER TRAINING

Driver training may occur pre- or post-licence. *Pre-licence training* involves teaching basic driving skills to learners before they obtain a driver’s licence. *Post-licence training*, also referred to as *advanced driver training*, aims to extend existing driving skills and often involves instruction on managing difficult situations, such as skid handling or emergency braking. The current report focuses on post-licence driver training for young drivers, but also includes substantial discussion of pre-licence training. There are two reasons for this. First, much of the young driver training literature focuses on pre-licence training. Second, in some (but not all) cases similar principles may apply to the training of pre- and post-licence young drivers.

2.3. TARGET DRIVERS

Different driver training programs target different groups of drivers. Many of the programs that have been scientifically evaluated targeted groups with higher crash rates, including: young drivers (e.g., Stock et al., 1983); older drivers (e.g., Cassavaugh & Kramer, 2009); drivers with acquired physical or brain injury; and repeat offenders (Ker et al., 2005). Although these groups may have similar crash rates, the reasons underlying the elevated crash risk varies between groups (Sjögren et al., 1996). For example, the problems experienced by young novice drivers are typically attributed to inexperience, risk-taking and overconfidence (Jonah, 1986). In contrast, problems experienced by older drivers are often attributable to deteriorating physical or cognitive capabilities, which result in slower reaction times and poorer sensory perception (e.g., Lundberg et al., 1998; Owsley et al., 1998). Given these differences, it is not clear to what extent any successful training interventions developed for older drivers may be generalised to younger drivers. As such, the current review is limited to studies that evaluate training for drivers aged 25 and younger.

CHAPTER 3. PRE-LICENCE TRAINING

As discussed in Chapter 2, pre-licence training involves teaching basic driving skills to learners before they obtain a driver's licence. The need for pre-licence driver training has long been recognised; drivers' licenses were first introduced over a hundred years ago and authorities quickly added a provision for learners' permits (Mayhew, 2003). Despite this, most countries do not have compulsory training requirements for learner drivers. The aim of this chapter is to review evidence regarding the efficacy of pre-licence driver training and to determine what the most effective form of training is for learner drivers. This chapter examines professional driving instruction, formal driver training programs, simulator training and resilience training.

3.1. PROFESSIONAL DRIVING INSTRUCTION

Professional driving instruction involves learner drivers receiving individualised training (i.e., one-on-one lessons) from an accredited instructor.

It is estimated that the optimal amount of supervised pre-licence driving practice is between 4,000 and 10,000km (Sagberg, 2002) or around 120 hours (Gregersen et al., 2003); however, to obtain this amount of professional training is highly cost-prohibitive. Consequently, most drivers learn to drive using a combination of professional instruction and supervised practice with a relative or friend (Hirsch et al., 2006; Nyberg et al., 2007). This combination is beneficial, with learners who receive both professional and lay instruction being more likely to pass their practical driving test, compared to those who receive one form of training in isolation (Nyberg et al., 2007). Further, for skill development the evidence suggests it is optimal to begin with lay instruction, and have professional training either throughout the learner period or in the later stages only; learners who undertake all their professional training at the beginning of their learner's permit are less likely to pass their practical test on the first attempt (Nyberg et al., 2007). Some statistics suggest that receiving more professional training is associated with poorer driving outcomes (Gregersen & Bjurulf, 1996); however, most analyses do not measure drivers' baseline performance and as such the effect may occur because people who are less skilled drivers require more training. For example, a Dutch study reported that learner drivers who made fewer errors during their first ever drive (taking place in a driving simulator) spent less time overall receiving driver training (de Winter et al., 2009).

There is some evidence that professional training produces safer drivers, particularly during the learner period. Learner drivers are less likely to crash when supervised by an accredited instructor compared to a lay instructor; a Swedish study found 87% of injury crashes and 100% of fatal crashes occurred during lay instruction (Gregersen et al., 2003); however, the analyses did not control for time of day or road and weather conditions. Crashes do occur during professional lessons; however, they are less serious: most are low-speed crashes in urban areas, such as rear-end collisions, whereas during lay supervision high-speed crashes in rural areas are more common (Berg et al., 2004). Gregersen et al. (2003) suggest this may be because lay instructors are unaware of learner drivers' limitations (e.g., hazard perception and management of cognitive workload). Finally, receiving professional driver training has been associated with more positive driving attitudes: drivers who received more professional training have more favourable attitudes towards reckless driving, drink driving, speeding and violations (Tronsmoen, 2010) and are less likely to overestimate their driving ability (Tronsmoen, 2008).

3.2. FORMAL DRIVER TRAINING PROGRAMS

This section covers formal driver training programs for learner drivers, in which a large group of drivers receive the same curriculum in a relatively standardised manner. Various forms of formal driver training exist, including school-based driver education that includes on-road training.

3.2.1. School-Based Driver Training: The DeKalb Study (1977-1982)

The most comprehensive evaluation of driver training was an evaluation of school-based driver education programs conducted in DeKalb County, Georgia, by the US National Highway Traffic Safety Administration (NHTSA; Stock et al., 1983). Over 16,000 students were randomly assigned to one of three groups: control; Safe Performance Curriculum (SPC); or Pre-Driver Licensing (PDL) training. The control group did not receive training and were prevented from obtaining subsequent driver training (Stock et al., 1983). The SPC group received 70 hours of instruction: 32 hours classroom lessons; 16 hours simulation; 16 hours driving range; 3 hours evasive manoeuvring; and 3 hours 20 minutes on-road instruction (Lund et al., 1986). The PDL group received 20 hours of combined classroom, simulation and range driving instruction, plus 1 hour on-road. Nearly all students completed their assigned program. Training effectiveness was assessed in terms of crash rates, violations, a written driving knowledge test and on-road performance tests.

The results indicated that training increased driver knowledge and skills; the SPC group achieved better on-road performance than the PDL group, and the PDL group performed better than controls (Stock et al., 1983). Further, SPC students showed a greater increase in driving knowledge than PDL students (knowledge of control participants was not measured). Despite the improvement in driving skills, there was no effect of training on overall crash and violation rates (Stock et al., 1983). When the data were analysed in six-month time periods, the program groups had fewer crashes than controls during the first six months of licensure but were comparable for the 18 months thereafter. Similarly, violations were lower for the program groups during the first 12 months but comparable for the second 12 months.

The three groups differed in driving exposure and time of licensure, both of which can affect crash rates. Lund et al. (1986) argued that the original data analysis was not sufficiently sensitive to accommodate such variation and therefore reanalysed the data to control for these factors. Their reanalysis indicated that both SPC and PDL students were more likely to obtain driver's licenses, and obtained them significantly earlier, compared to controls. Students in the SPC group were also significantly more likely to have crashes and violations than controls, but PDL students were not. Lund et al. concluded that the positive effects of the program (i.e., improved driving knowledge and on-road skills) were offset by early licensure.

Some consider the failure of the DeKalb study to find any safety benefit as indicative that driver training programs are ineffective (e.g., Christie, 2001); however, there are limitations of the study that are worth noting. First, it is difficult to evaluate why the programs did not lead to safer driving, since the curriculum details are unknown. Secondly, the SPC program was not properly piloted; a small-scale pilot was conducted but there was no follow-up evaluation due to administrative and practical problems (Stock et al., 1983). This has been likened to conducting a large-scale clinical trial without undertaking any initial laboratory testing (Hirsch, 2003). Third and finally, while the SPC program was much longer than other programs at the time (Lund et al., 1986), the amount of on-road practice was low and far below the 120 hours required to confer a safety benefit (Gregersen, 1996).

3.2.2. Compulsory Driver Training: Denmark (1986 onwards)

In Denmark, learner drivers can only practice under the supervision of a qualified driving instructor. Cartensen (2002) surveyed 1,000 drivers licensed before and after the introduction, in 1986, of a compulsory driver training curriculum and recorded their driving history for the first 5.5 years of licensure. The new curriculum, comprising linked theoretical and practical components (e.g., driving theory, basic car control, advanced car control, defensive driving, and hazard perception; Cartensen, 1994) was associated with reductions in drink driving and crash risk during the first 12 months of licensure. Multiple vehicle crashes decreased by 17% but single vehicle crash rates did not change. Cartensen (2002) suggested that multiple-vehicle crashes are more likely to result from issues addressed by driver training, such as hazard perception and vehicle handling, whereas single vehicle crashes are more likely to result from factors like risk-taking and speeding, although it is not clear whether this claim can be supported by any empirical evidence. Importantly, some students received the new curriculum before it became compulsory in 1986 and these drivers also had lower post-licensing crash risk. These results indicate, contrary to the DeKalb study, that a structured course of driver training produces safer drivers.

3.2.3. Driver Training and Graduated Driver Licensing Systems (GDLS)

Whereas driver training aims to reduce crash rates by increasing drivers' skill base, GDLS aim to protect novice drivers by restricting their exposure to high-risk situations when they begin driving, allowing them to develop skills gradually (Foss, 2007). However, some GDLS in North America and New Zealand have (or previously had) provisions for drivers to accelerate the GDLS process by completing approved driver training courses. These courses vary substantially between jurisdictions but typically involve both theoretical and on-road instruction; in Ontario, for example, learners must complete 25 hours of classroom instruction and 10 hours of behind-the-wheel training.[1]

In Nova Scotia the time discount removes 3 months from the 6-month minimum duration of the learner's permit and evidence suggests that drivers who receive this time discount have higher crash rates. Mayhew et al. (2003) found that drivers who received the time discount had a 27% higher crash rate during their first six months of unsupervised driving. Only 2% of drivers accepted the time discount (Mayhew et al., 2003), suggesting that this group is not representative of all young drivers. In another study in Ontario, two-thirds of drivers accepted a time discount to reduce their learner period from 12 to 8 months. Initial analyses suggested that driver training was associated with a 44% higher crash risk during the provisional licence stage (Boase & Tasca, 1998). However, similar to the DeKalb study, training was associated with accelerated licensure and increased driving exposure, meaning the results were confounded: increased crash rates could be due to these factors, rather than driver training. Later reanalysis of the data controlled for driving exposure, socio-economic status (SES) and behavioural risk factors, and found that drivers who received training had significantly lower crash rates as learners and did not have significantly higher crash rates as provisional drivers (Zhao et al., 2006).

[1] Australian jurisdictions do not allow drivers to reduce the duration of their learner's permit by completing formal driver training. NSW and Queensland drivers can reduce their required log book hours by undertaking professional driving instruction; 1 hour of professional instruction counts as 3 log book hours, up to a maximum of 10 hours (30 log book hours). This can reduce the minimum requirement for supervised driving practice from 120 hours to 100 hours. The Australian Capital Territory allows provisional drivers to complete a theoretical discussion course, which eliminates most restrictions that apply to provisional licences and therefore effectively (but does not officially) accelerates young drivers to full licensure. No published research has assessed whether either strategy influences post-license crash rates.

The crash risk of driver training graduates in GDLS depends on both their motivation for undertaking training and quality of training. A Quebec study found that young drivers who sought training to learn safer driving skills had lower crash rates and fewer violations (Hirsch et al., 2006). Those who completed training to receive accelerated licensure and/or discounted insurance premiums had the highest crash rates and violations. Quality of education was also found to predict subsequent violation rates. Drivers who received a training course that did not meet mandated requirements (12 hours on-road) had significantly higher violations and marginally higher crash rates than those that met or exceeded the requirements (Hirsch et al., 2006).

In New Zealand the driver training time discount applies to the provisional licence stage, allowing drivers to obtain an unrestricted licence earlier (Begg & Langley, 2009). After controlling for age, gender, and duration of licensure, Lewis-Evans (2010) found that drivers who received the time discount had crash rates 2.9 times higher than those who did not receive the time discount. However, the analyses did not control for driving exposure or report how many drivers received a time discount, which again raises the possibility that this group may have unique characteristics (e.g., they may be more motivated to progress to their full licence and may have greater driving exposure).

3.3. SIMULATOR TRAINING FOR LEARNER DRIVERS

Driving simulators provide an appealing alternative to on-road driver training as instructors can fully control the driving environment. This allows safe exposure of learner drivers to a wide range of traffic situations (de Winter et al., 2007). In the Netherlands, for example, simulators are used to train learner drivers before they progress to on-road driving (de Winter et al., 2009). There is currently limited research evaluating the effectiveness of simulator training for learner drivers. In general, evaluations demonstrate that training improves objective driving skills in simulated driving (Allen et al., 2003, 2007, 2010; de Winter et al., 2009) particularly when the scenarios are highly similar to those encountered in training (Falkmer & Gregersen, 2003). This implies that simulators are useful for training specific skills, but that the training may not transfer or generalise to more varied contexts (Falkmer & Gregersen, 2003; Vlakveld, 2005).

Driving simulators vary considerably in terms of their fidelity, or the extent to which they reproduce the characteristics of a real vehicle and on-road driving environment (Hays et al., 1992; Pinto et al., 2008). High-fidelity simulators incorporate a full vehicle and a projection screen with up to 180° horizontal field of view. Lower fidelity simulators use only some elements of the vehicle controls (e.g., a steering wheel and brake pedals) and project the driving environment via computer monitors. Higher fidelity simulators provide a more realistic driving experience, but are more expensive and less accessible. Research in California has suggested that training in high-fidelity simulators is associated with reduced crash risk, compared to traditional driver training (Allen et al., 2007, 2010), but overall the evidence suggests that low-fidelity simulators do not provide the same benefits (Allen et al., 2007, 2010; Falkmer & Gregersen, 2003). In addition, the finding that simulator training can reduce crash risk should be taken as tentative because these studies did not randomly assign participants to training conditions and did not include a genuine control group (trained participants were compared with crash statistics from another region), meaning that the same results may not occur in other circumstances (Allen et al., 2007, 2010).

3.4. RESILIENCE TRAINING

Resilience training focuses on reducing risk-taking behaviours. Distinct from other forms of driver training, these programs primarily teach interpersonal skills, which many drivers would not perceive as related to road safety. However, resilience programs have been successful in reducing risky adolescent behaviours, such as substance abuse, which are correlated with risky driving behaviour (Jessor, 1987). Given this, researchers have evaluated whether resilience programs can reduce unsafe driving behaviours in teenagers. Resilience programs are typically conducted with teenagers, who may or may not be licensed drivers (depending on the minimum age for licensure in the relevant jurisdiction), although they ultimately aim to influence post-licence driving behaviours.

Few studies have evaluated the effects of resilience training on driving behaviour, but all have found positive effects. These include two school-based programs in the US (Griffin et al., 2004; King et al., 2008) and a community-based program in regional Australia (Senserrick et al., 2009). Resilience training programs that specifically focus on driving have been associated with increased self-reported seatbelt use (King et al., 2008), increased capacity to avoid drink driving situations (King et al., 2008; Senserrick et al., 2009) and reduction in crash rates of up to 44% (Senserrick et al., 2009). Even if resilience programs do not directly address driving, they can still produce long-term reductions in risky behaviour and result in significantly lower violations and demerit points up to six years later (Griffin et al., 2004). These results are extremely promising; however, they should be taken as tentative because the evaluations were limited in scope. Only Griffin et al. (2004) used a fully-controlled design with participants randomly assigned to training and control groups. The other American study, evaluated by King et al. (2008), did not include a control group and therefore the observed effects may be due to factors other than the training. The Australian study by Senserrick et al. (2009) was conducted as part of the on-going DRIVE cohort study in New South Wales (Ivers et al., 2006) and had a large control group, but the resilience training participants were all from low SES regional or rural areas whereas the comparison groups included higher SES participants from urban and suburban areas (Senserrick et al., 2009). Future research is needed to more comprehensively evaluate resilience training, and should use a randomised controlled design that encompasses participants from a range of different SES and geographical areas.

3.5. SUMMARY

This chapter has reviewed evidence regarding the efficacy of several types of pre-licence training for drivers: professional driving instruction; structured driver training programs; simulator training; and resilience training.

Overall, the literature indicates that professional driving instruction and structured driver training increase driving skill and result in fewer crashes during the learner permit stage (Berg et al., 2004; Gregersen et al., 2003; Zhao et al., 2006). Previous research has suggested that driver training results in a higher post-licensing crash risk (Boase & Tasca, 1998; Lund et al., 1986); however, these analyses were confounded because driver training graduates have historically received their licenses earlier than non-graduates. This demonstrates that while driver training may confer some safety benefits, they are not substantial enough to offset the negative effects of accelerated licensing and that driver training should not be considered as a "short cut" to full licensure. Regardless of the standard of training, all learner drivers require extensive accumulated experience to develop their driving skill set.

Although the use of simulation for driver training is still in its infancy, the existing literature suggests that simulator training in high-fidelity driving simulators can increase driving skill and may reduce later crash rates (Allen et al., 2007, 2010). It is notable, however, that the research demonstrating this does have some major methodological limitations, including the lack of a control group and non-random assignment of participants to training groups.

Finally, there is persuasive evidence that resilience training programs have long-lasting beneficial effects on driver behaviour (Griffin et al., 2004) and this can lead to significant reductions in crash rates (Senserrick et al., 2009). While this research is extremely promising, further research is required in this area. In particular, randomised controlled studies should be conducted to fully assess the generalisability of these effects.

CHAPTER 4. ADVANCED DRIVER TRAINING

Advanced driver training refers to forms of training that are intended for already licensed drivers, including provisional or probationary drivers. There are two broad skill sets that are usually addressed in advanced driver training: procedural skills and higher-order skills.

4.1. PROCEDURAL SKILLS TRAINING

Procedural skills involve executing a sequence of actions, which may become automated with extensive practice (Schendel & Hagman, 1982). In the context of driving, procedural skills primarily involve vehicle handling. Procedural skills training for post-licence drivers covers a range of situations including emergency braking, skid control, and defensive driving, which are not typically covered during pre-licence training.

4.1.1. Vehicle Manoeuvring and Braking

Many advanced driver training courses aim to develop specific vehicle handling skills such as manoeuvring, braking and skid control. Isler et al. (2011) compared vehicle skills training to higher-order skill training (see Section 4.2) and a control group in a randomised controlled trial. The one-week course consisted of on-road and closed-circuit driving focused on vehicle manoeuvring, steering around curves, parallel parking, and giving and receiving peer feedback on their technical skills. Compared to the higher-order skill training control groups, the vehicle handling group showed improved on-road skills, including appropriate speed choices, but no improvement in hazard perception skills or attitudes towards risky driving (Isler et al., 2011). The study assessed only short-term effects of training, so it is unclear what the long-term effects would be (including on crash rates).

Several evaluations of advanced driver training have been conducted at the Holden Performance Driving Centre in Queensland (Petersen & Barrett, 2009; Petersen et al., 2006, 2008). This research has demonstrated that a two-day training course can significantly improve drivers' vehicle manoeuvring skills and postural stability, which influences vehicle control, when cornering (Petersen et al., 2008) and changing lanes (Petersen & Barrett, 2009). Although braking training led to smoother braking performance, trained drivers took longer to stop than untrained drivers when driving a car with ABS brakes (Petersen et al., 2006). This highlights the fact that appropriate driver training is not universal: training that improves safety in one context (non-ABS cars) may decrease safety in another (ABS cars).

Of specific vehicle handling skills, skid control has been the most extensively evaluated in relation to crash rates. Skid training has traditionally been taught to pre-licence drivers in Scandinavia but in countries where skid situations (i.e., snow, frost, wet gravel, mud) are less common, including Australia and the USA, skid training is more typically part of post-licence training. While skid training for icy situations (which has been the focus of most skid training research) has less relevance to a Western Australian context, the evaluation results are nevertheless relevant. Skid handling is an advanced driving skill, which demands complex vehicle manoeuvring, and the driver training principles that are relevant to skid handling can be usefully applied to other advanced vehicle handling skills (e.g., advanced braking).

Skid training has two aims: to teach drivers to anticipate and avoid slippery road situations; and to teach them vehicle handling skills for occasions when they find themselves in unavoidable slippery road situations (Katila et al., 1996). Contrary to these aims, initial evaluations indicated that skid training led to *increased* crash rates because students focused primarily on the manoeuvring skills rather than avoiding dangerous situations (Katila et al., 1996). Focusing on vehicle handling skills fosters overconfidence; Gregersen (1996) found that traditional skid training increased drivers' self-ratings of their driving skills but did not objectively improve their skills, resulting in trained drivers being less likely to avoid dangerous situations that they erroneously believe themselves capable of handling. Consequently most driver training courses have now discontinued or substantially revised their skid training components to avoid these negative effects. This includes both focusing on avoidance rather than technical skills and structuring driving exercises so that they cannot successfully be completed at speeds that would be unsafe in real-world situations (Katila et al., 1996). Research from Finland indicates that skid training does not increase crash rates if it strongly emphasises anticipation and avoidance of slippery situations; however, even with this strong emphasis on risk avoidance, the drivers who received skid training were more confident and less likely to avoid driving in dangerous weather or other conditions that would be highly likely to produce skid situations (Katila et al., 2004).

Overall, research suggests that driver training focused on vehicle handling skills can make drivers more efficient at vehicle handling; however, this does not necessarily make them safer since they may become overconfident. This overconfidence may in turn mean that young drivers do not take appropriate precautions to avoid dangerous driving situations; for example, they may be more willing to drive in poor weather conditions because they believe they have the vehicle manoeuvring skills to handle skids and/or difficult braking situations.

4.1.2. Defensive Driving: The Montana Study (2005-2009)

The Montana Department of Transportation sponsored a one-day defensive driver training course held in 2005 with a longitudinal evaluation from 2005-2009 (Kelly, 2005; Kelly & Stanley, 2006; Stanley & Mueller, 2010). The program curriculum was tailored to the local driving conditions and covered: preparing to drive; vision and motion control; steering techniques; intersection behaviours; acceleration and braking techniques; use of reference points; off-road recovery; skid control; emergency responses; risk factors; seat belt usage; common causes of accidents; forces that operate while driving and how they get out of balance; usefulness of visual targets; visual search/scanning strategies; and evasive manoeuvres (Kelly, 2005). Participants were teenaged drivers on unrestricted licenses, randomly assigned to either training or control groups (Kelly & Stanley, 2006). Crash and violation data were collected from official records and follow-up surveys sent to participants annually for four years after the course (Kelly, 2005).

Overall, there was no consistent between-groups difference in crash rates during the four-year follow-up period. The training group reported fewer violations than controls during 2006-07, but the two groups were equivalent during 2008-09 due to decreased violations in the control group. After controlling for driving exposure, there were no significant differences between the training and control groups on either crash rates or violations (Stanley & Mueller, 2010). However, the sample size was small (347 participants) meaning that only very large differences could be detected. There was a decline in the rate of near-crashes over the four year period, suggesting that increasing experience helps drivers to avoid dangerous situations. However, there were no differences in near-crashes comparing trained and control drivers. It should be noted that data from the Montana study were analysed in one-year intervals, which could obscure effects; novice drivers improve rapidly so three- or six-month intervals are more appropriate, especially since crash rates are highest during the first six months (Lee et al., 2011; Mayhew et al., 2003).

4.1.3. Police Driver Training

In the UK most advanced driver training courses are modelled on police driver training courses. Consequently, several studies have recruited police drivers as a group who have substantial driver training (Dorn & Barker, 2005; Dorn & Brown, 2003; Page et al., 2008). Using police officers precludes the possibility of relating driver training to crash rates, since the majority of police drivers experience crashes during work-related driving (Dorn & Brown, 2003). This highlights that even when driver training is intended to reduce crash rates, crash rates are not the most informative outcome measure; it is more appropriate to examine whether trained drivers differ on specific skill sets. For example, a recent study claimed that pursuit training improves drivers' visual memory for driving-related visual and auditory information (Page et al., 2008). The authors attributed the improvement to driving training because the effect was domain-specific; pursuit drivers did not show any improvements in general visual or auditory memory. However, the effect could be due to on-the-job experience as well as, or instead of, being due to driver training.

Dorn and Barker (2005) compared simulated driving performance by police trained drivers to untrained control drivers of equivalent age and driving experience. Non-trained drivers were significantly more likely to attempt overtaking manoeuvres at potentially unsafe locations in the road and were three times more likely to pull into dangerous situations. When approaching a parked bus, police drivers showed significantly greater reductions in speed and drove non-significantly slower past the bus. Route completion time did not vary between groups; in other words, the two groups had similar overall driving speeds, but police drivers slowed down more when approaching potential hazards (Dorn & Barker, 2005). Overall this study suggests that police-trained drivers demonstrate safer driving behaviours, particularly when overtaking or approaching hazards, consistent with the principles of their driver training courses. This study was conducted in a simulator, but in real-world settings this would equate to lower crash risk. However, the police drivers drove more frequently and drove greater distances than controls, which could have also contributed to differences in driving style. In addition, police drivers may take driver training more seriously than other drivers, particularly young drivers. Nearly all police drivers (90%) believe that they could benefit from further driver training and few believe that "naturally good drivers" exist (Dorn & Brown, 2003).

4.2. HIGHER-ORDER COGNITIVE SKILLS TRAINING

Higher-order cognitive skills involve situation monitoring, assessment, and response planning and execution (Pollatsek et al., 2011). Recently driver training programs have targeted these cognitive skills, attempting to improve safe driving performance by increasing hazard perception and situation awareness. Most evaluations have examined one aspect of cognitive skills in isolation; these evaluations are reviewed in the following subsections.

Only one study has evaluated a comprehensive program that addressed a range of higher-order cognitive skills including hazard perception, situation awareness, and self-assessment of skills. Isler et al. (2011) compared the one-week program of higher-order skills training with traditional procedural skills training (see Section 4.1.1) and a control group in a randomised controlled trial. The higher-order skills group showed improved hazard perception and visual search abilities, as well as decreased risky driving attitudes and reduced confidence in driving abilities. The procedural skills group showed improved technical skills but no improvement in safe driving attitudes or behaviour, while the control group did not improve on any driving measures (Isler et al., 2011). This demonstrates that better drivers are not necessarily safer drivers (or vice versa), especially among young drivers who may fail to understand that a key aim of driver training is to promote safe driving behaviour.

4.2.1. Hazard Perception

Hazard perception refers to a driver's ability to detect and anticipate potential hazards in the environment, and has been consistently linked to crash involvement (Horswill & McKenna, 2004). Novice drivers have poorer hazard perception than experienced drivers (Horswill & McKenna, 2004; Isler et al., 2009), possibly due to their less efficient visual scanning strategies: novices make fewer glances at the car's external mirrors (Underwood et al., 2002) and tend to fixate directly ahead of their car rather than scanning horizontally, which facilitates detection of peripheral hazards (Crundall & Underwood, 1998). Hazard Perception Tests (HPT) comprise part of the licensing process in WA and many other jurisdictions. In HPTs drivers typically watch brief video clips of traffic scenes and have to indicate when it is appropriate to execute a certain action (e.g., brake, turn, overtake), or when they detect a hazard. Drivers typically overestimate their hazard perception skills (Horswill et al., 2004, 2011) and there is no relationship between hazard perception and self-rated driving ability (Farrand & McKenna, 2001). However, HPT results predict crash involvement; Horswill et al. (2010a) found crash-free drivers detected hazards an average of 300ms faster than drivers who had crashed, which would allow an additional 5m braking distance at 60km/h.

Recent research has focused on whether training can improve HPT results and whether novices can achieve the same level of proficiency as experienced drivers. The standard procedure is to administer an initial HPT and then randomly allocate participants to either a training or control group. After the training, drivers complete a second HPT. If the training is successful then trainees should show a significantly greater improvement in HPT scores compared to controls, who should show little or no improvement. Two broad types of hazard perception training have been evaluated: commentary training and part-task training.

In commentary training participants provide and/or receive detailed verbal commentary on a driving scene, while either driving (Crundall et al., 2010) or watching video clips filmed from the driver's vantage point (Chapman et al., 2002; Isler et al., 2009; McKenna et al., 2006). Commentary training has been found to improve young drivers' HPT scores (Chapman et al., 2002; Crundall et al., 2010; Isler et al., 2009; McKenna et al., 2006) and increase horizontal scanning during driving (Chapman et al., 2002). Trained and control drivers do not differ in overall speeds (Chapman et al., 2002) but trained drivers show greater speed reductions when approaching hazards (Crundall et al., 2010). When tested on video-based tasks that assess speeding, close following and gap acceptance, trained drivers take fewer risks and commit fewer violations than control drivers (McKenna et al., 2006). This undermines some claims that young driver crash rates result from intentional risk-taking (e.g., Clarke et al., 2005), suggesting that both risk-taking and violations may result from ignorance rather than overconfidence. Commentary training also improves HPT scores for drivers with attention deficit hyperactivity disorder (Poulsen et al., 2010) and older drivers (Horswill et al., 2010b).

Similar to commentary training, Wang et al. (2010) exposed drivers to a series of hazardous situations in a simulator and then had the training group review a video of their performance and compare it to an expert driver's performance. Trained drivers showed greater hazard anticipation including greater speed reductions when approaching hazards (Wang et al., 2010). Overall this research suggests that reflecting on driving performance, through commentary or reviewing past drives, can significantly improve hazard perception.

In part-task training participants watch video clips of driving scenarios and complete set tasks such as highlighting areas of potential hazards, indicating what action they would take, or describing the visual scene (Fisher et al., 2002, 2006; Pollatsek et al., 2006; Pradhan et al., 2005; Regan et al., 2000). These include publicly-available PC-based programs such as DriveSmart (Regan et al., 1998, 1999, 2000). When evaluated in a driving simulator, trained drivers demonstrate more safe driving behaviours than controls (Fisher et al., 2002) and follow-up evaluations indicate these effects persist for at least a month (Regan et al., 2000). Trained drivers also exhibit superior visual scanning ability and are more likely to fixate on areas containing potential hazards, both during simulated driving (Fisher et al., 2002; Pollatsek et al., 2006; Pradhan et al., 2006) and on-road driving (Fisher et al., 2006).

Currently the results from hazard perception training are extremely encouraging; however, no published studies have directly tested the link between hazard perception training and crash risk. Although several studies have indicated that training leads to safer driving behaviours, these results should be interpreted cautiously for two reasons. First, most of these studies were conducted in driving simulators or using computer-based tasks that represent driving. The extent to which the behavioural changes extend to real-world driving therefore remains ambiguous. Secondly, because drivers received the training and assessment in the context of a single study they may have exhibited demand characteristics; i.e., made a conscious effort to drive cautiously because they knew the study was about hazard perception and safe driving.

4.2.2. Situation Awareness

Situation awareness, our understanding of "what is going on" (Endsley, 1995), is a critical commodity for drivers. In the context of driving, Salmon et al. (in press) define situation awareness as time-specific activated knowledge regarding driving tasks within the road system. Elements of situation awareness have been implicated in road traffic crashes; data from the US NHTSA 100-Car Naturalistic Study indicated that inattention was as a contributory factor in 78% of crashes and 65% of near-crashes observed (Klauer et al, 2006). There are two contexts in which situation awareness has been investigated in relation to driver training: whether driver training increases situation awareness (Stanton et al., 2007; Walker et al., 2009), and whether situation awareness training leads to safer driving (Soliman & Mathna, 2009).

Two studies have assessed whether situation awareness is affected by advanced driver training (Stanton et al., 2007; Walker et al., 2009). Both used a longitudinal on-road study in which three groups of 25 drivers were tested before and after an intervention: one group received advanced driver training; one group was accompanied while driving; and one group received no intervention. Driver situation awareness was assessed using network analysis based on in-vehicle observations and cognitive task analysis interviews. Walker et al. (2009) found that drivers who completed advanced driver training derived greater knowledge from the driving environment and were able to make more connections between pieces of information taken from the driving environment, both of which are indicative of heightened situation awareness and can lead to increased favourable driving behaviours. Similarly, Stanton et al. (2007) found that training improved drivers' knowledge of their driving environment and led to more effective use of that knowledge. Drivers also showed significant improvement in positive driving behaviours in most categories, whereas the control groups showed either no change or a significant decrement in performance on these categories (Stanton et al., 2007). These results confirm that advanced driver training can improve technical driving skills, but also extend past findings by indicating that these programs can also improve situation awareness while driving.

There is also evidence that cognitive training to improve situation awareness can improve novice driver performance. Soliman and Mathna (2009) randomly assigned novice and experienced drivers to either cognitive training or control groups. The training groups completed strategy training in which they planned and executed their own driving strategies in a computer game simulation and observed and evaluated the strategies of other drivers. All drivers were then evaluated on their driving performance in a low-fidelity driving simulator. Experienced drivers showed greater situation awareness than novices and trained drivers showed greater situation awareness than untrained drivers, in both the novice and experienced group (Soliman & Mathna, 2009). Situation awareness training significantly improved the technical driving performance of novice drivers, but not experienced drivers: trained novices showed significantly fewer collisions, errors, violations and lane excursions. As with the results from hazard perception training (e.g., McKenna et al., 2006), this suggests that the high crash rate of novice drivers may be largely due to ignorance rather than wilful risk-taking.

4.2.3. Insight Training

The suggestion that young drivers fail to apply safe driving skills has prompted the development of alternative types of training to address attitudinal factors like risk-taking and overconfidence. Examples include resilience training, which can be adapted for pre- or post-licence teenagers (see Section 3.4), and insight training, which is typically aimed at licensed drivers. *Insight training* encourages drivers to realistically evaluate their driving ability and was developed in response to evidence suggesting that procedural skills training creates overconfidence in young drivers (Gregersen, 1996; Katila et al., 1996). Drivers who believe they are more skilful also believe they are safer drivers (Horswill, 1994, cited in Horswill et al., 2004) and so overconfident drivers may not take appropriate precautions while driving. Although insight training is often recommended in the driver training literature, there have been few evaluations of its effectiveness. Two studies indicate that insight training reduces overconfidence and increases self-reported positive driving behaviours (Gregersen, 1996; Senserrick & Swinburne, 2001); however, neither study included a control group, which makes the results ambiguous.

Gregersen (1996) randomly assigned 58 young drivers to receive either insight training or traditional driver training in skid braking and avoidance manoeuvres. Both groups were tested in vehicle handling a week later and asked to rate their likelihood of success in the test. The groups did not differ in objective performance levels, but the skill training group gave significantly higher ratings of their driving ability. This result has widely been interpreted as evidence that insight training reduces overconfidence; however, the study did not include a control group who received no training, so it cannot fully explain the difference in self-ratings between groups. The effect may be due to insight training reducing overconfidence, but could also be due to skill training inflating overconfidence (or a combination of the two).

AAMI Insurance offers discounted insurance premiums to young drivers who complete a one-day insight training course. Evaluation of the course indicated that training was associated with reduced overconfidence for males, reduced self-reported speeding and close following, increased hazard awareness and increased perceived risk of having a crash (Senserrick & Swinburne, 2001). Overall, this suggests that insight training increases positive driving behaviours, but this evaluation is limited by its use of self-report measures.

Most insight training focuses on reducing overestimates of procedural skills; recently, Queensland researchers questioned whether insight training could reduce overconfidence or optimism bias for hazard perception skills (White et al., 2011). Insight training did not reduce overconfidence for either general or specific driving skills or hazard perception skills. Although this study suggests that insight training is not effective at reducing overestimates of hazard perception ability, the results should not be taken as conclusive because the insight manipulation was flawed. Participants were not given feedback about their skills and were unaware of when they made errors on the test, which means that the act of completing the test probably did not influence their self-awareness of skills. In addition, the insight manipulation only applied to hazard perception, so it is unsurprising that it had no effect on evaluations of driving skills.

Overall, there is limited empirical evidence that insight training can reduce young drivers' overconfidence and increase accurate self-assessment of skills, which could improve safety by increasing their avoidance of dangerous driving situations. However, recent research has questioned whether young drivers are in fact overconfident (Mynttinen et al., 2009a, 2009b;

Sundström, 2011). Many studies that found young drivers to overestimate their skills asked drivers to compare themselves to average drivers (Sundström, 2011). However, this type of comparison is vague and research demonstrates that most people rate themselves above average on most dimensions (Headey & Wearing, 1988), so it appears this is a general cognitive bias rather than genuine overconfidence. More recently, European researchers have assessed overconfidence by comparing drivers' self-ratings of specific driving skills to ratings provided by their driving instructor or examiner. Using this method up to 50% of novice drivers accurately assess their skills, while 30-40% overestimate and 10-20% underestimate their abilities (Mynttinen et al., 2009a, 2009b; Sundström, 2011). Drivers who have receive more professional instruction have more accurate self-perceptions (Mynttinen et al., 2009a) as do Finnish drivers, who receive explicit training on self-assessment during their learner phase (Mynttinen et al., 2009a, 2009b). Other research suggests only very inexperienced learner drivers significantly overestimate their driving skills (Boccara et al., 2011a); past this initial stage, self-ratings increase proportionate to actual skill level as rated by instructors (Boccara et al., 2011a, 2011b). This indicates that drivers can be trained to accurately self-assess their skills, which could in turn lead to safer driving. However, no studies to date have linked accurate self-assessment of driving skills with crash rates or other measures of safe driving behaviour.

4.3. SUMMARY

This chapter has reviewed evidence regarding the efficacy of several types of post-licence training for young drivers: vehicle manoeuvring; defensive driving; skid training; hazard perception training; situation awareness and insight training.

Many of the training evaluations, particularly those that address procedural skills training, have methodological flaws, which will be discussed in Chapter 5. This limits the conclusions that can be drawn based on existing research; however, evaluations consistently demonstrate that advanced driver training is effective at improving drivers' procedural skills (i.e., vehicle handling and manoeuvring). Some research suggests that improved procedural skills do not necessarily lead to safer driving behaviour, for two reasons. First, novice driver training for has often been associated with crash risk factors such as increased driving exposure or accelerated progression through GDLS. Secondly, it appears that many novice drivers misunderstand the purpose and focus of procedural skills training; students focus on developing their skills for handling dangerous situations and miss the broader message, which is that they should change their behaviours to avoid encountering these situations at all, and consequently they do not take appropriate precautions to avoid driving in dangerous situations (Gregersen, 1996; Katila et al., 1996). In addition, there is some empirical support for the notion that traditional driver training fosters overconfidence in young drivers, which could also explain why novice drivers fail to avoid risky driving situations.

Recently attention has turned to the influence of higher-order cognitive skills on safe driving. The results of hazard perception training interventions are particularly promising, although further research must be undertaken in order to conclusively demonstrate a link between hazard perception training and subsequent safer driving (including reduced crash risk). Less research has been conducted on situation awareness but this is also promising; evidence suggests that advanced driver training improves situation awareness, and also that situation awareness training leads to safer driving. Finally, several evaluations have demonstrated that insight training reduces driver overconfidence. This could lead to reduced crash rates, because drivers will behave more cautiously. It should be noted that insight training alone does not actually improve any driving-related skills; it merely assists drivers to make more accurate self-assessments of their existing skill levels.

CHAPTER 5. LIMITATIONS IN PAST RESEARCH

There is a considerable amount of literature evaluating driver training programs. As demonstrated in Chapters 3 and 4, these evaluations vary greatly in their methodology and program content. While it is acknowledged that the assessment of driver training is a highly complex process, the majority of studies presented in the literature have major flaws that limit the validity of their findings. This chapter discusses the main limitations and outlines a methodology for future evaluations.

5.1. EVALUATION DESIGN

5.1.1. Use of Control Groups

A major flaw in many evaluations of driver training is their lack of a control group. This means that observed effects could be due to factors other than the training. For example, crash rates vary considerably over time (French et al., 1993; McKenna et al., 1986) due to factors including weather variations (Katila et al., 2004), changes in licensure (e.g., introduction of GDLS) and improved vehicle safety. However, it is acknowledged that there are some instances where it is genuinely impossible to include a control group, such as when assessing the effects of compulsory training in a region (e.g., Carstensen, 2002).

Some studies include only short-term evaluations of control group performance because it is unethical to prevent control participants from accessing driver training (e.g., Isler et al., 2011); however, longitudinal comparisons of crash involvement are necessary to determine whether the benefits of driver training outweigh the costs. If the benefits of driver training are large enough to have practical significance, then they should emerge even if members of the control group access alternative types of training. Thus it would be advantageous for studies to follow the driving records of both training and control groups for at least two years in order to assess the effects of training.

5.1.2. Random Assignment to Groups

Another limitation evident in many evaluations is the lack of random assignment to groups. Several evaluations that compared different training courses were conducted in multiple locations, using different participant populations, meaning that observed effects may be due to underlying differences in the population rather than resulting from training. Further, in many evaluations, participants self-select into the training group and thus may not accurately represent the general population. This means that the results may be biased, although the type of bias will depend on participants' reasons for undertaking training (Hirsch et al., 2006). If they are aiming to learn safer driving skills, this could inflate the observed beneficial effects of driver training, whereas if they simply desire accelerated licensure or a reduced insurance premium then this may bias the results in the opposite direction and lead to the conclusion that driver training increases crash rates.

Even when participants are randomly assigned to groups and a control group is included, bias may still arise if there is selective dropout from the training group. This is most likely to occur when the outcome measures use official records; for example, when control group participants do not actively participate in the evaluation program and therefore are unlikely to drop out.

5.1.3. Unmeasured Variables

One of the most consistent flaws in driver training evaluations is that they do not account for variables that co-occur with driver training. As discussed in Chapter 3, pre-licence driver training historically led to higher rates of licensure at an earlier age. This confound led some researchers to the conclusion that driver training actually increases crash rates, when in actuality this effect is most likely due to accelerated licensure rather than driver training itself. In addition, many evaluations do not measure variables that have significant associations with crash risk (see Section 5.3.1 below), including driving exposure and risk-taking behaviour.

5.2. PROGRAM DESIGN

Even in cases where the evaluation is appropriately designed, many driver training evaluations are limited by the design of the driver training program itself. Often courses do not include an exit test or assessment of learning. This means that evaluations cannot differentiate between courses that do not affect driving behaviour at all and courses that affect driving behaviour but do not lead to safer driving.

In addition, the content and extent of training varies substantially between courses, which makes it hard to compare results of different evaluations. Training programs that appear similar (i.e., both are described as defensive driver training) may be quite different in nature and often there are insufficient details to determine how the course content was taught. Consequently, some evaluations find that training decreases crash rates, others find increased crash rates, and others still find no effect. Given the massive variability in the content of driver training, it is hard to assess whether these results reflect genuinely different effects of different programs or if they are due to methodological issues in the evaluation process.

5.3. OUTCOME MEASURES

5.3.1. Overall Crash Rates

The aim of this report is to assess whether advanced driver training programs can reduce the crash involvement of young drivers. Several studies examined this question directly by comparing whether the crash rates of trained and untrained drivers differ. Based on this approach, several reviews of the driver training literature concluded that advanced driver training is not associated with reduced crash rates (Christie, 2001; Engström et al., 2003; Ker et al., 2005; Mayhew & Simpson, 2002; Roberts & Kwan, 2008). Whilst using crash rates as an outcome measure for assessing advanced driver training makes intuitive sense, there are several reasons why overall crash rates may not be appropriate for this purpose:

- *Reliability*. Crash rates are an unreliable measure, meaning they vary over time (French et al., 1993; McKenna et al., 1986). This limits the extent to which crash rates can show a consistent relationship with other variables.

- *Biases*. Crash reporting is biased. Official records under-report crashes and are biased towards more serious crashes, since not all crashes are reported to police. Self-reports also under-report crashes because drivers fail to report all crashes, either deliberately (due to social desirability bias) or accidentally (due to forgetting).

- *Multiple causal factors*. Crashes have multiple determinants and different crash types have different underlying causes (af Wåhlberg, 2003). It may be reasonable to expect driver training to reduce single vehicle crashes, but not multiple-vehicle crashes where the other driver is at fault.

- *Rarity*. Crashes are rare events, which means that large samples (>10,000 drivers) are required to detect crash rate reductions of 5-10% (Stock et al., 1983).

Given these factors, the relationship between crash rates and any given variable will be small. Further, several personal characteristics have been associated with crash risk, including sex (Monárrez-Espino et al., 2006; Stock et al., 1983), social adjustment (Stock et al., 1983), aggression (Chliaoutakis et al., 2002), overconfidence (Lee et al., 2002) and conscientiousness (Arthur & Doverspike, 2001). Statistically controlling for these variables further increases the sample size required to detect any effects of driver training, which can make conducting robust evaluations of driver training research expensive and even unfeasible in some smaller jurisdictions.

It is concluded that overall crash rates are not a reliable or sensitive outcome measure. Three alternatives are discussed: crash type; time to first crash; and safe driving behaviour.

5.3.2. Crash Type and Severity

Rather than examining overall crash rates, a more sensitive measure of crash involvement would be to examine crash type and severity. Some of the training programs reviewed in this report produce small effects; for example, hazard perception training may result in a driver detecting a hazard, and therefore braking, approximately half a second earlier. This difference may not be sufficient to completely avoid a crash but may significantly reduce crash severity, resulting in fewer fatalities or less serious injuries. If this is the case, then the driver training would constitute a worthwhile intervention despite not reducing the total number of crashes, because it could nevertheless reduce the costs of road trauma.

5.3.3. Time to First Crash

A second option for assessing crash involvement is to calculate drivers' time to first crash, which provides a more sensitive measure of their crash involvement than overall crash rates (Senserrick & Swinburne, 2001). Overall crash rates are a cumulative measure, so as time progresses the likelihood that a given driver will have a crash history increases. Given this, studies with longer follow-up evaluation periods actually have a lower chance of finding differences in overall crash rates between trained and untrained drivers. Studies at the Monash University Accident Research Centre (MUARC) have used a statistical technique called survival analysis to assess the length of time it takes different groups or individuals to reach a particular outcome (e.g., first on-road crash), given the constraint that many but not all individuals will reach this outcome during the evaluation period (Newstead, 1993).

Using survival analysis to compare the time to first crash between trained and untrained drivers would provide a powerful way to assess whether crash involvement systematically differs between trained and untrained young drivers. This would be particularly useful when evaluating advanced driver training courses that occur shortly after licensing, since crash rates are highest in the first six months of licensure (Lee et al., 2011; Mayhew et al., 2003). Survival analysis could be used to indicate whether training interventions during the first six months of licensure are effective at reducing crash rates during this period.

5.3.4. Safe Driving Behaviour

Another alternative outcome measure is drivers' on-road behaviour to assess whether trained and untrained drivers differ in terms of safe or unsafe driving behaviours. Performance can be measured either in a driving simulator on on-road using an instrumented vehicle that can measure parameters such as vehicle speed, lane position, acceleration and deceleration. Several previous studies have used simulated driving performance as an outcome measure; with results suggesting that certain types of training lead to both improved vehicle handling skills and more cautious driving in potentially hazardous situations (e.g., Dorn & Barker, 2005).

It should be noted that using driving performance as an outcome measure also has limitations. In most evaluations it will only be practical to measure driving performance for a very brief period, usually 1-2 hours. This performance may not be representative of the participant's real-world driving, because of both the limited duration and possible demand characteristics. Demand characteristics occur when studies contain specific features or cues that alert the participants to the purpose of the study, which in turn influences their responses. In driver training evaluations, most participants will be aware of the study's purpose and this may prompt them to drive more cautiously during the driving assessment. For this reason, results from studies that use one-off driving performance evaluations should be taken as tentative.

A more rigorous evaluation design would be to install unobtrusive cameras in participants' own vehicles and record naturalistic observation of their driving behaviour, as in the 100-Car Naturalistic Driving Study (Dingus et al., 2006) or the recent Naturalistic Teenage Driving Study (Lee et al., 2011; Simons-Morton et al., in press) during which drivers were monitored continuously for 12-18 months. This methodology is costly and labour-intensive but can potentially provide the most accurate data regarding the short- and medium-term effects of training on driver behaviour, particularly regarding drivers' involvement in minor crashes and near-crashes (which are often not documented in official records or self-reports, as already discussed).

5.4. SUMMARY

This chapter has discussed some of the key limitations evident in many previous driver training evaluations. These limitations apply to the design of both the program itself and the evaluation, and limit the validity and reliability of the evaluation results.

Regarding the evaluation design, the major limitations identified were that evaluations often do not include a control group and/or do not randomly assign participants to training and control groups, meaning that observed effects may be due to pre-existing participant characteristics rather than being due to the training. In addition, many evaluations do not appropriately control for variables that are associated with unsafe driving behaviour and do not account for variables that co-occur with training. These unmeasured variables may explain why some studies have found negative effects of driver training; for example, some evaluations indicated that participating in driver training led to increased crash risk, but in most driver training was correlated with accelerated licensure, which increases crash risk.

Regarding the program design, the content and extent of driver training varies substantially between programs and in many cases details of program content are unavailable, which limits researchers' ability to draw valid comparisons between programs. Some programs include inappropriate elements, which can increase crash rates (e.g., skid training). Given this, it is unwise to generalise between programs where the content is either unknown or includes undesirable elements.

Finally, most studies have failed to find a relationship between driver training and subsequent crash risk. This has been interpreted as evidence that driver training does not improve, and cannot improve, safe driving behaviour. However, overall crash rates are not an appropriate outcome measure because crashes are rare events with multiple causal effects and because crash rates are a biased and unreliable statistical measure. More sensitive measures of crash involvement, including crash type, crash severity, and time to first crash, would be more appropriate to assess the relationship between driver training and crash involvement. In addition, it may be beneficial to look at on-road safe driving performance, which could be accomplished through either simulator studies or naturalistic driving studies that use unobtrusive cameras to record drivers' behaviour in their own vehicles.

CHAPTER 6. DISCUSSION

The aim of this review was to determine how effective driver training has been in reducing young drivers' crash involvement and to identify key research gaps and limitations. Despite the proliferation of studies focusing on the evaluation of driver training, there is currently limited evidence regarding its safety potential. As discussed in Chapter 5, previous assessments of advanced driver training programs are beset by major methodological limitations, which limit the reliability and generalisability of evaluation results. Given this, it is argued that previous reviews condemning driver training as ineffective were unjustified in that they generalised results from one training program to all driver training.

6.1. THE EFFICACY OF DRIVER TRAINING

Two key points have emerged from the current review. First, the efficacy of driver training can be evaluated from two distinct perspectives: whether it improves target skills, and whether it improves on-road safety. This distinction is important, because some types of driver training can improve driving skill but not safety (e.g., vehicle manoeuvring training) while other types of training improve safety without influencing skill (e.g., insight training). Secondly, it is apparent that different types of training may increase the safety of young drivers at different stages of the licensure process and as such programs should be tailored to specific populations. This point is critical when evaluating the efficacy of driver training; Groeger and Banks (2007) argue that it is unrealistic to expect the skills taught in pre-licence training to have a significant effect on post-licence driving safety, because the circumstances of pre- and post-licence driving are substantially different.

6.1.1. Effective Pre-Licence Training

There is clear evidence that some forms of pre-licence driver training are effective at improving driving skills and/or reducing crash risk, which is summarised in Table 6-1. Resilience training has long-term protective effects and reduces crash rates and violations, even if it does not directly address driving and is administered several years before adolescents begin driving. Learner drivers can potentially benefit from driver training that addresses procedural skills, including both professional driving instruction and formal driver training programs, provided that these do not lead to a reduction in hours of supervised practice or accelerate their progression to full licensure. The success of voluntary driver training programs depends on drivers' motivations for undertaking training. If drivers are motivated to learn safe driving skills, then training is associated with reductions in crash involvement and traffic violations. If drivers are solely motivated by the opportunity to receive insurance discounts or accelerate their licensure, road safety outcomes may be poor (Hirsch et al., 2006). Some studies have investigated whether simulator training can improve driving performance; however, the current evidence is limited and insufficient to conclude whether simulation driver training is effective. Overall, the results indicate that pre-licence driver training has potential to improve young drivers' on-road safety outcomes, but should not be considered a substitute for on-road experience and should focus on safety rather than skill development.

6.1.2. Effective Post-Licence Training

There is currently limited evidence regarding the efficacy of post-licence training for improving on-road safety and reducing crash risk. As summarised in Table 6-2, several types of training have demonstrated efficacy at improving target skills, including both procedural skills and higher-order cognitive skills. Existing evidence implies that higher-order skills training (particularly hazard perception training) has the potential to significantly reduce crash risk, but this link has not been directly tested. Traditional advanced driver training, which focuses on vehicle-handling skills, does not appear to be effective at reducing crash risk for young drivers but typically is effective at increasing young drivers' technical skills. However, advanced driver training is associated with safer driving behaviours in police drivers. This suggests that advanced driver training aimed at young drivers which focuses solely or primarily on vehicle handling skills may be misguided; it provides them with the skills to drive safely, but often they do not apply them appropriately. Several explanations have been offered for this: most persuasively, it appears that many young drivers are ignorant of the risks that they face while driving (e.g., McKenna et al., 2006; Soliman & Mathna, 2009). In addition, there is some evidence that traditional skills training, such as skid handling, promotes overconfidence, and even without this type of training a large minority of young drivers overestimate their driving skills. Fortunately, it appears that these issues can be overcome through higher-order cognitive skills training.

6.2. DIRECTIONS FOR FUTURE RESEARCH

Although some advanced driver training programs appear to offer substantial safety benefits, these need to be fully assessed using more rigorous evaluation methodology. This review has identified several limitations in previous evaluations of driver training, which limit the reliability and validity of their findings. These include: failure to use a control group; non-random assignment of participants to different groups; failure to account for variables that co-occur with training; poor program design; and the use of crash rates as an outcome measure. In order for future evaluations of advanced driver training programs to produce valid, generalisable findings, it is imperative that these limitations are overcome.

Future evaluation studies should be designed to include a control group and should randomly assign participants to the training and control groups. As discussed, it is unethical to prohibit control group participants from accessing alternative forms of driver training and this may lead to contamination of the control group, which could weaken the effects of driver training. One method for avoiding this problem is to use a time-lagged longitudinal design, in which half the participants are initially assigned to a control group. The driving history of all drivers would then be recorded for a 1-2 year period after initial training. At the conclusion of this evaluation period, the control group would then receive the same training course. Time-lag designs enable researchers to evaluate a genuine control group for a substantial period of time, but still allow members of the control group to access the intervention. This type of design was employed for a trial of a motorcycle rider on-road coaching course (VicRide) that is currently being evaluated by MUARC.

Evaluations should also carefully consider how to best measure the efficacy of advanced driver training. Several points are important here. At a minimum, baseline measures of driver performance should be obtained; that is, participants' existing levels of hazard perception, situation awareness, vehicle control, and positive driving behaviours and attitudes should be assessed at the beginning of the study. Without these measures, it is difficult to gauge the true effect of the program. Further, it is important to distinguish between possible outcomes of driver training, particularly improvements in driving skills versus improvements in safety.

Previously the main method for assessing driving safety was to examine overall crash rates. The limitations of overall crash rates of an outcome measure have been discussed in depth already. Fortunately, there are several alternative measures that can be used to assess crash involvement, including crash type, crash severity, and time to first crash. Assessing these variables will involve more complex data analysis than was previously used for overall crash rates and will also require more detailed crash data. The introduction of electronic databases for police records means that it is now easier to access this data. Future studies that evaluate driver training should therefore seek participants' permission to prospectively access their driving histories from these databases, including both crash and violation records. While the measures of crash involvement that have been proposed in this report are more sensitive than overall crash rates, it should be remembered that crashes remain rare events and therefore large sample sizes (i.e., over 10,000 participants) may be required to reliably detect any effects of driver training.

Advances in driver behaviour assessment methodology now provide new opportunities for assessing the efficacy of advanced driver training. In particular, it is now possible to assess drivers' on-road behaviour using either instrumented vehicles or naturalistic observation. Instrumented vehicles are dedicated test vehicles that have special technology fitted to enable researchers to record vehicle parameters such as speed or lane positioning and driver behaviour including eye movements, braking, accelerating, and use of other controls. Some previous evaluations of driver training used instrumented vehicles to assess how training affects on-road driving behaviour (e.g., Underwood et al., 2002); however, one limitation of this method is that it involves a one-off measure of driving performance that may not properly represent the driver's normal behaviour. Recently, researchers have begun to study naturalistic driving behaviour using unobtrusive cameras (DriveCam) that are installed in the driver's own vehicle. DriveCam studies have been used in other contexts to record drivers' on-road performance for up to 18 months (Dingus et al., 2006; Lee et al., 2011; Simons-Morton et al., in press). If applied to driver training evaluation, DriveCam could provide accurate and comprehensive data on drivers' performance for 12-18 months after the completion of their driver training course. This would provide information on the prevalence of safe and unsafe driving behaviours (e.g., close following, risky overtaking or lane changing) and would also provide detailed data regarding any crashes and near crashes. The disadvantages of DriveCam studies are that they are expensive and therefore impractical for a large-scale study; however, one appealing possibility would be to use DriveCam to assess the behaviour of a small subset of drivers (e.g., 50-100 participants) within a larger evaluation of driver training that assesses crash involvement and self-reported driving behaviour. This would also allow researchers to assess the relationship between the different outcome measures (i.e., on-road performance, crash involvement, and self-reported behaviour).

6.3. CONCLUSION

Based on existing evidence, it is concluded that several forms of advanced driver training are beneficial in terms of skill development. Encouragingly, some forms of advanced driver training also appear to have the potential to improve the safety of young drivers, although the safety benefits have either not been adequately evaluated (in the case of procedural skills training) or has not been directly evaluated at all (in the case of higher-order cognitive skills training).

Following the release of the DeKalb study results, many governments and funding agencies responded by withdrawing funding for driver training and education (Senserrick et al., 2009). Rather than abandon driver training, road safety professionals should redesign training courses to make them more effective at promoting safe driving behaviours. The current trend seems to be towards interventions that make drivers more cautious, without necessarily improving their skill base. There is a bias against training that includes any form of vehicle handling; however, this bias is both illogical and unwarranted. Training in vehicle handling does not promote unsafe driving; car control training can increase situation awareness while driving and it is associated with more cautious driving behaviour in police officers. However, vehicle handling should be taught in conjunction with other skills, particularly hazard perception and risk awareness, to ensure that drivers understand that good driving involves more than skilful control of the vehicle.

Table 6-1. Summary of the efficacy of pre-licence driver training programs.

Type of Training	Target Skills	Source	Does it improve target skills?	Does it improve on-road safety?
		Procedural Skills		
Professional driving instruction	On-road vehicle handling skills	Gregersen et al. (2003) Nyberg et al. (2007)	Yes	Yes
Driver training (voluntary)	On-road driving skills, driving theory	Stock et al. (1983)	Yes	Inconclusive
Driver training (compulsory)	On-road driving skills, driving theory	Cartensen (2002)	Unknown	Yes
Driver training (with GDLS discount)	On-road driving skills, driving theory	Boase & Tasca (1998) Hirsch et al. (2006) Lewis-Evans (2010) Mayhew et al. (2003) Zhao et al. (2006)	Unknown	No – may increase crash rates
Simulation training	Driving skills (simulated and on-road)	Allen et al. (2003, 2007, 2010) Falkmer & Gregersen (2003)	Yes	Inconclusive
		Higher-Order Cognitive Skills		
Resilience training	Interpersonal skills, attitudes to risky behaviours (i.e. drug and alcohol use, seatbelts).	Griffin et al. (2004) King et al. (2008) Senserrick et al. (2009)	Unknown	Yes

Table 6-2. Summary of the efficacy of post-licence training programs.

Type of Training	Target Skills	Source	Does it improve target skills?	Does it improve on-road safety?
		Procedural Skills		
Advanced vehicle control skills	Vehicle manoeuvring, braking, skid control	Isler et al. (2011) Petersen & Barrett (2009) Petersen et al. (2006, 2008)	Yes	Unknown
Skid control training	Skid control	Katila et al. (1996, 2004) Gregersen (1996)	No	No – may increase crash rates
Defensive driving	Vehicle handling, skid control, hazard perception	Kelly (2005) Kelly & Stanley (2006) Stanley & Mueller (2010)	Unknown	No
Police driver training	Vehicle manoeuvring	Dorn & Barker (2005)	Yes	Unknown – possibly
		Higher-Order Skills		
Higher-order skills training	Hazard perception Situation awareness Self-assessment	Isler et al. (2011) Walker et al (2009)	Yes	Unknown
Hazard perception: Commentary training	Hazard perception	Chapman et al. (2002) Crundall et al. (2010) Isler et al. (2009) McKenna et al. (2006) Wang et al. (2010)	Yes	Unknown
Hazard perception: Part-task training	Hazard perception	Fisher et al. (2002, 2006) Pollatsek et al. (2006) Pradhan et al. (2005) Regan et al. (2000)	Yes	Unknown
Insight training	Self-assessment of driving-related abilities, reduced overconfidence	Gregersen (1996) Senserrick & Swinburne (2001) White et al. (2011)	Yes (mostly)	Unknown
Cognitive training	Situation awareness	Soliman & Mathna (2009)	Yes	Unknown

ABBREVIATIONS

ABS	Anti-lock Braking System
C-MARC	Curtin-Monash Accident Research Centre
GDLS	Graduated Driver Licensing System
NHTSA	National Highway Traffic Safety Administration [US]
MUARC	Monash University Accident Research Centre
NSW	New South Wales
PDL	Pre-Driver Licensing
RAC	Royal Automobile Club
RACV	Royal Automobile Club of Victoria
SES	Socio-economic status
SPC	Safe Performance Curriculum
WA	Western Australia

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